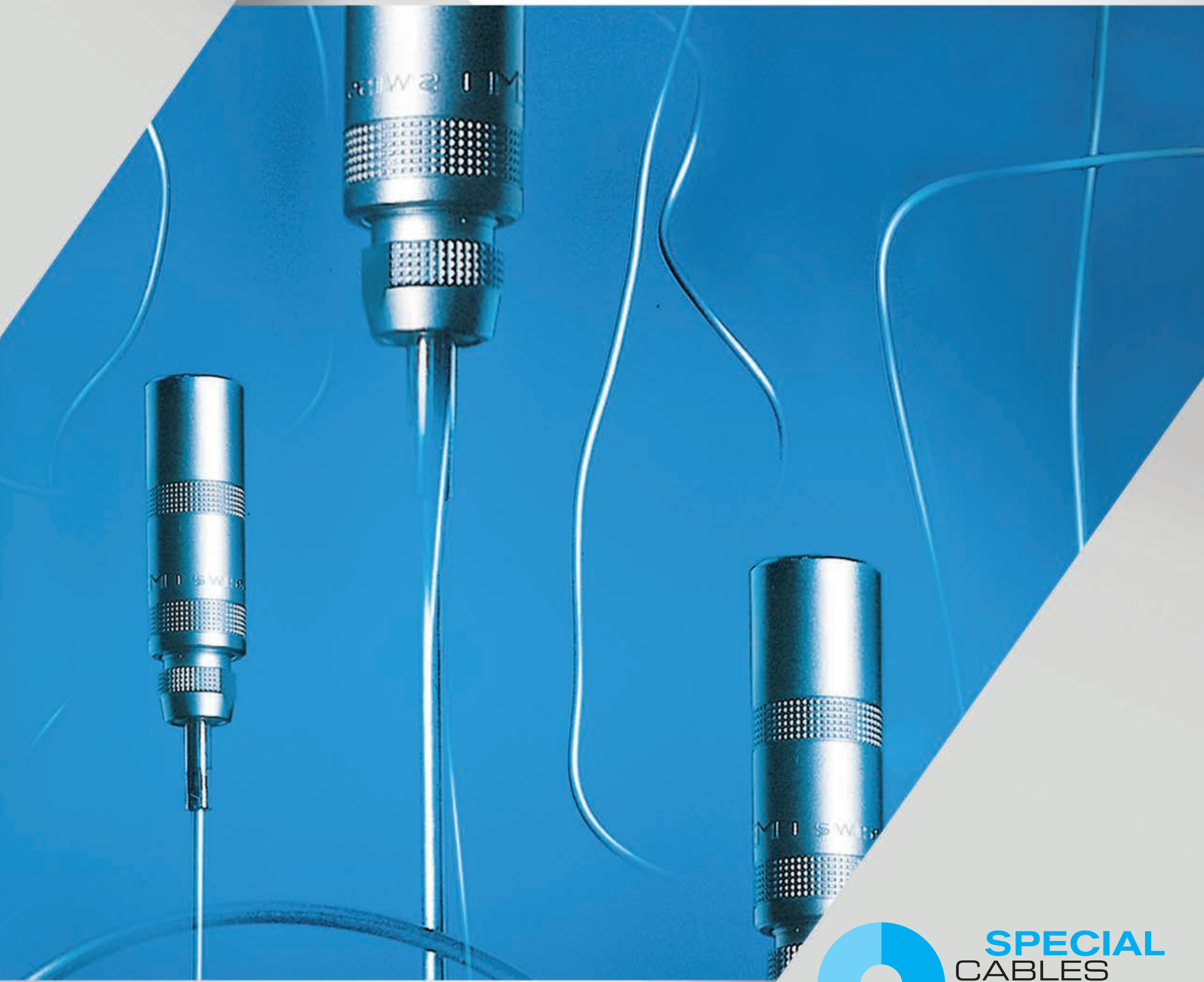
THERMOCOUPLES AND RESISTANCE THERMOMETERS

MINERAL INSULATED



SPECIAL CABLES
SAB North America

www.sabcable.com
866-722-2974 ■ info@sabcable.com

About Us

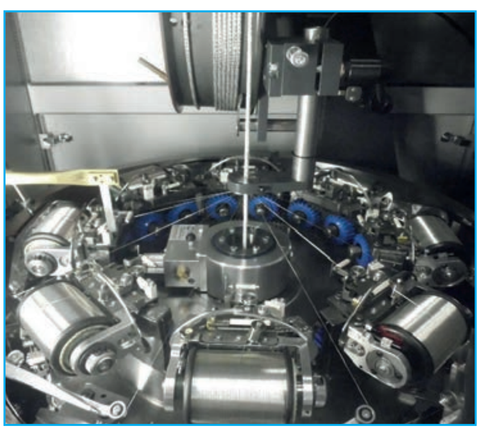
SAB North America is a focused supplier for the automation, aerospace, medical, high temperature, and robotics industries, providing cable and thermocouple solutions that meet, exceed, and set new standards in the flexible cable market. In addition to flexible cable products, we offer an extensive inventory of high-quality cable accessories, including cord grips, grounding glands and other accessories that complement our flexible control and automation cables.

Whatever the need may be, look to SAB North America for Special Cables that can, for example, help minimize maintenance costs and increase productivity, reduce downtime, and solve specific problems. Here is a small sample of some of the challenges that Special Cables from SAB North America can help address:

- Hybrid designs for multiple functions
- Harsh environments
- Difficult applications
- Industry-specific requirements

Thermocouples transfer heat with the help of thermoelectricity into electrical energy. A thermocouple is a component consisting of two different metallic conductors connected together at one end. A temperature difference creates a heat flow and a thermoelectric voltage. A temperature measuring device with a thermocouple as data indicator tends to consist of the thermocouple itself with a measuring tip, an extension cable, a cold junction with a specified constant temperature and a voltmeter. The temperature measurement with resistance thermometers (RTD) is based on the characteristic of conducting materials to change their electrical resistance with temperature. For metals, the resistance increases with rising temperature. If the relation between temperature and resistance is known, you can determine the temperature by measuring the resistance.

As a longtime manufacturer of mineral-insulated thermocouples with more than 75 years of experience we are able to design a special thermocouple which can be produced especially for your application and according to your specifications. The type can be chosen freely depending on the application, e.g. type K, type J, type L, type S/T etc.



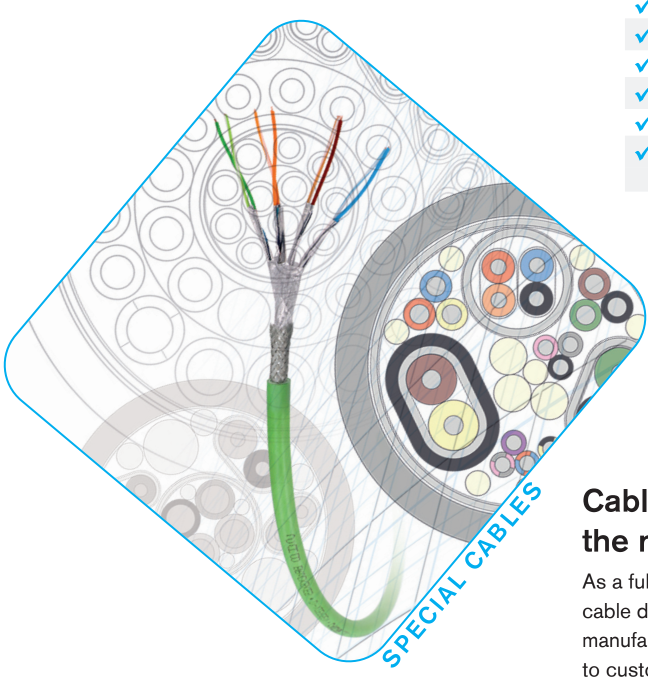
SAB Advantage...We make it Easy

- Engineering & technical assistance
- Cut to length with no cut charges
- Prepaid freight within US for orders over $2,500
- Specialty cable designs (1500 ft minimum)
- No minimum on orders from stock
- Free drop shipments (no surcharges)
- 24-hour shipments from stock
- Cord Grips for securing and grounding cables

CONTENT

Flexible cables and wires “Made in Germany”

As a leading manufacturer we develop and produce cables for industrial purposes.
Our wide range of materials offer a lot of possibilities for your individual product requirement.
The following survey shows an extract of our production possibilities:



Conductor Materials:

- ✓ bare copper
- ✓ tinned copper
- ✓ silver plated copper
- ✓ nickel plated copper
- ✓ nickel
- ✓ nickel pure
- ✓ compensating cable alloys

Insulation and Jacketing Materials:

- ✓ PVC
- ✓ Polyethylene
- ✓ Polypropylene
- ✓ Polyurethane
- ✓ TPE
- ✓ SABIX® (zero halogen)
- ✓ Besilen® - Silicone
- ✓ FEP, ETFE, PFA, PTFE
- ✓ PI foil
- ✓ Fiberglass

Conductors:

- ✓ cross sections 0.055 - 300 mm²
- ✓ unshielded and shielded over 100 conductors

Temperature Ranges:

Thermoplastic Elastomers
- ✓ -50°C up to +145°C

SABIX®
- ✓ -50°C up to +220°C

Besilen® - Silicone
- ✓ -40°C up to +220°C

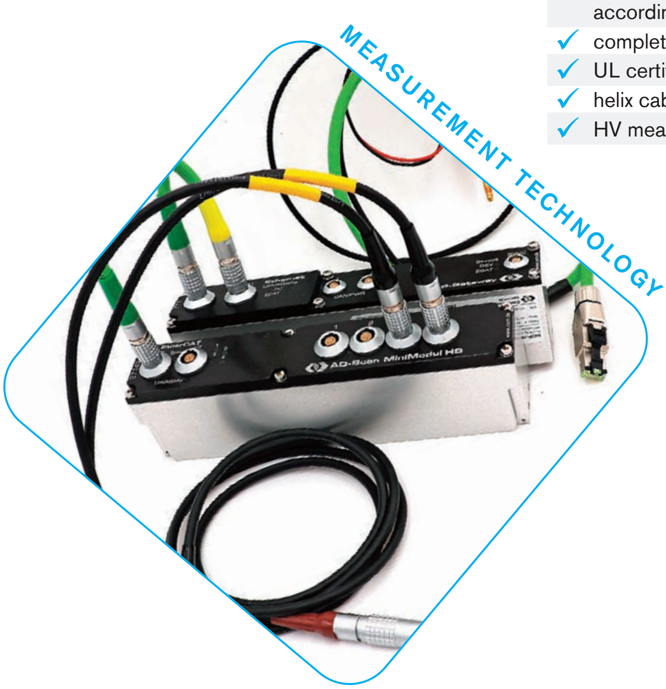
FEP, ETFE, PFA
- ✓ -90°C up to +260°C

Fiberglass
- ✓ up to +600°C

Cable assemblies directly from the manufacturer SAB:

As a full service partner, we are able to offer cable design and production as well as the manufacturing of cable assemblies according to customer´s request. Please trust on our experience for decades in the treatment of cables and connectors.

