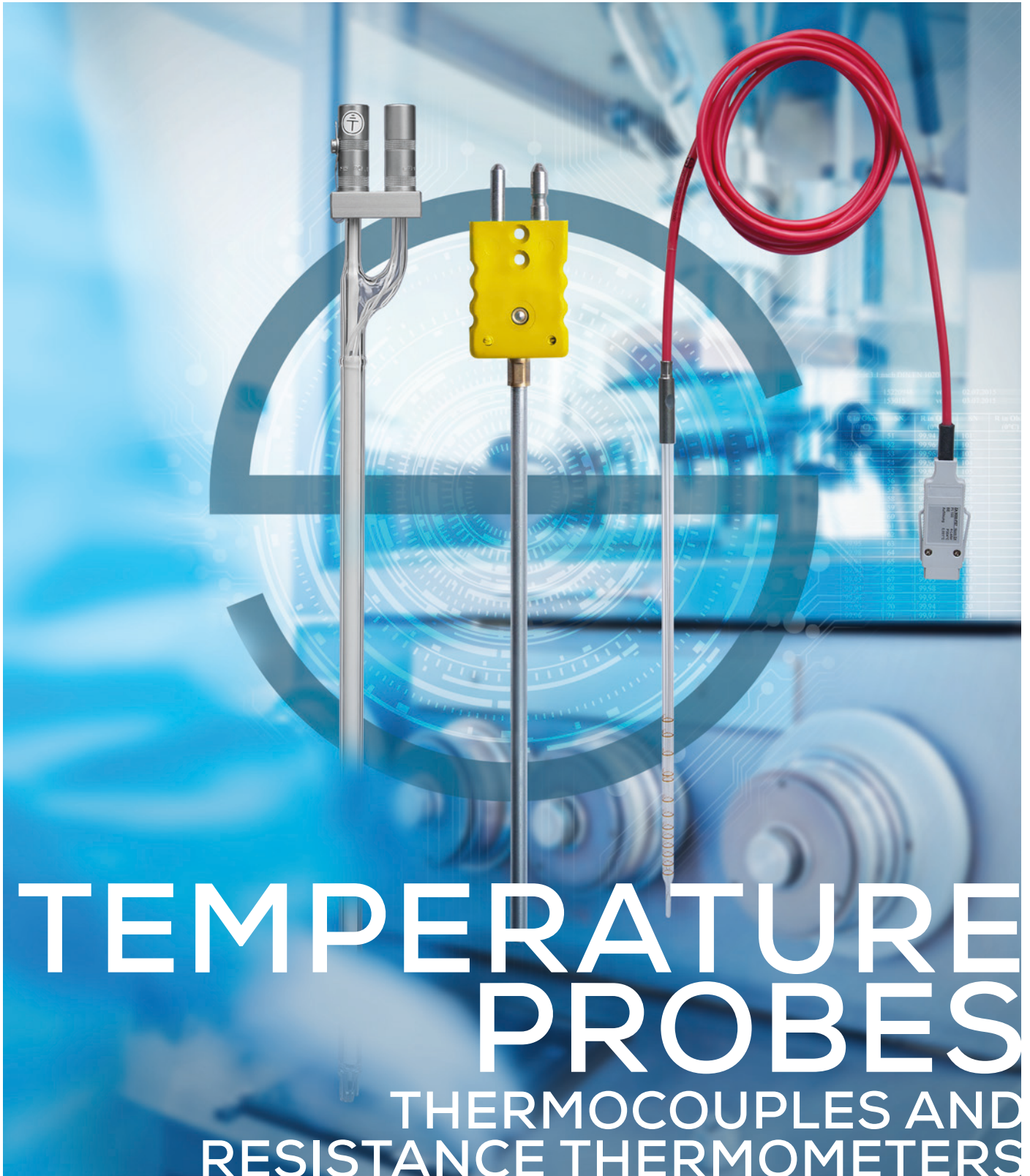




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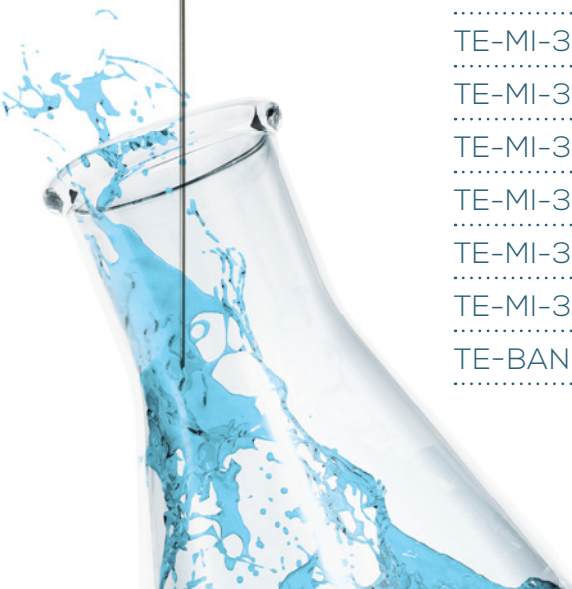
TEMPERATURE PROBES

THERMOCOUPLES AND
RESISTANCE THERMOMETERS

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HOW TO ORDER

All cable sensors in this catalog are described in detail in their technical specifications and identified by a short designation.

The "OPTIONS" sections provide information with which you can modify the cable sensors.

Please note that apart from the versions described in the catalog there are a wide variety of application-specific solutions. Please contact us should you require one.

ELECTRICAL TEMPERATURE MEASUREMENT WITH THERMOCOUPLES

TEMPERATURE

From the point of view of physics, heat is an expression of the internal energy in a body arising from the molecular movement within it. Just like the kinetic energy of a vehicle increases as the speed increases, the internal energy of a body also increases as the temperature increases. Correspondingly the temperature is a variable of state that is suitable for describing the internal energy of a body. In physics the Kelvin [K] is used as the unit of measurement for temperature. At zero Kelvin the lowest state of energy is reached and molecular movement no longer takes place. To achieve objective representation of the temperature corresponding effects of the change in temperature such as, for example, a change in the electrical resistance or the measurement of an occurring thermoelectric voltage are used.

In addition to the meter, kilogram, second, mole, candela and ampere, the temperature is a basic unit within the metric system of units (SI) and is represented by the formula sign T.

In addition to the temperature scale to Kelvin, measurement in °C is very common. ϑ is used as the formula symbol for the Celsius temperature. Alternatively, the formula symbol t is bindingly defined in DIN 1345.

The following correlation exists between the two units:

$$0 \text{ K} = -273.15 \text{ }^{\circ}\text{C}$$

$$0 \text{ }^{\circ}\text{C} = 273.15 \text{ K}$$

TEMPERATURE SCALE

The physical basis of temperature measurement is the thermodynamic temperature scale.

It is based on the laws of Boyle-Mariotte ($p \sim 1/V$) as well as Gay-Lussac ($p \sim V$) and the resulting equation for ideal gases:

$$p \cdot V = R \cdot T$$

**p = Pressure, V = Specific volume,
R = Specific gas constant, T = Temperature**

The thermodynamic temperature can be represented excellently with a gas thermometer. Since this method is too laborious for practical temperature measurement, an international temperature scale has been created that was specified through defined fixed points of pure substances.

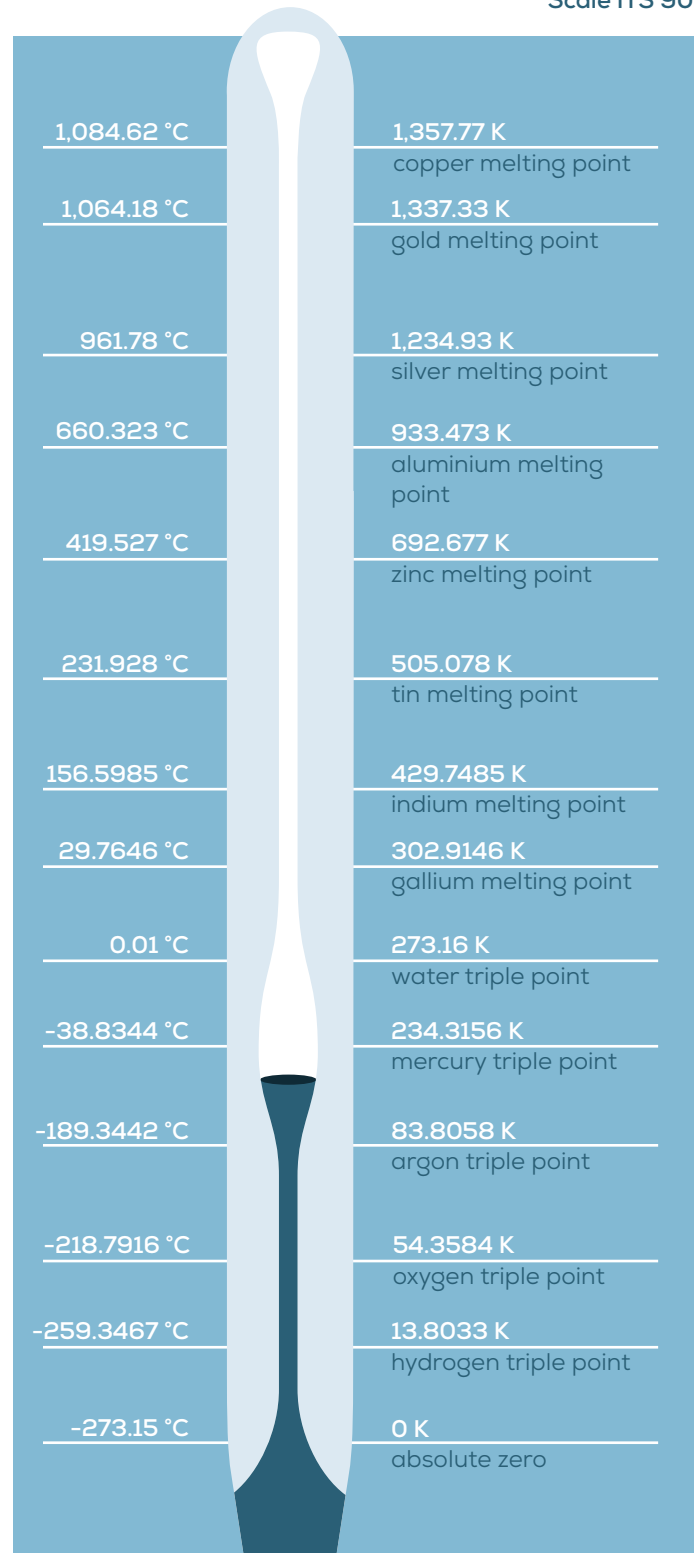
The term 'fixed points' is used for states of equilibrium at phase transitions (such as the freezing point and boiling point). Since 1990 the International Temperature Scale (ITS 90) has been valid. This replaced the International Practical Temperature Scale (IPTS 68) of 1968 due to improved possibilities with regard to the reproducibility of fixed points.

THE THERMOELECTRIC EFFECT

Temperature evaluation in industrial processes belongs to the common tasks within sensor technology. Since the measured value acquisition often takes place some meters away from the temperature evaluation and regulation, electrical measuring elements are used here to convert the measured temperature into an electrical voltage signal. Thanks to their robust design and their maintenance freedom, resistance thermometers or also thermocouples are used in a wide variety of industrial sectors.

The thermoelectric functional principle is based on the effect described by Seebeck in 1821 that a current flow arises when two metal conductors made of different materials are connected with each other and a temperature change takes place at a connection point. The connected conductors are designated as thermocouples and the physical process is defined as the thermoelectric effect. The thermoelectric voltage, meaning the voltage at the thermocouple, increases as the temperature increases.

International Temperature Scale ITS 90



Thermocouples have some advantages compared to resistance thermometers:

Smaller construction forms are possible, they have a larger temperature measuring range and are notably less sensitive to mechanical stresses. However, the higher temperature tolerance classes and the increased installation work are opposing factors. The combination of the thermoelectric wires and the material composition are standardized in order to ensure trouble-free interchangeability.

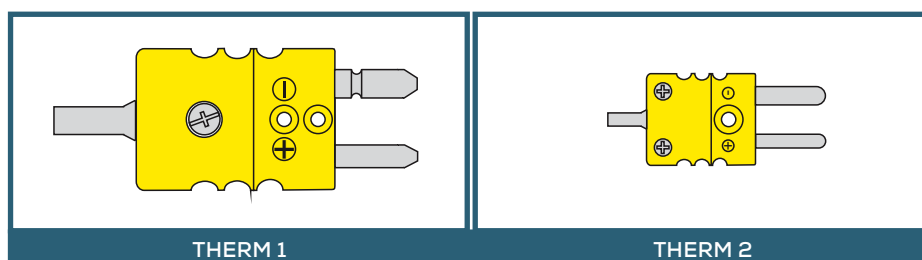
The thermoelectric voltage is very low and amounts to only a few $\mu\text{V}/\text{K}$. In order to carry out the measurement the electric circuit has to be closed, whereby thermoelectric voltage also arises at the connection point (reference junction). In the case of thermoelectric temperature measurement it has to be taken into account that only the temperature difference between the measuring point and the reference junction is measured. In the case of the same temperatures at the measuring and reference point the two thermoelectric voltages offset each other. In the case of differing temperatures a voltage difference between the two partial voltages ensues and a current flow arises. In order to carry out correct temperature measurement with a thermocouple it is important to know the reference junction temperature and to keep it constant as far as possible. Otherwise the reference junction temperature has to be detected constantly and to be taken into consideration. In addition it has to be ensured that additional thermoelectric voltages arise in the transmission line between the reference junction and measuring point in order to exclude measurement errors. The most reliable connection method would thus be the connection of the thermo legs to the reference junction. In practice, however, a compensating cable is often used as a transmission line for grounds of cost. At a compensating cable substitute materials are used that correspond to the thermoelectric properties of the thermocouple. This ensures that no additional thermoelectric voltage is caused.

STANDARDS FOR THERMOCOUPLES

The specifications of the thermocouples are described in the standards IEC 584 and EN 60584 respectively. The temperature-specific thermoelectric voltages, the limiting deviations and in part the material composition of the thermoelectric wires were in particular defined. The color coding was specified in IEC 584-2 and is to be applied symbolically or in color. The specified identification colors and the thermocouples mentioned in IEC 584-1 are shown in the following overview.

TYPE T – Cu/CuNi	copper/constantan	■ Identification color brown
TYPE J – Fe/CuNi	ferric/constantan	■ Identification color black
TYPE E – NiCr/CuNi	nickel-chromium/constantan	■ Identification color purple
TYPE K – NiCr/Ni	nickel-chromium/nickel	■ Identification color green
TYPE N – NiCrSi/NiSi	nicrosil/nisil	■ Identification color pink
TYPE S – Pt10Rh/Pt	platinumrhodium/platinum	■ Identification color orange
TYPE R – Pt13Rh/Pt	platinumrhodium/platinum	■ Identification color orange
TYPE B – Pt30Rh/Pt6Rh	platinumrhodium/platinumrhodium	■ Identification color gray

Color coding and pin assignment of the THERM connector (Example Type K)



LIMIT DEVIATIONS

Thermocouples are divided into three tolerance classes in accordance with EN 60584. These reference thermoelectric wires with a \varnothing 0.25 mm to 3 mm and apply to the state of delivery. Possible aging during operation cannot be taken into consideration, since it is application-specific. The specified temperature ranges do not contain any limits for the application. These are ranges within which the described tolerances are defined.