- ✓ cable assemblies according to customer´s demands
- ✓ complete cable assemblies
- ✓ UL certified assemblies
- ✓ helix cables
- ✓ HV measuring assemblies



Measuring technology for industrial applications

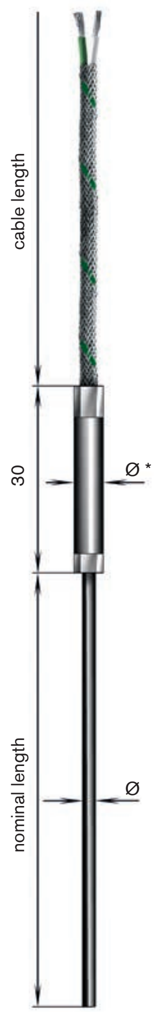
Manufacturer of temperature sensors for industrial applications with 75 years of experience!

- ✓ mineral insulated thermocouples
- ✓ mineral insulated resistance thermometers
- ✓ temperature sensors
- ✓ mobile high voltage measuring technology
- ✓ temperature sensors for vehicle testing

MTC 201

Mineral insulated thermocouple with PFA connection cable Th 22 LTV

thermocouple:	type K or J acc. to DIN EN 60584
measuring tip:	form A insulated or form B welded
measuring temperature:	**type K:** max. 800°C with jacket material 1.4541 max. 1100°C with jacket material 2.4816 **type J:** max. 750°C



THERMOCOUPLE:

❑ 1 x L(1) ❑ 1 x J ❑ 1 x K

❑ 2 x L(1) ❑ 2 x J ❑ 2 x K ❑ other thermocouples ____________

type L acc. to DIN 43710 type J and K acc. to DIN EN 60584

JACKET - Ø:

❑ 0.25 mm (only type K) ❑ 0.4 mm (only type K)

❑ 0.64 mm ❑ 1.0 mm ❑ 1.5 mm ❑ 2.0 mm

❑ 3.00 mm ❑ 4.5 mm ❑ 6.0 mm ❑ 8.0 mm ❑ other jacket-Ø ____________

JACKET MATERIAL:

❑ 1.4541 ❑ 2.4816 ❑ other jacket materials ____________

TYPE OF CABLE ENDS:

❑ bare ends ❑ cable lugs M4

❑ end sleeves ❑ tinned

❑ 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 lengths ____________

TYPE OF MEASURING TIP:

❑ form A, insulated measuring tip, without kink protection

❑ form B, welded measuring tip, without kink protection

❑ form A, insulated measuring tip, with kink protection

❑ form B, welded measuring tip, with kink protection

all types in class 1

NOMINAL LENGTH: ____________ mm

(1) since 04/94 the standard DIN 43710 is no longer valid

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

CONNECTION CABLE TH 22 LTV

Construction

Insulation:	PFA
Stranding:	conductors together
Braiding:	fiber-glass
Armoring:	stainless steel wire armoring (VA) with tracer
Shape:	round
Cable section:	2 x 0.22 mm²
Conductor:	7 x 0.20 mm Ø
Outer-Ø:	approx. 3.2 mm
Weight / 100 m:	approx . 1.9 kg

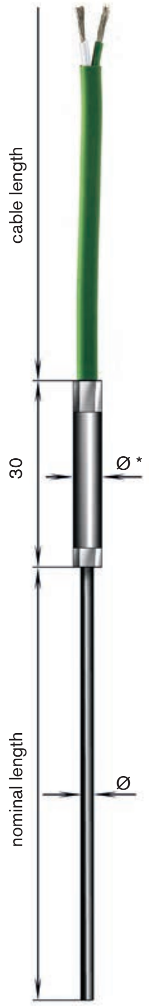
Technical data

Min. bending radius:	12 x O.D.
temperature range of insulation:	**flexible:** max. +250°C **static:** max. +250°C **short-term use:** +260°C
Insulation resistance:	>1MΩ x km
Fire performance:	no flame propagation acc. to IEC 60332 + EN 60332 Cat. C or D. flame retardant and self-extinguishing acc. to IEC 60332-1-2 and EN 60332-1-2
Absence of harmful substances:	acc. to RoHS directive of the European Union

MTC 203

Mineral insulated thermocouple with PVC connection cable A 9-022

thermocouple:	type K or J acc. to DIN EN 60584
measuring tip:	form A insulated or form B welded
measuring temperature:	**type K:** max. 800°C with jacket material 1.4541 max. 1100°C with jacket material 2.4816 **type J:** max. 750°C



THERMOCOUPLE:

❑ 1 x L(1) ❑ 1 x J ❑ 1 x K

❑ 2 x L(1) ❑ 2 x J ❑ 2 x K ❑ other thermocouples ___________

type L acc. to DIN 43710 type J and K acc. to DIN EN 60584

JACKET - Ø:

❑ 0.25 mm (only type K) ❑ 0.4 mm (only type K)

❑ 0.64 mm ❑ 1.0 mm ❑ 1.5 mm ❑ 2.0 mm

❑ 3.00 mm ❑ 4.5 mm ❑ 6.0 mm ❑ 8.0 mm ❑ other jacket-Ø ___________

JACKET MATERIAL:

❑ 1.4541 ❑ 2.4816 ❑ other jacket materials ___________

TYPE OF CABLE ENDS:

❑ bare ends ❑ cable lugs M4

❑ end sleeves ❑ tinned

❑ 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 lengths ___________

TYPE OF MEASURING TIP:

❑ form A, insulated measuring tip, without kink protection

❑ form B, welded measuring tip, without kink protection

❑ form A, insulated measuring tip, with kink protection

❑ form B, welded measuring tip, with kink protection

all types in class 1

NOMINAL LENGTH: ___________ mm

(1) since 04/94 the standard DIN 43710 is no longer valid

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

CONNECTION CABLE A 9 - 022

Construction

Insulation:	PVC
Stranding:	2 conductors together
Jacket:	PVC
Shape:	round
Cable section:	2 x 0.22 mm²
Conductor:	7 x 0.20 mm Ø
Outer-Ø:	approx. 4.0 mm
Weight / 100 m:	approx. 2.2 kg

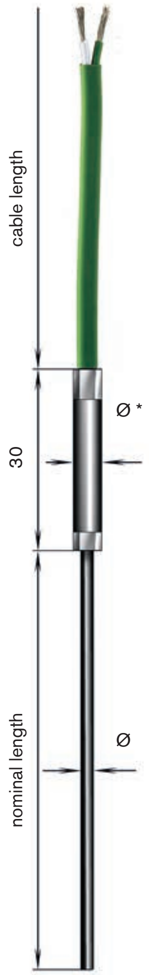
Technical data

Min. bending radius:	7.5 x O.D.
temperature range of insulation:	**flexible:** +5/ +70°C **static:** -40/ +70°C
Insulation resistance:	>1MΩ x km
Fire performance:	flame retardant and self-extinguishing acc. to IEC 60332-1-2 and EN 60332-1-2
Absence of harmful substances:	acc. to RoHS directive of the European Union

MTC 204

Mineral insulated thermocouple with Besilen® (silicone) connection cable A 15 - 022 HT

thermocouple:	type K or J acc. to DIN EN 60584
measuring tip:	form A insulated or form B welded
measuring temperature:	**type K:** max. 800°C with jacket material 1.4541 max. 1100°C with jacket material 2.4816 **type J:** max. 750°C



THERMOCOUPLE:

- ❑ 1 x L(1) ❑ 1 x J ❑ 1 x K
- ❑ 2 x L(1) ❑ 2 x J ❑ 2 x K ❑ other thermocouples ____________

type L acc. to DIN 43710 type J and K acc. to DIN EN 60584

JACKET - Ø:

- ❑ 0.25 mm (only type K) ❑ 0.4 mm (only type K)
- ❑ 0.64 mm ❑ 1.0 mm ❑ 1.5 mm ❑ 2.0 mm
- ❑ 3.00 mm ❑ 4.5 mm ❑ 6.0 mm ❑ 8.0 mm ❑ other jacket-Ø ____________

JACKET MATERIAL:

- ❑ 1.4541 ❑ 2.4816 ❑ other jacket materials ____________

TYPE OF CABLE ENDS:

- ❑ bare ends ❑ cable lugs M4
- ❑ end sleeves ❑ tinned
- ❑ 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 lengths ____________

TYPE OF MEASURING TIP:

- ❑ form A, insulated measuring tip, without kink protection
- ❑ form B, welded measuring tip, without kink protection
- ❑ form A, insulated measuring tip, with kink protection
- ❑ form B, welded measuring tip, with kink protection

all types in class 1

NOMINAL LENGTH: ____________ mm

(1) since 04/94 the standard DIN 43710 is no longer valid
*type of sleeve corresponds to jacket-Ø and connection cable

CONNECTION CABLE A 15 - 022 HT

Construction

Insulation:	fiber-glass
Stranding:	2 conductors together
Jacket:	Besilen®
Shape:	round
Cable section:	2 x 0.22 mm²
Conductor:	7 x 0.20 mm Ø
Outer-Ø:	approx. 4.8 mm
Weight / 100 m:	approx. 2.9 kg

Besilen® is a specially developed Silicone rubber-based material with good electrical characteristics and it is a registered trademark of SAB Bröckskes GmbH & Co. KG.