Limit deviations for thermocouples according to EN 60584

Type	Class		
Type J Fe - CuNi	1	-40 °C bis 375 °C \pm 1.5 °C	375 °C bis 750 °C \pm 0.004 • t °C
	2	-40 °C bis 333 °C \pm 2.5 °C	333 °C bis 750 °C \pm 0.0075 • t °C
Type T Cu - CuNi	1	-40 °C bis 125 °C \pm 0.5 °C	125 °C bis 350 °C \pm 0.004 • t °C
	2	-40 °C bis 133 °C \pm 1.0 °C	133 °C bis 350 °C \pm 0.0075 • t °C
	3	-67 °C bis 40 °C \pm 1.0 °C	-200 °C bis -67 °C \pm 0.015 • t °C
Type K NiCr - Ni	1	-40 °C bis 375 °C \pm 1.5 °C	375 °C bis 1,000 °C \pm 0.004 • t °C
	2	-40 °C bis 333 °C \pm 2.5 °C	333 °C bis 1,200 °C \pm 0.0075 • t °C
	3	-167 °C bis 40 °C \pm 2.5 °C	-200 °C bis -167 °C \pm 0.015 • t °C
Type N NiCrSi - NiSi	1	-40 °C bis 375 °C \pm 1.5 °C	375 °C bis 1,000 °C \pm 0.004 • t °C
	2	-40 °C bis 333 °C \pm 2.5 °C	333 °C bis 1,200 °C \pm 0.0075 • t °C
	3	-167 °C bis 40 °C \pm 2.5 °C	-200 °C bis -167 °C \pm 0.015 • t °C
Type E NiCr - CuNi	1	-40 °C bis 375 °C \pm 1.5 °C	375 °C bis 800 °C \pm 0.004 • t °C
	2	-40 °C bis 333 °C \pm 2.5 °C	333 °C bis 900 °C \pm 0.0075 • t °C
	3	-167 °C bis 40 °C \pm 2.5 °C	-200 °C bis -167 °C \pm 0.015 • t °C
Type S Pt10Rh - Pt	1	0 °C bis 1,100 °C \pm 1.0 °C	1,100 °C bis 1,600 °C \pm [1 + 0.003 • (t - 1,100)] °C
	2	0 °C bis 600 °C \pm 1.5 °C	600 °C bis 1,600 °C \pm 0.0025 • t °C
Type R Pt13Rh - Pt	1	0 °C bis 1,100 °C \pm 1.0 °C	1,100 °C bis 1,600 °C \pm [1 + 0.003 • (t - 1,100)] °C
	2	0 °C bis 600 °C \pm 1.5 °C	600 °C bis 1,600 °C \pm 0.0025 • t °C
Type B Pt30Rh - Pt6Rh	1	-	-
	2	-	600 °C bis 1,700 °C \pm 0.0025 • t °C
	3	600 °C bis 800 °C \pm 4.5 °C	800 °C bis 1,700 °C \pm 0.005 • t °C

BASIC VALUES

Put generally, the thermoelectric voltage/K is higher, the greater the difference in the metals of both legs are. Of the thermocouples listed, the NiCr/CuNi element (Type E) has the highest EMF. By contrast, the thermocouple Type B has the lowest EMF, since the two thermo legs differ only in the height of the rhodium alloy content.

The thermoelectric voltages as a factor of the temperature were calculated as the basic values and defined in the standards IEC 584 or EN 60584 respectively. These values all refer to a reference junction temperature of 0 °C. If a deviating reference junction temperature is used, the listed values have to be corrected correspondingly. The basic values for the thermocouples are specified in μV , calculated on the basis of the International Temperature Scale (ITS 90), and listed for the temperature range of -200 °C to 1,800 °C.

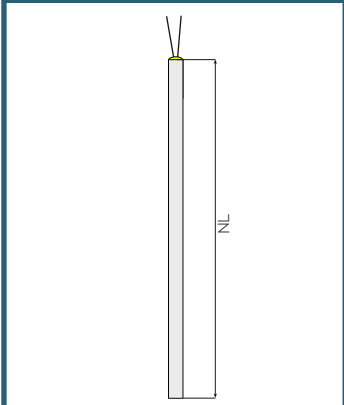
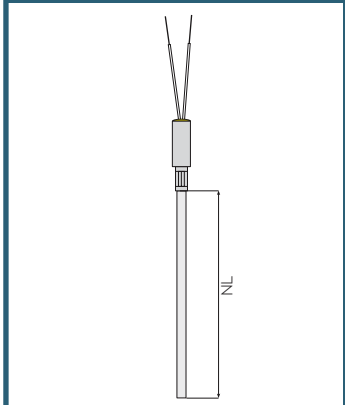
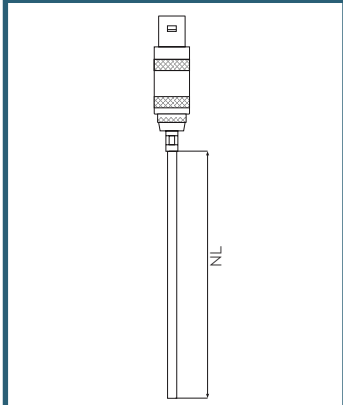
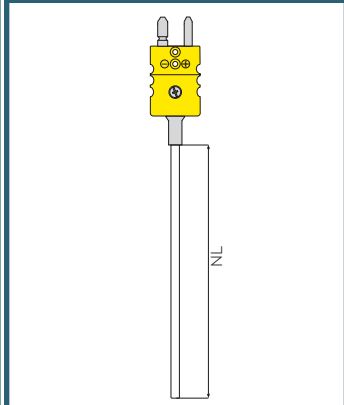
The step line is to be understood as the limit for the continuous operating temperature of the thermocouples in pure air. Since changes in the thermoelectric voltage can be caused by many factors, exact specifications on the limit of the continuous operating temperature are unfortunately not possible.