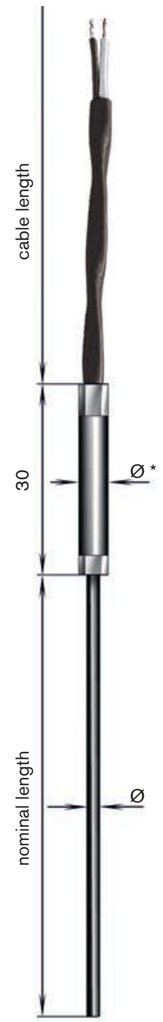
Technical data

Min. bending radius:	7.5 x O.D.
temperature range of insulation:	**flexible:** -25/ +180°C **static:** -40/ +180°C **short-term use:** +250°C
Insulation resistance:	>1MΩ x km
Halogen-free:	acc. to DIN VDE 0472 part 815 + IEC 60754-1 for silicone
Fire performance:	flame retardant and self-extinguishing acc. to IEC 60332-1-2 and EN 60332-1-2
Corrosiveness of conflagration gases:	IEC 60754-2 + EN 50267-2-2 + VDE 0482 part 267-2-2 are accomplished – no development of corrosive conflagration gases
Absence of harmful substances:	acc. to RoHS directive of the European Union

MTC 205

Mineral insulated thermocouple with PFA connection cable Th 22 LTT

thermocouple:	type K or J acc. to DIN EN 60584
measuring tip:	form A insulated or form B welded
measuring temperature:	**type K:** max. 800°C with jacket material 1.4541 max. 1100°C with jacket material 2.4816 **type J:** max. 750°C



THERMOCOUPLE:

❑ 1 x L(1) ❑ 1 x J ❑ 1 x K

❑ 2 x L(1) ❑ 2 x J ❑ 2 x K ❑ other thermocouples ____________

type L acc. to DIN 43710 type J and K acc. to DIN EN 60584

JACKET - Ø:

❑ 0.25 mm (only type K) ❑ 0.4 mm (only type K)

❑ 0.64 mm ❑ 1.0 mm ❑ 1.5 mm ❑ 2.0 mm

❑ 3.00 mm ❑ 4.5 mm ❑ 6.0 mm ❑ 8.0 mm ❑ other jacket-Ø ____________

JACKET MATERIAL:

❑ 1.4541 ❑ 2.4816 ❑ other jacket materials ____________

TYPE OF CABLE ENDS:

❑ bare ends ❑ cable lugs M4

❑ end sleeves ❑ tinned

❑ 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 lengths ____________

TYPE OF MEASURING TIP:

❑ form A, insulated measuring tip, without kink protection

❑ form B, welded measuring tip, without kink protection

❑ form A, insulated measuring tip, with kink protection

❑ form B, welded measuring tip, with kink protection

all types in class 1

NOMINAL LENGTH: ____________ mm

(1) since 04/94 the standard DIN 43710 is no longer valid

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

CONNECTION CABLE TH 22 LTT

Construction

Insulation:	PFA
Stranding:	conductors together
Jacket:	PFA
Shape:	round
Cable section:	2 x 0.22 mm^2
Conductor:	7 x 0.20 mm Ø
Outer-Ø:	approx. 2.8 mm
Weight / 100 m:	approx. 1.2 kg

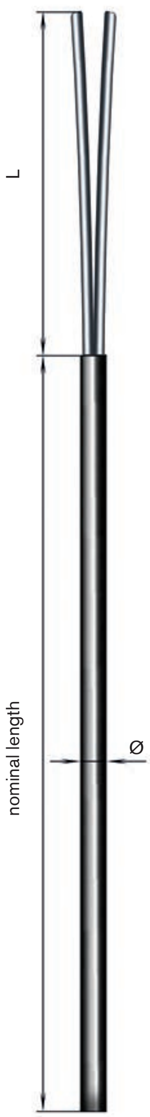
Technical data

Min. bending radius:	7.5 x O.D.
Radiation resistance:	5×10^6 cJ/kg
temperature range of insulation:	**flexible:** -55/ +250°C **static:** -90/ +250°C **short-term use:** +260°C
Fire performance:	flame retardant and self-extinguishing acc. to IEC 60332-1-2 and EN 60332-1-2
Chemical resistance:	very good against acids, halogens, bases, chlorinated solvents as well as organic and inorganic compounds
Absence of harmful substances:	acc. to RoHS directive of the European Union

MTC 301

Mineral insulated thermocouple with bare connection ends

thermocouple:	type K or J acc. to DIN EN 60584
measuring tip:	form A insulated or form B welded
measuring temperature:	**type K:** max. 800°C with jacket material 1.4541 max. 1100°C with jacket material 2.4816 **type J:** max. 750°C



[1] since 04/94 the standard DIN 43710 is no longer valid

THERMOCOUPLE:

❑ 1 x L[1] ❑ 1 x J ❑ 1 x K

❑ 2 x L[1] ❑ 2 x J ❑ 2 x K ❑ other thermocouples ____________

type L acc. to DIN 43710 type J and K acc. to DIN EN 60584

JACKET - Ø:

❑ 0.25 mm (only type K) ❑ 0.4 mm (only type K)

❑ 0.64 mm ❑ 1.0 mm ❑ 1.5 mm ❑ 2.0 mm

❑ 3.00 mm ❑ 4.5 mm ❑ 6.0 mm ❑ 8.0 mm ❑ other jacket-Ø ____________

JACKET MATERIAL:

❑ 1.4541 ❑ 2.4816 ❑ other jacket materials ____________

TYPE OF CABLE ENDS:

❑ bare ends L=10mm ❑ bare ends L=50mm

❑ bare ends L=25mm ❑ bare ends L=60mm

❑ bare ends L=40mm ❑ other cable ends ____________

ACCESSORIES (FIX):

❑ without ❑ with accessories ____________

TYPE OF MEASURING TIP:

❑ class 1, form A

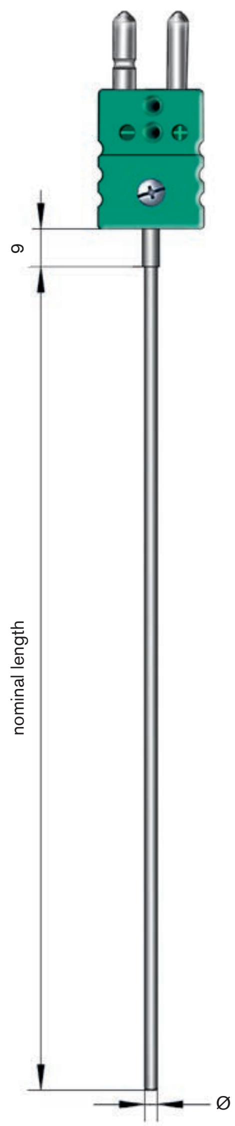
❑ class 1, form B

NOMINAL LENGTH: ____________ mm

MTC 302

Mineral insulated thermocouple with thermo plug

thermocouple:	type K or J acc. to DIN EN 60584
measuring tip:	form A insulated or form B welded
measuring temperature:	**type K:** max. 800°C with jacket material 1.4541 max. 1100°C with jacket material 2.4816 **type J:** max. 750°C



[1] since 04/94 the standard DIN 43710 is no longer valid

THERMOCOUPLE:

- ❑ 1 x L[1] ❑ 1 x J ❑ 1 x K
- ❑ 2 x L[1] ❑ 2 x J ❑ 2 x K ❑ other thermocouples ____________

type L acc. to DIN 43710 type J and K acc. to DIN EN 60584

JACKET - Ø:

- ❑ 0.25 mm (only type K) ❑ 0.4 mm (only type K)
- ❑ 0.64 mm ❑ 1.0 mm ❑ 1.5 mm ❑ 2.0 mm
- ❑ 3.00 mm ❑ 4.5 mm ❑ 6.0 mm ❑ 8.0 mm ❑ other jacket-Ø ____________

JACKET MATERIAL:

- ❑ 1.4541 ❑ 2.4816 ❑ other jacket materials ____________

CONNECTION ELEMENT:

- ❑ without plug ❑ high temperature plug
- ❑ standard plug ❑ standard socket
- ❑ miniature plug ❑ miniature socket
- ❑ high temperature socket ❑ Tuchel plug
- ❑ appliance box ❑ special color ____________

ACCESSORIES (FIX):

- ❑ without ❑ with accessories:____________

TYPE OF MEASURING TIP:

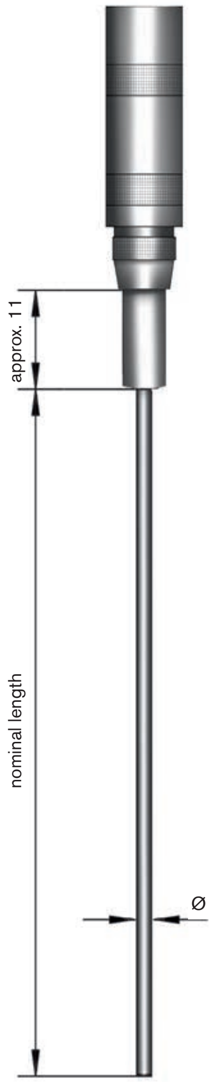
- ❑ class 1, form A
- ❑ class 1, form B

NOMINAL LENGTH: ____________ mm

MTC 303

Mineral insulated thermocouple with Lemo connection element

thermocouple:	type K or J acc. to DIN EN 60584
measuring tip:	form A insulated or form B welded
measuring temperature:	**type K:** max. 800°C with jacket material 1.4541 max. 1100°C with jacket material 2.4816 **type J:** max. 750°C
plug/ socket size:	size 0 with jacket-Ø 0.25 mm – 1.00 mm size 1 with jacket-Ø 1.50 mm – 4.50 mm size 2 with jacket-Ø 6.00 mm



[1] since 04/94 the standard DIN 43710 is no longer valid

THERMOCOUPLE:

❑ 1 x L[1] ❑ 1 x J ❑ 1 x K
❑ 2 x L[1] ❑ 2 x J ❑ 2 x K ❑ other thermocouples ___________

type L acc. to DIN 43710 type J and K acc. to DIN EN 60584

JACKET - Ø:

❑ 0.25 mm (only type K) ❑ 0.4 mm (only type K)
❑ 0.64 mm ❑ 1.0 mm ❑ 1.5 mm ❑ 2.0 mm
❑ 3.00 mm ❑ 4.5 mm ❑ 6.0 mm ❑ other jacket-Ø ___________

JACKET MATERIAL:

❑ 1.4541 ❑ 2.4816 ❑ other jacket materials ___________

CONNECTION ELEMENT:

❑ socket size 0 ❑ plug size 0
❑ socket size 1 ❑ plug size 1
❑ socket size 2 ❑ plug size 2
❑ other connection elements ___________

ACCESSORIES (FIX):

❑ without socket/plug housing
❑ with socket/plug housing
❑ special accessories ___________

TYPE OF MEASURING TIP:

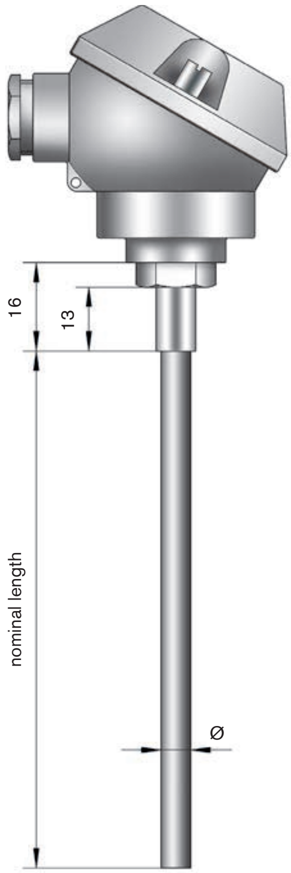
❑ class 1, form A
❑ class 1, form B

NOMINAL LENGTH: ___________ mm

MTC 304

Mineral insulated thermocouple with connection head

thermocouple:	type K or J acc. to DIN EN 60584
measuring tip:	form A insulated or form B welded
measuring temperature:	**type K:** max. 800°C with jacket material 1.4541 max. 1100°C with jacket material 2.4816 **type J:** max. 750°C



[1] since 04/94 the standard DIN 43710 is no longer valid

THERMOCOUPLE:

❑ 1 x L[1] ❑ 1 x J ❑ 1 x K

❑ 2 x L[1] ❑ 2 x J ❑ 2 x K ❑ other thermocouples ___________

type L acc. to DIN 43710 type J and K acc. to DIN EN 60584

JACKET - Ø:

❑ 1.5 mm ❑ 2.0 mm ❑ 3.0 mm

❑ 4.5 mm ❑ 6.0 mm ❑ other jacket-Ø ___________

JACKET MATERIAL:

❑ 1.4541 ❑ 2.4816 ❑ other jacket materials ___________

CONNECTION HEAD:

❑ form MA

❑ form S

❑ form L

❑ other connection heads ___________

ACCESSORIES (FIX):

❑ without ❑ with accessories ___________

TYPE OF MEASURING TIP:

❑ class 1, form A

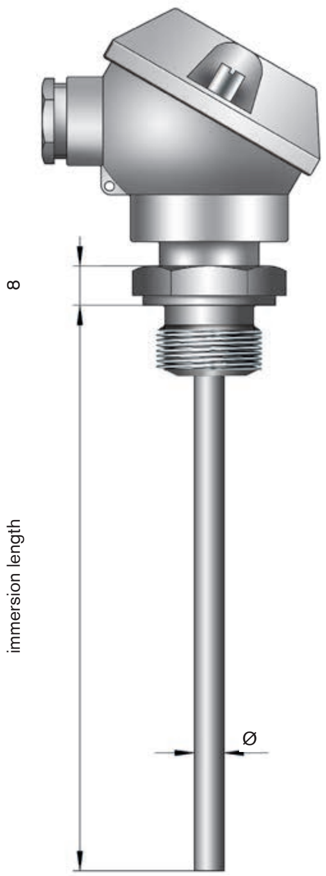
❑ class 1, form B

NOMINAL LENGTH: ___________ mm

MTC 305

Mineral insulated thermocouple with connection head and thread

thermocouple:	type K or J acc. to DIN EN 60584
measuring tip:	form A insulated or form B welded
measuring temperature:	**type K:** max. 800°C with jacket material 1.4541 max. 1100°C with jacket material 2.4816 **type J:** max. 750°C



[1] since 04/94 the standard DIN 43710 is no longer valid

THERMOCOUPLE:

❑ 1 x L[1] ❑ 1 x J ❑ 1 x K

❑ 2 x L[1] ❑ 2 x J ❑ 2 x K ❑ other thermocouples ____________

type L acc. to DIN 43710 type J and K acc. to DIN EN 60584

JACKET - Ø:

❑ 1.5 mm ❑ 2.0 mm ❑ 3.0 mm

❑ 4.5 mm ❑ 6.0 mm ❑ other jacket-Ø ____________

JACKET MATERIAL:

❑ 1.4541 ❑ 2.4816 ❑ other jacket materials ____________

CONNECTION HEAD:

❑ form MA / G 1/2 A ❑ form B / G 1/2 A ❑ form B / G 1/4 A

❑ form MA / G 3/8 A ❑ form B / G 3/8 A ❑ form DAN-S / G 1/2 A

❑ form MA / G 1/4 A ❑ other connection heads ____________

ACCESSORIES (FIX):

❑ without ❑ with accessories ____________

TYPE OF MEASURING TIP:

❑ class 1, form A

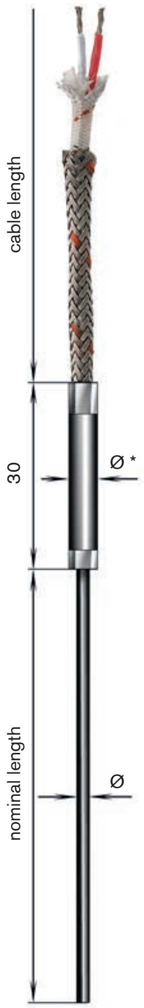
❑ class 1, form B

IMMERSION LENGTH: ____________ mm

RTD 501

Mineral insulated resistance thermometer with PFA connection cable TGV

RTD:	Pt 100 acc. to DIN EN 60751
jacket material:	mat. no. 1.4541
measuring range:	-50 up to +400°C and -50 up to +600°C



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

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

CIRCUIT OF INNER WIRES:

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

JACKET - Ø:

- ❑ 1.5 mm
- ❑ 3.0 mm
- ❑ 4.5 mm
- ❑ 6.0 mm
- ❑ other jacket-Ø ____________

TYPE OF CABLE ENDS:

- ❑ bare ends
- ❑ cable lugs M4
- ❑ end sleeves
- ❑ tinned
- ❑ 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 lengths ____________

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

CONNECTION CABLE TGV

Construction

Insulation:	PFA
Stranding:	conductors together
Braiding:	fiber-glass
Armoring:	stainless steel wire armoring (VA) with tracer
Shape:	round
Cable section:	0.18 mm²

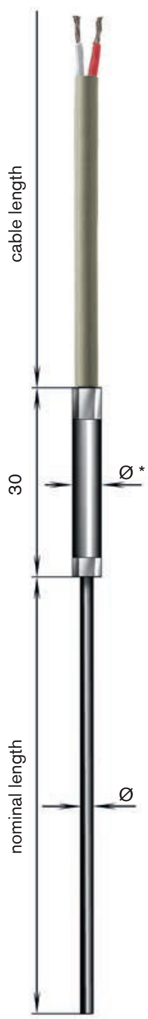
Technical data

Min. bending radius:	12 x O.D.
temperature range of insulation:	**flexible:** max. +250°C **static:** max. +250°C **short-term use:** +260°C
Insulation resistance:	>1MΩ x km
Fire performance:	no flame propagation acc. to IEC 60332 + EN 60332 Cat. C or D. Flame retardant and self-extinguishing acc. to IEC 60332-1-2 and EN 60332-1-2
Absence of harmful substances:	acc. to RoHS directive of the European Union

RTD 503

Mineral insulated resistance thermometer with PVC data cable LiYY

RTD:	Pt 100 acc. to DIN EN 60751
jacket material:	mat. no. 1.4541
measuring range:	-50 up to +400°C and -50 up to +600°C



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

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

CIRCUIT OF INNER WIRES:

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

JACKET - Ø:

❑ 1.5 mm ❑ 3.0 mm ❑ 4.5 mm ❑ 6.0 mm ❑ other jacket-Ø ____________

TYPE OF CABLE ENDS:

❑ bare ends ❑ cable lugs M4

❑ end sleeves ❑ tinned

❑ 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 lengths ____________

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

Jacket-ø: 1.5 mm on request

CONNECTION CABLE LiYY

Construction

Insulation:	PVC
Stranding:	in layers
jacket material:	PVC
Cable section:	0.25 mm^2

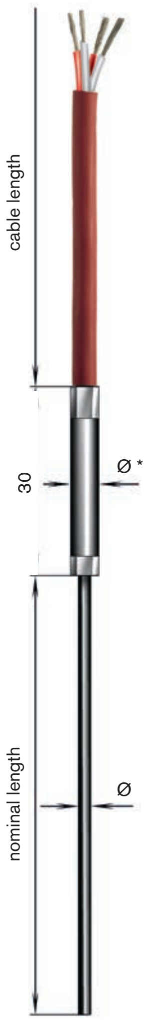
Technical data

Min. bending radius:	**fixed installation:** 5 x O.D. **free movement:** 10 x O.D.
temperature range of insulation:	**flexible:** -5°C/+70°C **static:** -30°C/+70°C
Radiation resistance:	8 x 10^7 cJ/kg
Fire performance:	no flame propagation acc. to IEC 60332 + EN 60332 Cat. C or D. Flame retardant and self-extinguishing acc. to IEC 60332-1-2 and EN 60332-1-2
Absence of harmful substances:	acc. to RoHS directive of the European Union

RTD 504

Mineral insulated resistance thermometer with Besilen® (silicone) connection cable BiHF

RTD:	Pt 100 acc. to DIN EN 60751
jacket material:	mat. no. 1.4541
measuring range:	-50 up to +400°C and -50 up to +600°C



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

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

CIRCUIT OF INNER WIRES:

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

JACKET - Ø:

- ❑ 1.5 mm
- ❑ 3.0 mm
- ❑ 4.5 mm
- ❑ 6.0 mm
- ❑ other jacket-Ø ____________

TYPE OF CABLE ENDS:

- ❑ bare ends
- ❑ cable lugs M4
- ❑ end sleeves
- ❑ tinned
- ❑ 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 lengths ____________

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

Jacket-ø: 1.5 mm on request

CONNECTION CABLE BiHF

Construction

Insulation:	Besilen® (silicone)
Stranding:	in layers
jacket material:	Besilen® (silicone)
Cable section:	0.25 mm²

Besilen® is a specially developed Silicone rubber-based material with good electrical characteristics and it is a registered trademark of SAB Bröckskes GmbH & Co. KG.

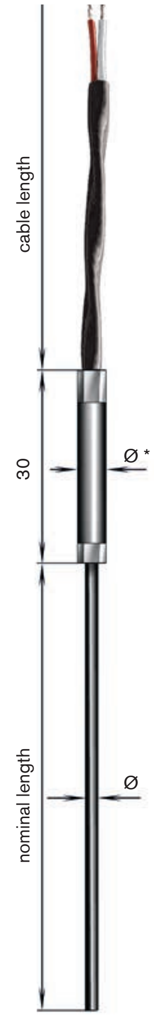
Technical data

Min. bending radius:	**fixed installation:** 4 x O.D. **free movement:** 6 x O.D.
temperature range of insulation:	**flexible:** -25°C/+180°C **static:** -40°C/+180°C **short-term use:** +250°C
Radiation resistance:	8 x 10⁷ cJ/kg
Fire performance:	flame retardant and self-extinguishing acc. to IEC 60332-1-2 and EN 60332-1-2.
Corrosiveness of conflagration gases:	IEC 60754-2 + EN 50267-2-2 +VDE 0482 part 267-2-2 are accomplished – no development of corrosive conflagration gases
Absence of harmful substances:	acc. to RoHS directive of the European Union

RTD 505

Mineral insulated resistance thermometer with PFA connection cable TTL

RTD:	Pt 100 acc. to DIN EN 60751
jacket material:	mat. no. 1.4541
measuring range:	-50 up to +400°C and -50 up to +600°C



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

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

CIRCUIT OF INNER WIRES:

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

JACKET - Ø:

- ❑ 1.5 mm
- ❑ 3.0 mm
- ❑ 4.5 mm
- ❑ 6.0 mm
- ❑ other jacket-Ø ____________

TYPE OF CABLE ENDS:

- ❑ bare ends
- ❑ cable lugs M4
- ❑ end sleeves
- ❑ tinned
- ❑ 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 lengths ____________

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

Jacket-ø: 1.5 mm on request

CONNECTION CABLE TTL

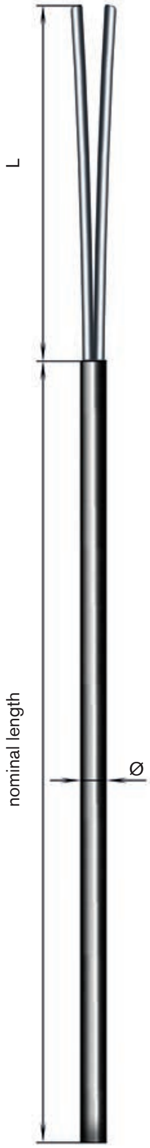
	Construction
Insulation:	PFA
Stranding:	conductors together
jacket material:	PFA
Shape:	round
Cable section:	0.18 mm²

	Technical data
Min. bending radius:	7.5 x O.D.
Radiation resistance:	5 x 10^6 cJ/kg
temperature range of insulation:	**flexible:** -55/+250°C **static:** -90/+250°C **short-term use:** +260°C
Fire performance:	flame retardant and self-extinguishing acc. to IEC 60332-1-2 and EN 60332-1-2.
Chemical resistance:	very good against acids, halogens, chlorinated solvents as well as organic and inorganic compounds
Absence of harmful substances:	acc. to RoHS directive of the European Union

RTD 601

Mineral insulated resistance thermometer with bare connection ends

RTD:	Pt 100 acc. to DIN EN 60751
jacket material:	mat. no. 1.4541
measuring range:	-50 up to +400°C and -50 up to +600°C



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

CIRCUIT OF INNER WIRES:

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

JACKET - Ø:

- ❑ 1.5 mm
- ❑ 3.0 mm
- ❑ 4.5 mm
- ❑ 6.0 mm
- ❑ other jacket-Ø ____________

TYPE OF CONNECTION WIRES:

- ❑ bare ends L=25mm
- ❑ bare ends L=50mm
- ❑ bare ends L=40mm
- ❑ bare ends L=60mm
- ❑ other cable ends ____________

ACCESSORIES (FIX):

- ❑ without
- ❑ with accessories ____________

MEASURING RANGE:

- ❑ -50 up to +400°C
- ❑ -50 up to +600°C
- ❑ other measuring range ____________

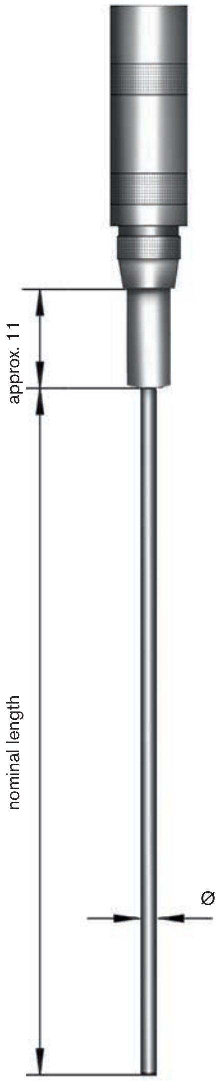
NOMINAL LENGTH: ____________ mm

Jacket-ø: 1.5 mm on request

RTD 603

Mineral insulated resistance thermometer with Lemo connection end

RTD:	Pt 100 acc. to DIN EN 60751
jacket material:	mat. no. 1.4541
measuring range:	-50 up to +400°C and -50 up to +600°C
plug/ socket size:	size 0 with jacket-Ø 1.6 mm size 1 with jacket-Ø 1.6 mm – 4.5 mm size 2 with jacket-Ø 6.00 mm



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

CIRCUIT OF INNER WIRES:

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

JACKET - Ø:

- ❑ 1.5 mm
- ❑ 3.0 mm
- ❑ 4.5 mm
- ❑ 6.0 mm
- ❑ other jacket-Ø ___________

CONNECTION ELEMENT:

- ❑ socket size 0
- ❑ plug size 0
- ❑ socket size 1
- ❑ plug size 1
- ❑ socket size 2
- ❑ plug size 2
- ❑ other connection elements ___________

ACCESSORIES (FIX):

- ❑ without socket/plug housing
- ❑ with socket/plug housing
- ❑ special accessories ___________

MEASURING RANGE:

- ❑ -50 up to +400°C
- ❑ -50 up to +600°C
- ❑ other measuring range ___________

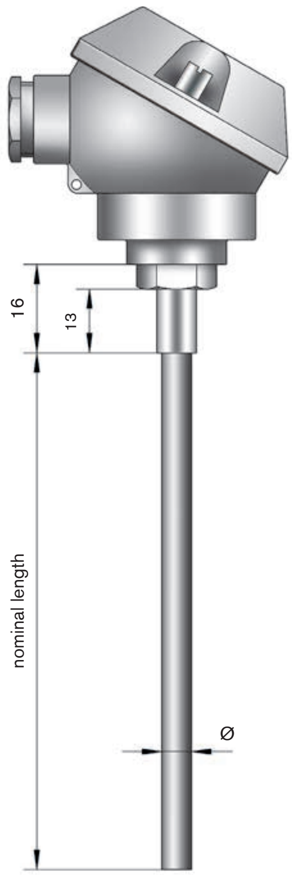
NOMINAL LENGTH: ___________ mm

Jacket-ø: 1.5 mm on request

RTD 604

Mineral insulated resistance thermometer with connection head

RTD:	Pt 100 acc. to DIN EN 60751
jacket material:	mat. no. 1.4541
measuring range:	-50 up to +400°C and -50 up to +600°C



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

CIRCUIT OF INNER WIRES:

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

JACKET - Ø:

- ❑ 3.0 mm
- ❑ 4.5 mm
- ❑ 6.0 mm
- ❑ other jacket-Ø ____________

CONNECTION HEAD:

- ❑ form MA
- ❑ form S
- ❑ form L
- ❑ other connection heads ____________

ACCESSORIES (FIX):

- ❑ without
- ❑ with accessories ____________

MEASURING RANGE:

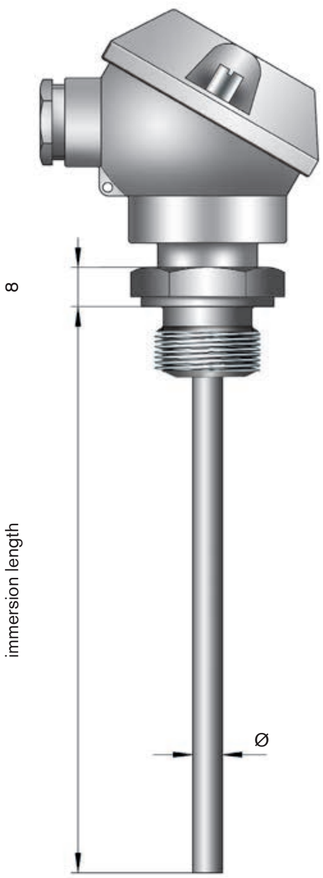
- ❑ -50 up to +400°C
- ❑ -50 up to +600°C
- ❑ other measuring range ____________

NOMINAL LENGTH: ____________ mm

RTD 605

Mineral insulated resistance thermometer with connection head and thread

RTD:	Pt 100 acc. to DIN EN 60751
jacket material:	mat. no. 1.4541
measuring range:	-50 up to +400°C and -50 up to +600°C



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

CIRCUIT OF INNER WIRES:

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

JACKET - Ø:

- ❑ 3.0 mm
- ❑ 4.5 mm
- ❑ 6.0 mm
- ❑ other jacket-Ø ____________

CONNECTION HEAD:

- ❑ form MA / G 1/2 A
- ❑ form B / G 3/8 A
- ❑ form MA / G 3/8 A
- ❑ form B / G 1/4 A
- ❑ form MA / G 1/4 A
- ❑ form DAN-S / G 1/2 A
- ❑ form B / G 1/2 A
- ❑ other connection heads ____________

ACCESSORIES (FIX):

- ❑ without
- ❑ with accessories ____________

MEASURING RANGE:

- ❑ -50 up to +400°C
- ❑ -50 up to +600°C
- ❑ other measuring range ____________

IMMERSION LENGTH: ____________ mm

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)

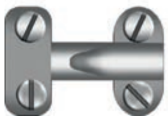
Miniature thermo plug up to max. 200 °C	
item no.	min.t/c type
T 021-007-071	J (Fe-CuNi)
T 021-007-072	K (NiCr-Ni)

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 temp. plug
item no.
T 021-007-035

Miniature plug
item no.
T 021-007-041



Locking plate
item no.
T 021-029-182

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

*outer-Ø of cable

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 021-000-595	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

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
600	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 PTFE thrust collar made are appropriate for temperatures 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 temperatures 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 minimum order quantities!

For centuries people were only able to grasp temperatures subjectively as cold or hot. The invention of the first objective temperature measuring device based on the expansion of air goes back to Galileo Galilei approx. in 1592. Today, temperature measurement technique utilizes a great number of highly specialized sensors and methods that allow to exactly determine and reproduce the thermodynamic state of the matter and thus its temperature almost between 0°K and for example the temperature of the sun.

- **The Fahrenheit scale**

  The German Gabriel Fahrenheit settled down in the Netherlands as instrument maker and built glass thermometers with mercury filling. In 1714, he divided the temperature range between a so called "cold mixture" (ice and salt) and the temperature of human blood (these were his points of reference) into 96 pieces. Later on it was determined in England that the solidification point of water corresponds to 32°F and its boiling point to 212°F.

- **The Celsius scale**

  In 1742, the Suede Anders Celsius divided the range between the solidification and boiling point of water into 100 pieces.

- **The Kelvin scale**

  In 1842, the Englishman William Thomson (later Lord Kelvin) developed on the basis of the Carnot process a thermodynamic temperature scale with the absolute zero point as reference and the scale interval of Celsius.

The conversion between the different scales is done as follows:

0 K = - 273.15°C
0°C = + 273.15 K

Electric thermometers turn the physical value of temperature into a dependent signal. They are self-contained constructive components that deliver an output signal for further treatment. Dependent on the sensor principle in most cases an auxiliary energy source is necessary.

An important advantage is the result of the good transferability of electric symbols over far distances. The transducer and indicator of temperature can be situated far away from each other. The measuring signals can be integrated and treated with small effort into control respectively process guiding systems.

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 based on the special characteristic of conducting materials changing 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 characterize 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.

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 following the corresponding process precisely. 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 FOR MINERAL INSULATED THERMOCOUPLES / RESISTANCE THERMOMETERS

mineral insulated thermocouples

insulated hot junction	response time in			
(form A) jacket-Ø (mm)	water with 0.2 m/s t 0.5 (s)	t 0.9 (s)	air with 2.0 m/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) jacket-Ø (mm)	water with 0.2 m/s t 0.5 (s)	t 0.9 (s)	air with 2.0 m/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

jacket-ø (mm)	response time in			
	water with 0.2 m/s t 0.5 (s)	t 0.9 (s)	air with 2.0 m/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

▶ General

Mineral insulated thermocouples and mineral insulated resistance thermometers can be bent with a radius of 5 x the outer diameter of the jacket material. The measuring tip must not be bent over a length of 60 mm.

TEST CERTIFICATES

Test reports or test certificates acc. to DIN EN 10204 are available for an additional fee.

1. **Declaration of compliance with the order acc. to DIN EN 10204-2.1**
   Manufacturer's declaration of compliance with the order without test results.

2. **Test report acc. to DIN EN 10204-2.2 (batch certificate)**
   Manufacturer's declaration of compliance with the order, with test results based on non specific inspection.

3. **Inspection certificate acc. to DIN EN 10204-3.1**
   Manufacturer's declaration of compliance with the order, with test results based on specific inspection.

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.

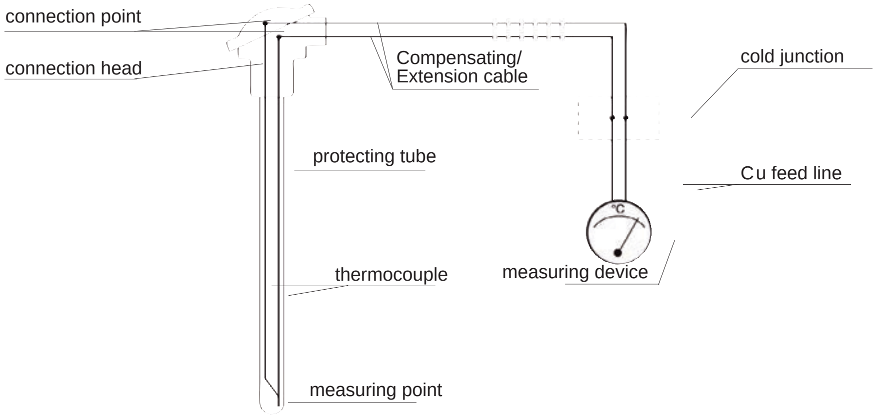
List of individual tests per measuring point available for an additional fee
calibration in “Kryostat” bath: temperature range -50°C up to +50°C
calibration in oil bath: temperature range +60°C up to +200°C
calibration in “Trockenblock-Kalibrator”: temperature range -30°C up to +165°C, +100°C up to +1100°C
response time in water: determination of 0.1-time, 0.5-time and 0.9-time
response time in air: determination of 0.1-time, 0.5-time and 0.9-time

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 dependance 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, fiber-glass and SABtex insulated or jacketed compensating and extension cables are not suitable for outdoor use. Exception: PVC jacketed 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.

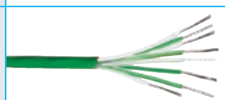
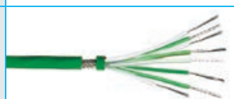
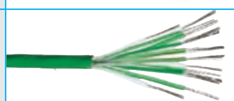
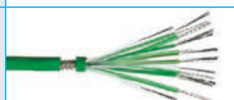
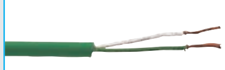
The cables have to be chosen so that they are appropriate for their environment that means that they resist against thermal, mechanical, and chemical influences. All cable contacts have to be done well. Measuring cable shall be laid > 0.5 m away from any energy cable. In order to suppress electromagnetic or magnetic interferences, the cables shall be shielded and have twisted pairs.