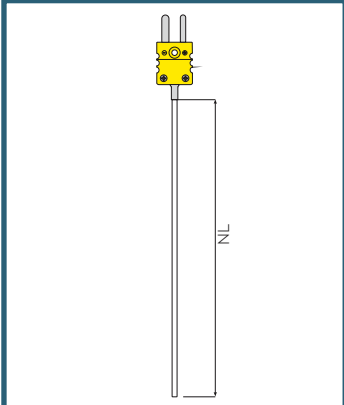
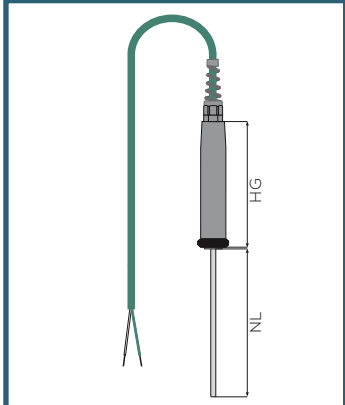
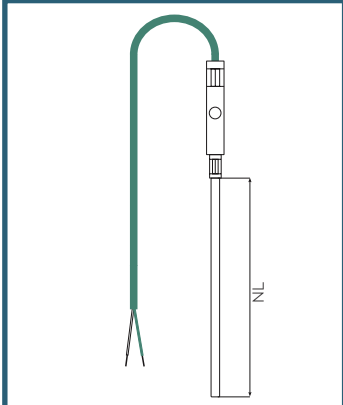
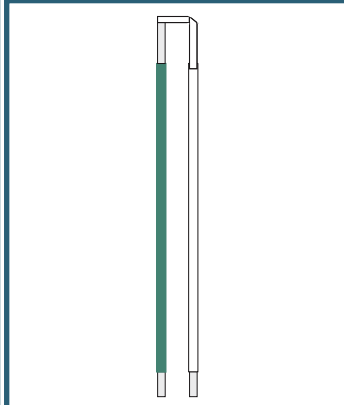
BASIC VALUES IN μV , WITH REGARD TO A REFERENCE JUNCTION TEMPERATURE OF 0 °C

Plus-terminal Minus-terminal	Type T Cu CuNi	Type J Fe CuNi	Type E NiCr CuNi	Type K NiCr Ni	Type N NiCrSi NiSi	Type S Pt10Rh Pt	Type R Pt13Rh Pt	Type B Pt30Rh Pt6Rh
°C	μV	μV	μV	μV	μV	μV	μV	μV
-200	-5603	-7890	-8825	-5891	-3990	-	-	-
-175	-5167	-7265	-8121	-5454	-3702	-	-	-
-150	-4648	-6500	-7279	-4913	-3336	-	-	-
-125	-4052	-5616	-6314	-4276	-2902	-	-	-
-100	-3379	-4633	-5237	-3554	-2407	-	-	-
-75	-2633	-3566	-4058	-2755	-1859	-	-	-
-50	-1819	-2431	-2787	-1889	-1269	-	-	-
-25	-940	-1239	-1432	-968	-646	-	-	-
0	0	0	0	0	0	0	0	0
25	992	1277	1495	1000	659	143	141	-
50	2036	2585	3048	2023	1340	299	296	-
75	3132	3918	4656	3059	2045	467	466	-
100	4279	5269	6319	4096	2774	646	647	-
125	5470	6634	8031	5124	3527	834	839	-
150	6704	8010	9789	6138	4302	1029	1041	-
175	7977	9392	11587	7140	5098	1232	1251	-
200	9288	10779	13421	8138	5913	1441	1469	178
225	10634	12167	15287	9141	6747	1655	1693	231
250	12013	13555	17181	10153	7597	1874	1923	291
275	13423	14942	19098	11176	8462	2096	2159	358
300	14862	16327	21036	12209	9341	2323	2401	431
325	16327	17710	22993	13248	10233	2553	2646	510
350	17819	19090	24964	14293	11136	2786	2896	596
375	19335	20469	26950	15343	12050	3021	3150	688
400	20872	21848	28946	16397	12974	3259	3408	787

Plus-terminal Minus-terminal	Type T Cu CuNi	Type J Fe CuNi	Type E NiCr CuNi	Type K NiCr Ni	Type N NiCrSi NiSi	Type S Pt10Rh Pt	Type R Pt13Rh Pt	Type B Pt30Rh Pt6Rh
°C	µV	µV	µV	µV	µV	µV	µV	µV
425		23228	30952	17455	13906	3500	3669	891
450		24610	32965	18516	14846	3742	3933	1002
475		25998	34983	19579	15794	3987	4201	1119
500		27393	37005	20644	16748	4233	4471	1242
550		30216	41053	22776	18672	4732	5021	1505
575		31650	43075	23842	19641	4984	5301	1646
600		33102	45093	24905	20613	5239	5583	1792
625		34575	47107	25967	21588	5495	5869	1944
650		36071	49116	27025	22566	5753	6157	2101
675		37590	51118	28079	23546	6013	6448	2263
700		39132	53112	29129	24527	6275	6743	2431
725		40696	55100	30174	25508	6539	7040	2604
750		42281	57080	31213	26491	6806	7340	2782
775		43881	59053	32247	27473	7074	7644	2965
800		45494	61017	33275	28455	7345	7950	3154
825		47109	62974	34297	29436	7618	8259	3347
850		48715	64922	35313	30416	7893	8571	3546
875		50306	66860	36323	31394	8170	8887	3749
900		51877	68787	37326	32371	8449	9205	3957
925		53427	70701	38323	33346	8731	9526	4170
950		54956	72603	39314	34319	9014	9850	4387
975		56464	74492	40298	35289	9300	10177	4608
1000		57953	76373	41276	36256	9587	10506	4834
1100				45119	40087	10757	11850	5780
1200				48838	43846	11951	13228	6786
1300				52410	47513	13159	14629	7848
1400						14373	16040	8956
1500						15582	17451	10099
1600						16777	18849	11263
1700								12433
1800								13591

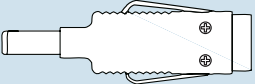

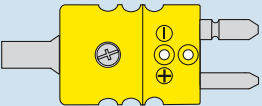
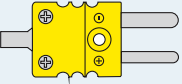
TYPE OVERVIEW OF THE SHEATHED AND CABLE THERMOCOUPLES

			
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TE-MI-314 Page 16	TE-MI-303-HG Page 17	TE-MI-303 Page 18	WT-BAND Page 19

NL = Nominal length

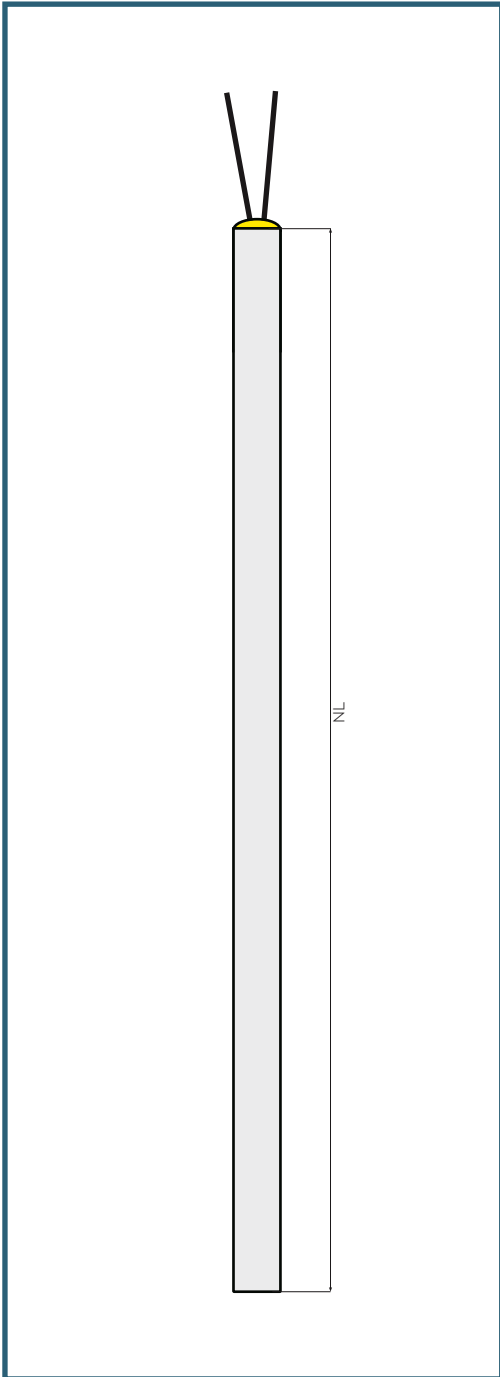
TYPE OVERVIEW OF STANDARD PLUG CONNECTIONS

Plug connection	Specifications	Ref.-Nr.	TE-MI-306	TE-MI-313	TE-MI-314	TE-MI-303-HG	TE-MI-303
Plug PHYSICS, Resolution 0.1 °C 	Type K	31860				x	x
	Type K with integrated reference junction	67789				x	x
	Type J	59596				x	x
	Type N	59953				x	x
	Type S with integrated reference junction	67299				x	x
Plug LEMO, (couplers) 	0S, MIL-Diameter 0.5 up to 1.5 mm		x				
	1S, MIL-Diameter 1.5 up to 6 mm		x			x	x
	2S, MIL-Diameter 4.5 mm or 6 mm		x			x	x
	LEMO couplers are optionally available		x			x	x
THERM 1 plug /couplers 	Type K – plug, green	31418		x		x	x
	Type K – couplers, green	31415		x		x	x
	Type K – plug, yellow	31419		x		x	x
	Type K – couplers, yellow	31417		x		x	x
	Type K – plug, brown, high-temperature up to max. 350 °C	41339		x			
	Type K – couplers, brown, high-temperature up to max. 350 °C	41337		x			
THERM 2 plug /couplers 	Type K – plug, green	31462			x	x	x
	Type K – couplers, green	31463			x	x	x
	Type K – plug, yellow	31461			x	x	x
	Type K – couplers, yellow	31464			x	x	x
	Type K – plug, yellow, duplex version	57847			x	x	x
	Type K – couplers, yellow, duplex version	57848			x	x	x
	Type K – plug, brown, high-temperature up to max. 350 °C	64399			x		
	Type K – couplers, brown, high-temperature up to max. 350 °C	64400			x		
	Type N – plug, pink	65781			x	x	x
	Type S – plug, orange	31466			x	x	x
Type J – plug, black	61457			x	x	x	

Option: Individual connector mounting at customer request (provision)

TE-MI-301

MINERAL INSULATED THERMOCOUPLE FLEXIBLE WITH REINFORCED WIRE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Flexible mineral insulated thermocouple
- + Nominal length up to 500 mm – diameter up to 6.0 mm
- + MI cable sheath made of Inconel 2.4816
- + Diameter consistent
- + Thermocouple NiCr-Ni (Type K)
- + Measuring point insulated
- + Thermocouple tolerance to EN 60584 Class 1
- + Connection via free wire ends (20 mm length)
- + Measuring range -100 °C to 500 °C

OPTIONS:

- + Version with 2 measuring points
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Diameter change

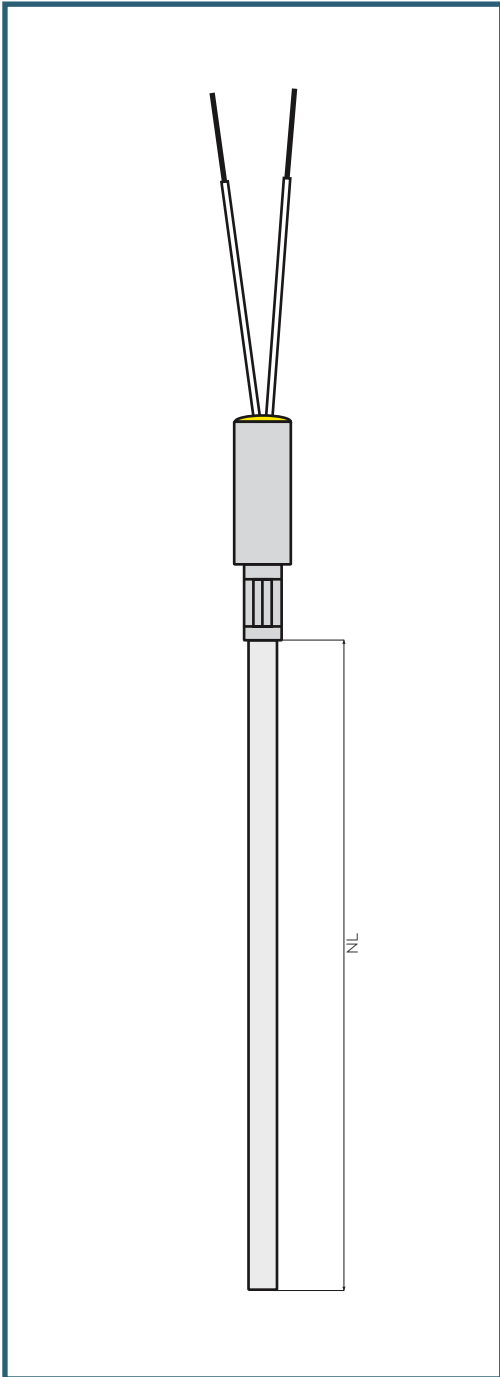


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

TE-MI-302

MINERAL INSULATED THERMOCOUPLE FLEXIBLE WITH FREE WIRE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Flexible mineral insulated thermocouple
- + Nominal length up to 500 mm – diameter up to 6.0 mm
- + With brass adapter sleeve
- + MI cable sheath made of Inconel 2.4816
- + Diameter consistent
- + Thermocouple NiCr-Ni (Type K)
- + Measuring point insulated
- + Thermocouple tolerance to EN 60584 Class 2
- + FEP-insulated connection strands – length 50 mm
10 mm stripped and tin-plated
- + Measuring range -100 °C to 500 °C

OPTIONS:

- + Version with 2 measuring points
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Diameter change
- + Length change of the connection wires or strands

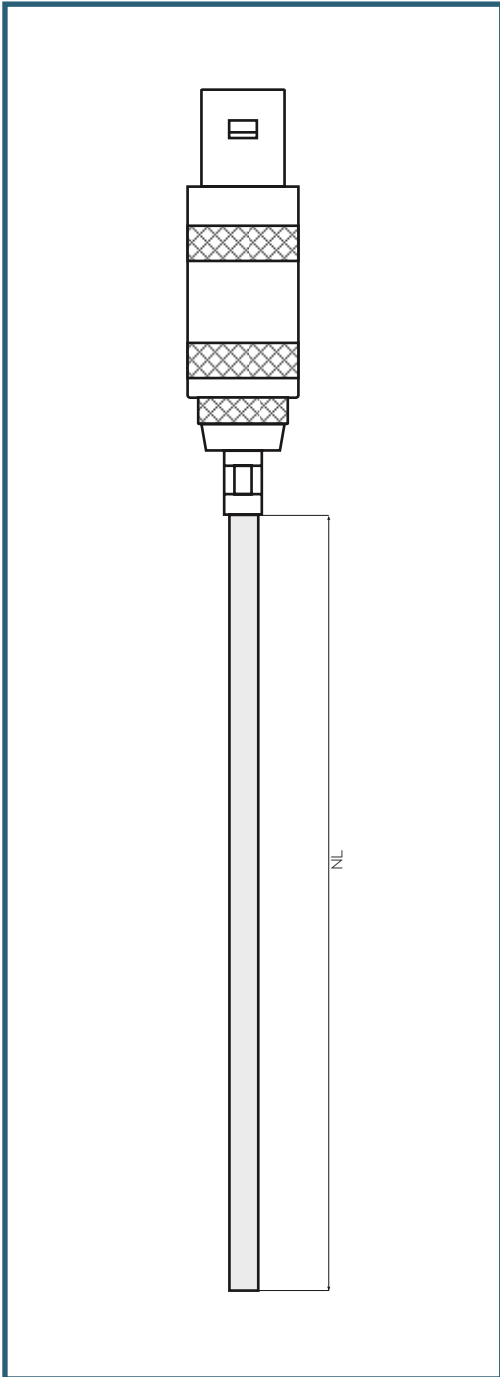


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

TE-MI-306

MINERAL INSULATED THERMOCOUPLE FLEXIBLE WITH DIRECT PLUG CONNECTION THERM 1



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Flexible mineral insulated thermocouple
- + Nominal length: up to 500 mm - diameter up to 6.0 mm
- + With directly mounted plug LEMO
- + MI cable sheath made of Inconel 2.4816
- + Diameter consistent
- + Thermocouple NiCr-Ni (Type K)
- + Measuring point insulated
- + Thermocouple tolerance to EN 60584 Class 1
- + Measuring range -100 °C to 500 °C