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

CuNi is also called Constantan®

SURVEY COMPENSATING AND EXTENSION CABLES / CONNECTION CABLES FOR RESISTANCE THERMOMETERS

SAB item no.	Picture	Cable type	T/C type	Insulation	Section	Cond.	Form	Outer-Ø	temperature-range of insulation	thermoelectric voltage
fiber-glass insulated thermo-cables (solid wire)										
4899002		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
4892144		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
4899003		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
4909016		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 (solid wire)										
4339138		thermo-couple-cable	type K	KN-Polyimide KP-blank/ Polyimide	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
4339186		thermo-couple-cable	type K	KN-Polyimide KP-blank/ Polyimide	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
4339149		thermo-couple-cable	type K	Polyimide + PTFE/ Polyimide	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
4339168		thermo-couple-cable	type K	KN-Polyimide KP-PTFE/ Polyimide	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 (solid wire)										
4339196		thermo-couple-cable	type K	KN-Polyimide KP blank/ Polyimide/ 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 (solid wire)										
4339152		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 (stranded)										
4339177		thermo-couple-cable	type K	TPE/TPE	2 x 0.2 mm²	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 (stranded)										
4339193		thermo-cable	type K	FEP/FEP/ Bi	2 x 0.2 mm²	strands	round	approx. 3.8 mm	flexible: -25°C upto +180°C fixed: -40°C upto +180°C	DIN IEC 584 class 2

SAB item no.	Picture	Cable type	T/C type	Insu-lation	Section	Cond.	Form	Outer-Ø	temperature-range of insulation	thermoelectric voltage
FEP/Besilen® connection cables for resistance thermometers (stranded)										
4709224		connection cable	tinned copper strands copper figure: 2.7 kg/km	FEP/Bi	2 x 0.14 mm²	strands	round	approx. 2.8 mm	flexible: -25°C up to +180°C fixed: -40°C up to +180°C	
4700423		connection cable	tinned copper strands copper figure: 8.4 kg/km	FEP/Bi	4 x 0.22 mm²	strands	round	approx. 3.9 mm	flexible: -25°C up to +180°C fixed: -40°C up to +180°C	
38339132		connection cable	tinned copper strands copper figure: 19.3 kg/km	FEP/C/ FEP	4 x 0.22 mm²	strands	round	approx. 3.0 mm	flexible: -55°C up to +180°C fixed: -90°C up to +180°C	
FEP insulated thermo-cables (stranded)										
4339240		thermo-couple-cable	type K	FEP	2 x 0.20 mm	wire	round	approx. 1.0 mm	flexible: -25°C up to +180°C fixed: -25°C up to +180°C	DIN IEC 584, class 1
4339157		thermo-cable	type K	FEP/FEP	2 x 0.22 mm²	strands	oval	approx. 2.5 x 1.5 mm	flexible: -25°C up to +180°C fixed: -25°C up to +180°C	DIN IEC 584, tolerance +/- 1°C
4339137		thermo-cable	type K	FEP/FEP	2 x 0.22 mm²	strands	round	approx. 2.0 mm	flexible: -25°C up to +180°C fixed: -25°C up to +180°C	DIN IEC 584, tolerance +/- 1°C
4339154		thermo-cable	type K	FEP/FEP	8 x 2 x 0.22 mm² twisted pair	strands	round	approx. 6.4 mm	flexible: -25°C up to +180°C fixed: -25°C up to +180°C	DIN IEC 584 class 2
4359129		thermo-cable	type K	FEP/C/ FEP	8 x 2 x 0.22 mm² twisted pair	strands	round	approx. 6.9 mm	flexible: -25°C up to +180°C fixed: -25°C up to +180°C	DIN IEC 584 class 2
4339135		thermo-cable	type K	FEP/FEP	16 x 2 x 0.22 mm² twisted pair	strands	round	approx. 7.7 mm	flexible: -25°C up to +180°C fixed: -25°C up to +180°C	DIN IEC 584 class 2
4359135		thermo-cable	type K	FEP/C/ FEP	16 x 2 x 0.22 mm² twisted pair	strands	round	approx. 8.3 mm	flexible: -25°C up to +180°C fixed: -25°C up to +180°C	DIN IEC 584 class 2
4359085		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 up to +180°C fixed: -90°C up to +180°C	DIN IEC 584 class 1
FEP insulated thermo-cables with shielding (stranded)										
4359037		thermo-cable	type K	FEP/C/ FEP	2 x 0.22 mm²	strands	round	approx. 2.6 mm	flexible: -25°C up to +180°C fixed: -25°C up to +180°C	DIN IEC 584, tolerance +/- 1.5°C
Besilen® insulated thermo-cables (stranded)										
4519019		thermo-cable	type K	GL/ Silicone	2 x 0.22 mm²	strands	round	approx. 3.2 mm	flexible: -25°C up to +200°C fixed: -25°C up to +200°C	DIN IEC 584 class 1

temperature t 90/°C	type K +NiCr -Ni DIN EN 60584	type L +Fe -CuNi (1)DIN 43710	type J +Fe -CuNi DIN EN 60584	type U +ECu -CuNi (1)DIN 43710	type T +ECu -CuNi DIN EN 60584	type E +NiCr -CuNi DIN EN 60584	type N +NiCrSi -NiSi DIN EN 60584	type S +PtRh 10 -Pt DIN EN 60584	type R +PtRh 13 -Pt DIN EN 60584	type B +PtRh 30 -PtRh 6 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
MINERAL INSULATED THERMOCOUPLES

tolerances of outer diameter

tolerance of outer diameter	
outer-Ø of thermocouples	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 catalog 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. Mineral insulated thermocouples keep the given minimum insulation resistance acc. to DIN EN 61515 of >1000 MΩ at room temperature.

Form B – grounded mineral insulated thermocouple

- The measuring tip is electrically connected to the jacket.

tolerances of length

tolerances of length		
cutting length (mm)	cutting length up to (mm)	tolerances in (mm)
0	300	+/- 2
300	1000	+/- 4
1000	∞	+/- 10

special tolerances acc. to agreement

tolerances of thermocouples

			class 1		class 2		class 3	
type	standard	material	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	±0.5°C or 0.40%	-40 up to +350°C	±1.0°C or 0.75%	-200 up to +40°C	±1.0°C or 1.5%
(1) U	DIN 43710	Cu-CuNi	–	–	0 up to +600°C	±3.0°C or 0.75%	–	–
J	DIN EN 60584	Fe-CuNi	-40 up to +750°C	±1.5°C or 0.40%	-40 up to +750°C	±2.5°C or 0.75%	–	–
(1) L	DIN 43710	Fe-CuNi	–	–	0 up to +900°C	±3.0°C or 0.75%	–	–
K	DIN EN 60584	NiCr-Ni	-40 up to +1000°C	±1.5°C or 0.40%	-40 up to +1200°C	±2.5°C or 0.75%	-200 up to +40°C	±2.5°C or 1.5%
E	DIN EN 60584	NiCr-CuNi	-40 up to +800°C	±1.5°C or 0.40%	-40 up to +900°C	±2.5°C or 0.75%	-200 up to +40°C	±2.5°C or 1.5%
N	DIN EN 60584	NiCrSi-NiSi	-40 up to +1000°C	±1.5°C or 0.40%	-40 up to +1200°C	±2.5°C or 0.75%	-200 up to +40°C	±2.5°C or 1.5%
S	DIN EN 60584	PtRh 10-Pt	0 up to +1600°C	±1.0°C or (3)	0 up to +1600°C	±1.5°C or 0.25%	–	–
R	DIN EN 60584	PtRh13-Pt	0 up to +1600°C	±1.0°C or (3)	0 up to +1600°C	±1.5°C or 0.25%	–	–
B	DIN EN 60584	PtRh30-PtRh6	–	–	+600 up to +1700°C	±1.5°C or 0.25%	+600 up to +1700°C	±4.0°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) x 0.003] °C

CHARACTERISTIC OF THERMOCOUPLES

characteristics / thermocouples	general	composition	temperature 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	▶ in pure, oxidizing (air) or neutral atmosphere (inert gases) ▶ high resistance against corrosion ▶ small thermal conductivity	▶ do not apply in 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	▶ from 0 - +760°C in vacuum, oxidizing (air), reducing or inert atmosphere (inert gases)	▶ 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-aluminum) 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% aluminum, 1-3,2% manganese, 0.5% cobalt, balance: Fe, Cu, Pb	-270°C/+1372°C	▶ from +250°C - +1260°C in pure, oxidizing (air) and neutral atmosphere (inert gases) ▶ for higher temperatures bigger wire diameters are recommended	▶ 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 at- mosphere without protection ▶ do not use in atmosphere prone to “green mold”
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, ballance: other impurities **LN-leg:** 55% copper, 45% nickel, approx. 0.1% cobalt, iron and manganese	0°C/+900°C	▶ from 0°C - +760°C in vacuum, oxidizing (air), reducing or inert atmosphere (inert gases) ▶ above +500°C bigger wire diameters are recommended	▶ 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-legl:** 84% nickel, 14-14.4% chrome, 1.3-1.6% silicium, ballance (not more than 0.1%): Mn, Fe, C, Co **NN-legl:** 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	▶ from +300°C - +1260°C in pure, oxidizing (air) and neutral atmosphere (inert gases)	▶ 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 with“green mold” ▶ 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	▶ pure, oxidizing atmosphere (air), non aggressive (inert-) gases and short-term in vacuum ▶ above +1200°C type B more appropriate	▶ reducing atmosphere ▶ metal gases (for example plomb or zinc) ▶ aggressive vapors 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	▶ pure, oxidizing atmospheres (air), non aggressive (inert-) gases and short-term in vacuum ▶ above +1200°C type B more appropriate	▶ reducing atmosphere ▶ metal gases (for example plomb or zinck) ▶ aggressive vapors 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	▶ pure, oxidizing atmosphere ▶ neutral atmospheres ▶ vacuum	▶ reducing atmosphere or such with aggressive vapors 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	▶ from -200°C - +370°C in vacuum, oxidizing (air), reducing or inert atmosphere (inert gases) ▶ with higher temperatures bigger wire diameters are recommended	▶ 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)	▶ from -200°C - +370°C in vacuum, oxidizing (air), reducing or inert atmosphere (inert gases) ▶ with higher temperatures bigger wire diameters are recommended	▶ 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:

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

Other jacket 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.	jacket material	max. application temperature
1.4541	special steel	800°C
2.4816	Alloy 600	1100°C

- An important quality characteristic of the jacket 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 jacket 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

jacket materials for mineral insulated thermocouples:

trade mark	mat. no.	material characteristics	application	availability
Inconell Alloy 600	2.4816	very good general resistance against corrosion as well as resistant against stress corrosion / excellent resistance against oxidation temperatures about approx. 1000°C	pressurized water reactor / nuclear power / industrial furnaces / steam boiler / turbines / exhaust gas measurement	type L (Ø 1.5/3/6) / type K (Ø 0.25/....10) / type K double wall thickness (Ø 1.5/3) / type S (Ø 1.5/3/18) / type J (Ø 1. 5/6) / type N (Ø 1/1.5/3/6)

Choice of material

max. application temperature	mat.no.	material characteristics	application range
Unalloyed, high-temperature steel			
400°C	1.0305 (ASTM 105)	unalloyed steel	weld-in and screw-in protecting tubes in steam lines
500°C	1.5415 (AISI A204 Gr.A)	low-alloy and high-temperature steel with molybdenum addition	weld-in and screw-in protecting tubes
540°C	1.7335 (AISI A182 F11)	low-alloy and high-temperature steel with chromium and molybdenum addition	weld-in and screw-in protecting tubes
570°C	1.7380 (AISI A182 F22)	low-alloy and high-temperature steel with chromium and molybdenum addition	weld-in and screw-in protecting tubes
650°C	1.4961	high-temperature austenitic chromium nickel steel (Niobium stabilized)	weld-in and screw-in protecting tubes
Rust and acid resistant steel			
550°C*	1.4301 (AISI 304)	good resistance against organic acids with medium temperatures, saline solutions p.e. sulphates, sulphides, alkaline solvents with medium temperature	food and luxury, food industry, medical apparatus engineering
550°C*	1.4404 (AISI 316 L)	by the addition of molybdenum it is more corrosion-proof in oxidizing acids, p.e. acid of vinegar, acidity of wine, phosphoric acid, sulphuric acid and others. There is an elevated resistance against intercrystalline corrosion by a reduced carbon content.	chemical, pulp industry, nuclear technology, textile, color, fatty adid, soup and pharmaceutical industries as well as dairies and breweries
550°C*	1.4435 (AISI 316L)	elevated resistance against corrosion compared with 1.4404, smaller delta ferrite portion	pharmaceutical industries
550°C*	1.4541 (AISI 321)	good intercrystalline corrosion resistance, good resistance against heavy oil products, vapor and combustion gases. Good resistance against oxidation.	Chemical industry, nuclear power plants, textile, color, fatty acids, soap industry
550°C*	1.4571 (AISI 316 TI)	elevated corrosion resistance compared to certain acids due to the addition of molybdenum. Resistant against crevice corrosion, salt water and aggressive industrial influences.	pharmaceutical industry as well as dairies and breweries
Heat resistant steel			
1100°C	1.4749 (AISI 446)	very good resistance against sulphuric gases and salts due to the high chromium content, very good oxidation resistance as well as with constant and cyclic thermal stress, (low resistance again nitrogenated gases)	smoke and combustion gases, industrial furnaces
1200°C	1.4762 (AISI 446)	high resistance against sulphuric gases due to the high chromium content, (low resistance against nitrogenated gases)	smoke and combustion gases, industrial furnaces
1150°C	1.4841 (AISI 314)	high resistance against nitrogenated and lower oxygen gases. Permanent operation not below 900°C due to embrittlement (more heat resistant than 1.4749 and 1.4762)	power plant construction, petrochemistry, industrial furnaces
1150°C	1.4845 (AISI 310)	same characteristics as 1.4841, however advantage against sigma-phase-embrittlement due to the high portion of silicium	industrial furnace construction, apparatus construction, melting houses, power plant construction, petrochemistry, furnace tubes
1100°C	2.4816 (Inconell 600)	good corrosion resistance, resistance against stress corrosion cracking, excellent oxidation resistance, not recommended with CO2 and sulphuric gases above 550°C and sodium above	hydraulic reactors, nuclear power, industrial furnaces, steam boilers, turbines
1100°C	1.4876 (Incoloy 800)	due to the addition of titanium and aluminum the material shows very good heat resistant values. Appropriate for applications where high mechanical strength besides scaling resistance are demanded. Excellent resistance against carburization and nitrogen content increase.	hydraulic reactors, power plant construction, petrochemistry, industrial furnaces
1300°C	Pt 10% Rh platinum-rhodium alloy	1300°C with oxidizing conditions, in absence of oxygen, silicium and sulphur high heat resistance up to 1200°C, especially resistant in halogens, vinegar acid, NaOCl solutions etc., embrittlement by absorption of silicium out of armoring ceramics, phosphorous sensitiveness, inappropriate in reducing hydrogen atmospheres with sulphurous components.	glas, electrochemical and catalyst technique chemical industry, laboratories, melting houses, annealing furnaces

* In dependence on pressure stress and corrosion attack, the application temperature may reach up to 800°C

THERMOCOUPLE	Material ⊕ ⊖	DIN IEC 584	DIN 43710*	ANSI MC 96.1	BS 4937	NF C 42-324
		Identification THL AGL	Identification THL AGL	Identification THL AGL	Identification THL AGL	Identification 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
K	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
K	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 S	Pt Rh 13 - Pt Pt Rh 10 - Pt	RCB/ SCB 0° to +200°C		0° to +200°C	0° to +200°C	0° to +200°C
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 to +200°C (SAB-Type BC-200). Variant color 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

BASICS OF RESISTANCE THERMOMETERS

Resistance thermometers change their electrical resistance in dependent of 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 different construction types of platinum resistance thermometers are applied in industrial measuring technique.

Our standard mineral insulated resistance thermometers are delivered for measuring ranges from -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. 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 39.

Platinum resistance thermometers are the most accurate sensors and show an excellent long-time stability. Due to the chemical resistance 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. -/+ 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 higher accuracy and reproducibility and the measuring points are a little bit bigger than those of thermocouples. Due to the construction, resistance thermometers use planar measurements which have a slower response time.

TECHNICAL DESCRIPTION OF MINERAL INSULATED RESISTANCE THERMOMETERS

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 dismounting 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 jacket 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 jacket 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 27.

Accuracy classes acc. to DIN EN 60751:2009-5

class	validity range °C		limit deviation[a] °C
	leaded resistor	film resistor	
AA	-50 up to +250	0 up to +150	± (0.1 + 0.0017 [t])
A	-100 up to +450	-30 up to +300	± (0.15 + 0.002 [t])
B	-196 up to +600	-50 up to +500	± (0.3 + 0.005 [t])
C	-196 up to +600	-50 up to +600	± (0.6 + 0.01 [t])
[a] [t] = Value of temperature in °C without considering the sign.			

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

$$\alpha = \frac{R_{100} - R_0}{100 \times R_0} =$$ and has the numerical value 0.003851/°C

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

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	basic value	allowed deviation			
		class A		class B	
°C	Ω	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.

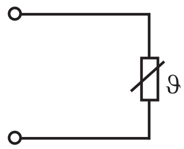
CONNECTION OF RESISTANCE THERMOMETERS

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 x 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.

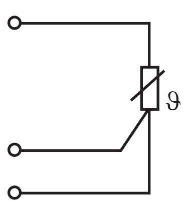
example:

cable section:	0.35 mm²
spec. resistance:	0.0175 Ω mm² m⁻¹
cable length:	50 m
cable material:	E-copper (E-CU)

$$R = 0.0175\ \Omega\ \text{mms}^2\ \text{m}^{-1} \times \frac{2 \times 50\ \text{m}}{0.35\ \text{mm}^2} = 5.0\ \Omega$$

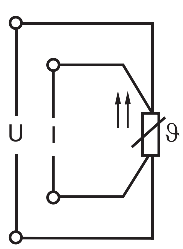
5.0 Ω correspond to a temperature change of 12.8 °C with a Pt 100. In order to avoid this fault, the cable resistance is compensated electrically: The electronic unit is designed in a way that always a cable resistance of 10 Ω is considered. When the resistance thermometer is connected, a balancing resistance 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



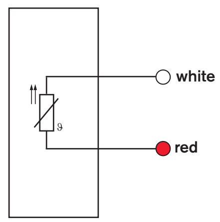
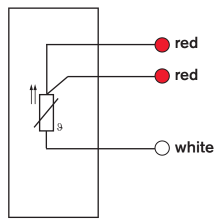
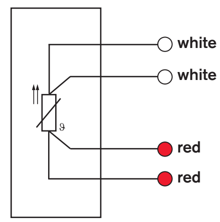
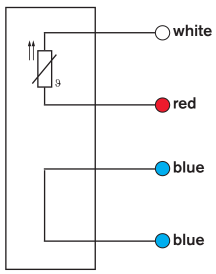
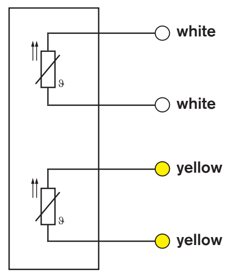
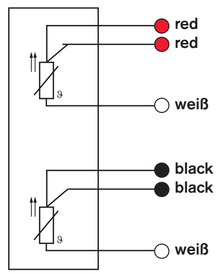
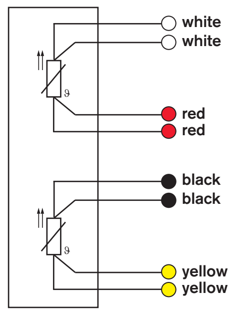
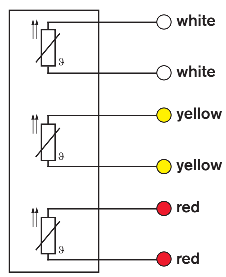
In order to minimize the influences of the cable resistance and its temperature dependant fluctuations, the 3-wire circuit is frequently used instead of the above mentioned 2-wire circuit. Therefore, an additional cable is led to a contact of the RTD. Thus 2 measuring circuits are created, one of them 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. 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.

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				

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