OPTIONS:

- + Connector mounting at customer request (see page 11)
- + Thermal contacts Type K
- + Version with two measuring points
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Diameter change

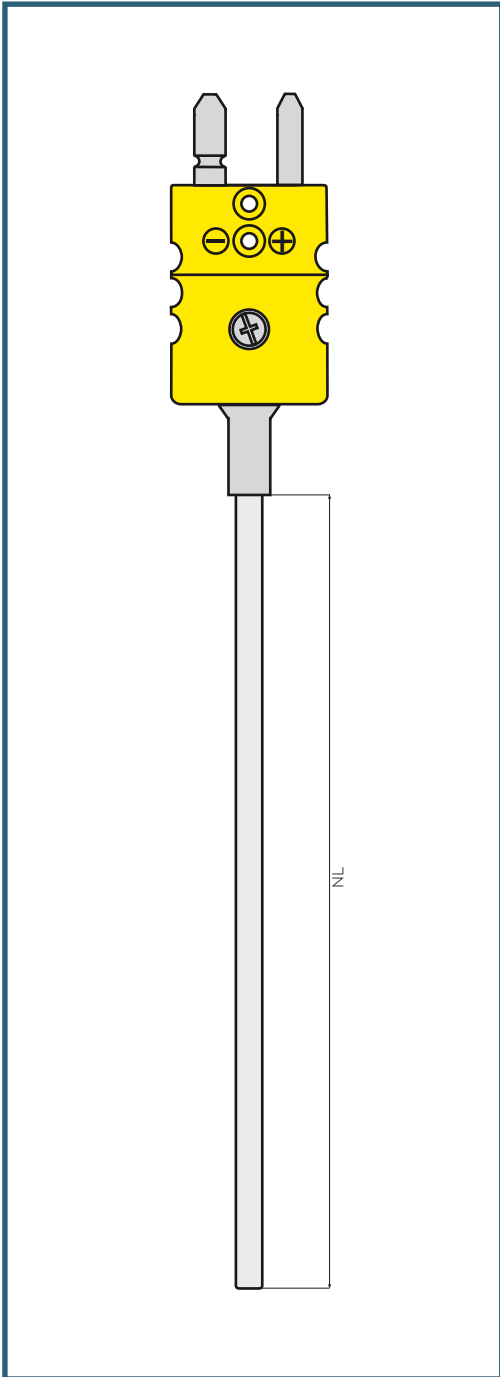


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

TE-MI-313

MINERAL INSULATED THERMOCOUPLE FLEXIBLE WITH DIRECT PLUG CONNECTION LEMO



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Flexible mineral insulated thermocouple
- + Nominal length up to 500 mm – diameter up to 4.5 mm
- + With directly mounted THERM 1 plug
- + MI cable sheath made of Inconel 2.4816
- + Diameter consistent
- + Thermocouple NiCr-Ni (Type K)
- + Measuring point insulated
- + Thermocouple tolerance to DIN EN 60584 Class 1
- + Measuring range -100 °C to 500 °C

OPTIONS:

- + Connector mounting at customer request
e.g. Type K – high-temperature up to max. 350 °C (see page 11)
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Diameter change

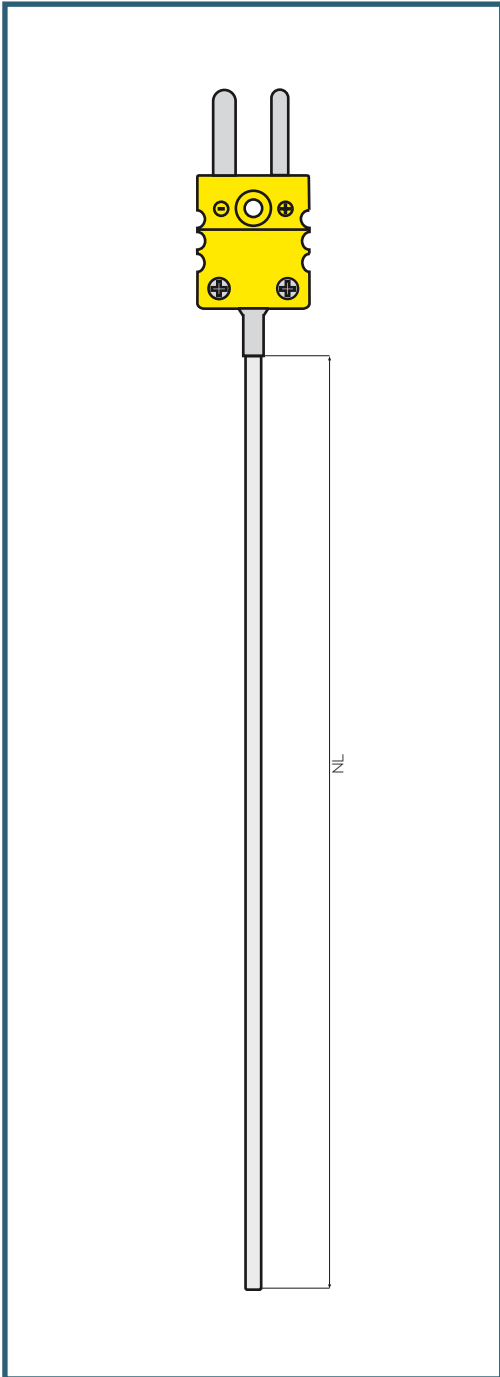


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

TE-MI-314

MINERAL INSULATED THERMOCOUPLE FLEXIBLE WITH DIRECT PLUG CONNECTION THERM 2



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Flexible mineral insulated thermocouple
- + Nominal length up to 500 mm – diameter up to 3.0 mm
- + With directly installed THERM 2 plug
- + MI cable sheath made of Inconel 2.4816
- + Diameter consistent
- + Thermocouple NiCr-Ni (Type K)
- + Measuring point insulated
- + Thermocouple tolerance to DIN EN 60584 Class 1
- + Measuring range -100 °C to 500 °C

OPTIONS:

- + Connector mounting at customer request
e.g. type K – high-temperature up to max. 350 °C (see page 11)
- + Version with 2 measuring points and duplex connector – yellow
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Diameter change

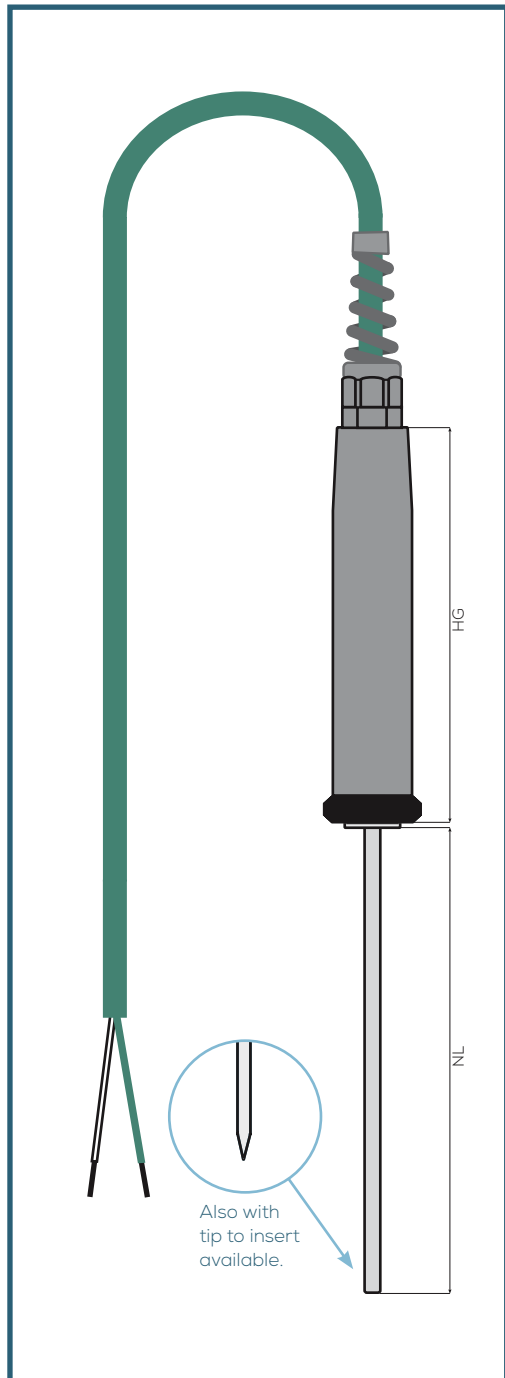


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

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TE-MI-303-HG

MINERAL INSULATED THERMOCOUPLE WITH HANDLE, COMPENSATING CABLE AND FREE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Mineral insulated thermocouple to immerse or insert with handle
- + Nominal length up to 500 mm – diameter up to 6.0 mm
- + MI cable sheath made of Inconel 2.4816
- + Diameter consistent
- + With handle made of PA6 – \varnothing 20 mm
- + Cable outlet secured with bend protection and strain relief
- + Fixed connection compensating cable
- + Cable length 2-5 m
- + FEP/silicone insulated
- + Thermocouple NiCr-Ni (Type K)
- + Measuring point insulated
- + Thermocouple tolerance to EN 60584 Class 2
- + Connection end 50/10 mm stripped with free ends
- + Measuring range $-100\text{ }^{\circ}\text{C}$ to $500\text{ }^{\circ}\text{C}$

OPTIONS:

- + Connector mounting at customer request
e.g. PHYSICS, LEMO, THERM 1 or THERM 2 (see page 11)
- + Nominal length change with possible
adjustment of the measuring range
- + Cable length change
- + Diameter change

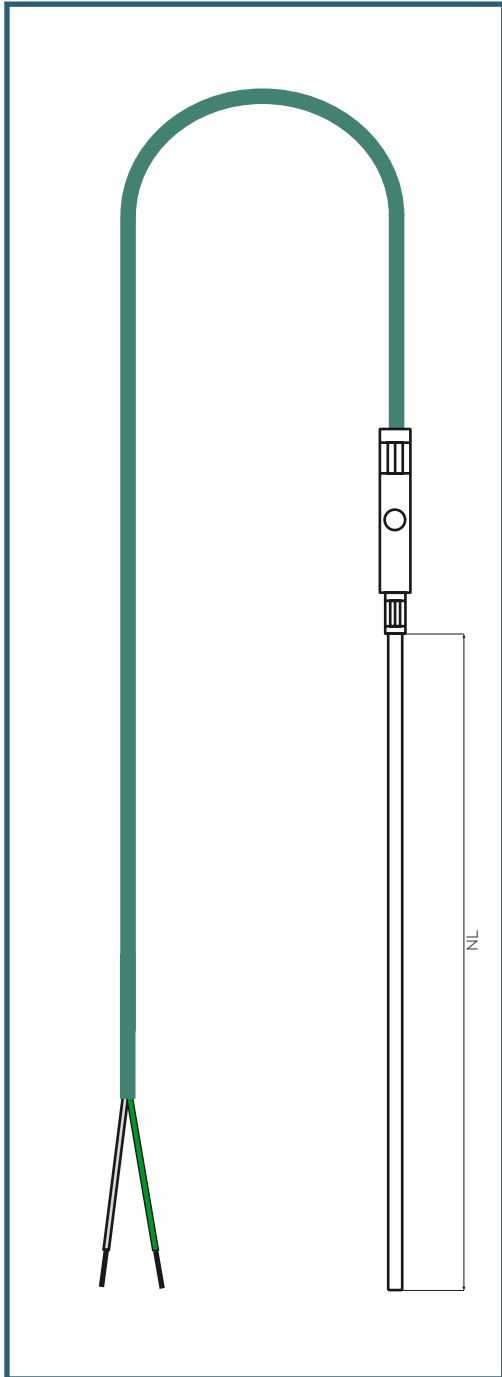


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

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TE-MI-303

MINERAL INSULATED THERMOCOUPLE FLEXIBLE WITH COMPENSATING CABLE AND FREE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Mineral insulated thermocouple
- + Nominal length up to 500 mm – diameter up to 6.0 mm
- + MI cable sheath made of Inconel 2.4816
- + Diameter consistent
- + With adapter sleeve made of stainless steel
- + Fixed connection compensating cable
- + Cable length 2-5 m
- + FEP/silicone insulated
- + Thermocouple NiCr-Ni (Type K)
- + Measuring point insulated
- + Thermocouple tolerance to EN 60584 Class 2
- + Connection end 50/10 mm stripped with free ends
- + Measuring range -100 °C to 500 °C

OPTIONS:

- + Connector mounting at customer request
e.g. PHYSICS, LEMO, THERM 1 or THERM 2 (see page 11)
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Cable length change
- + Diameter change
- + Adapter sleeve made of brass
- + With adjustable screw fitting



- + With screw-in thread M8 x 1
- + With screw-in thread M10 x 1
- + With screw-in thread G¼
- + With PTFE clamp ring
- + With steel cutting ring



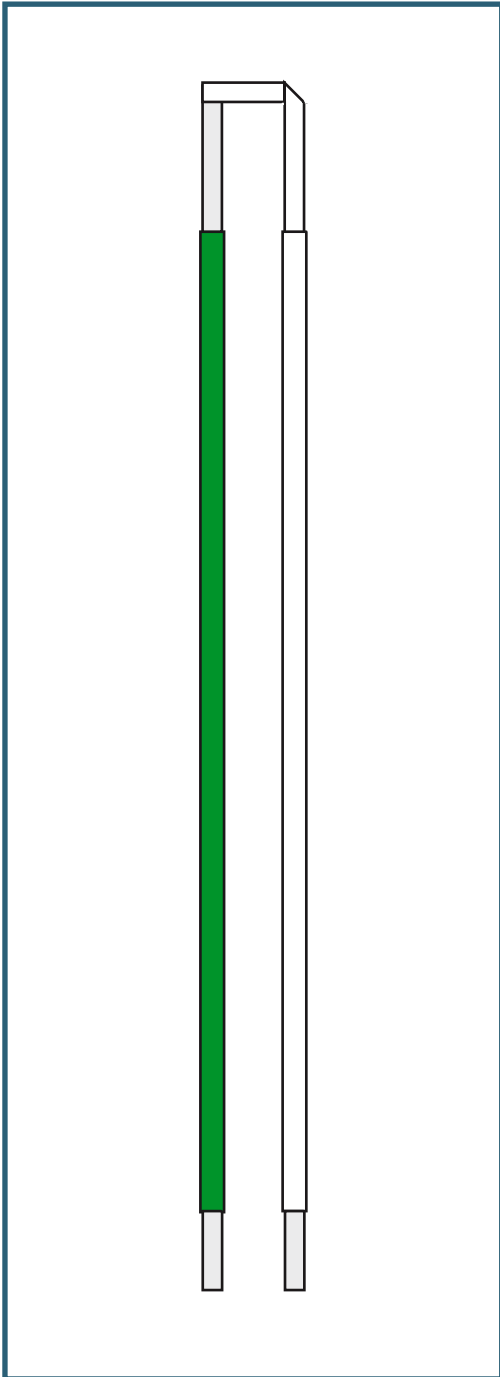
ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

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TE-BAND

STRIP THERMOCOUPLE TYPE K

GLASS SILK-INSULATED WITH FREE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Strip thermocouples
- + Thermocouple NiCr-Ni (Type K)
- + Thermocouple tolerance to EN 60584 Class 2
- + Strip 2.5 x 0.2 mm
- + Insulated with glass silk
- + Nominal length up to 500 mm
- + With 10 mm free ends

OPTIONS:

- + Nominal length change



ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

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ELECTRICAL TEMPERATURE MEASUREMENT WITH RESISTANCE THERMOMETERS

INTRODUCTION

In electrical temperature measurement technology measuring resistors that are installed in resistance thermometers are used very frequently. With this measurement method you use the temperature-dependent, electrical resistance of metals that increases with increasing temperatures. In this context we talk of a positive temperature coefficient or a PTC behavior. (Positive Temperature Coefficient) To use this property, a metallic material has to be selected that ensures a reproducible resistance change. This means that the specific characteristic may not change through external or internal influence to rule out systematic measurement errors.

For this reason platinum has established itself in industrial temperature measurement. Platinum has the advantage that it can be obtained in a purified form so that the electrical properties are very well reproducible as a result. It can be processed easier, which is required for the wire manufacturing. In addition it has a higher melting point and very good chemical resistance.

WORKING PRINCIPLE

The measuring resistor is operated with a constant measuring current. This way a voltage drop that is measured occurs at the measuring resistor. This voltage drop can be derived directly from Ohm's law:

$$U = R \cdot I \quad U = \text{voltage in V, } R = \text{resistance in } \Omega, I = \text{current intensity in A}$$

It must be ensured that the measuring voltage is transferred as unaltered as possible to the location of evaluation or display. In particular in the case of transfer with a 2-wire circuit, which will be discussed in more detail later, the additional line resistance results in an increase of the overall resistance as therefore inevitably to measurement errors. So that the measuring resistor is not heated impermissibly it should be selected as small as possible. It is to be assumed that a measuring current ≤ 1 mA only causes a negligible self-heating in the measuring resistor.

STANDARDS FOR MEASURING RESISTORS

The requirements for industrial platinum measuring resistors were specified in the international standard IEC 751 as derived as a European norm EN 60751 from it. The German standard corresponds to the European version and is often generally called DIN EN 60751. The standards named apply for a temperature range of -200 °C to 850 °C and ensure international comparability as well as the interchangeability. There the nominal value, the basic values and the limit deviations of the measuring resistors are defined. The data specified in the standards reference only to the platinum measuring resistor Pt100, although other measuring resistors such as Pt500 or Pt1000 are often used in practical applications as well. Their advantage lies in the higher sensitivity. This means that they have a higher resistance change depending on the measurement temperature. For these measuring resistors the numerical values of the EN 60751 standard have to be multiplied by the factor of 5 or 10 respectively.

NOMINAL VALUE

The nominal value is the resistor value of the measuring resistor that it has at 0 °C. The designation Pt stands for the platinum measuring resistance. This means:

A measuring resistor **Pt100** has a resistance of **100 Ω** at **0 °C**

A measuring resistor **Pt500** has a resistance of **500 Ω** at **0 °C**

A measuring resistor **Pt1000** has a resistance of **1000 Ω** at **0 °C**

BASIC VALUES

The electrical resistance values in relation to the temperature were calculated using specified equations as basic values. For temperature specifications the International Temperature Scale (ITS 90) of 1990 was taken as a basis.

The equation for the temperature range -200 °C to 0 °C is: $R_t = R_0 \cdot [1 + At + Bt^2 + C(t - 100 \text{ °C}) \cdot t^3]$

The equation for the temperature range 0 °C to 600 °C is: $R_t = R_0 (1 + At + Bt^2)$

The following constant values apply in both equations for the quality of the platinum as it is usually used for industrial measuring resistors:

$$A = 3.9083 \cdot 10^{-3} (\text{°C}^{-1}) \quad B = -5.775 - 7 \cdot 10^{-7} (\text{°C}^{-2}) \quad C = -4.183 \cdot 10^{-12} (\text{°C}^{-4})$$

to

The temperature coefficient is defined as follows for platinum measuring resistors that fulfil the above correlation:

$$\alpha = \frac{R_{100} - R_0}{100 \cdot R_0} = 0.00385 \text{ °C}^{-1} \quad R_{100} = \text{Resistance at } 100 \text{ °C}, R_0 = \text{Resistance at } 0 \text{ °C}$$

Note: The exact value of $\alpha = 0.00385055 \text{ °C}^{-1}$ applies for calculation purposes ⁻¹.

LIMIT DEVIATIONS

The term limit deviation is used for the maximum permissible deviation in °C of a platinum measuring resistor from the standardized basic values. The limit deviations refer to the measuring resistor Pt100 with a nominal value of 100 Ω at 0 °C. The standardized tolerance classes A, B and AA exist. In this context the tolerance class B is considered to be the basic tolerance class for the complete temperature range of -196 °C to 600 °C. As a result of further development in the manufacturing of measuring resistors and through the requirements of diverse applications, further non-standardized tolerance classes are also being offered (such as 1/5 B, 1/10 B).

Tolerance class	Limit deviation in °C	For temperature range
B standardized	$\pm 0.30 + 0.00500 \cdot t$	-196 °C to 600 °C
A standardized	$\pm 0.15 + 0.00200 \cdot t$	-100 °C to 450 °C
AA standardized	$\pm 0.10 + 0.00167 \cdot t$	-50 °C to 250 °C
1/5 B	$\pm 0.06 + 0.00100 \cdot t$	-50 °C to 250 °C
1/10 B	$\pm 0.03 + 0.00050 \cdot t$	-30 °C to 250 °C

CONNECTION TECHNOLOGIES

2-WIRE CIRCUIT

The resistance thermometer is connected via a 2-wire connection cable with the display device or the data logger. This variant is the simplest, but also most imprecise connection technology because the total resistance is increased through the additional resistance of the connection cable that has to be added to the measuring resistance value. This increase inevitably results in a higher temperature display and, depending on the connection distance, in considerable distortions of the measured value.

$$R_{\text{Display}} = R_{\text{Sensor}} + R_{\text{Connection cable}}$$

The error can be avoided by the compensation of the line resistance. In this context the resistance thermometer is first replaced by a resistance with 100.00 Ω and a trimming resistor is circuited into a connection wire. With the trimming resistor the setting at the display or the data logger is adjusted to 0 °C. This procedure is very laborious and does not take any changes on the line resistance due to temperature influences into consideration.

3-WIRE CIRCUIT

The resistance thermometer is connected via a 3-wire connection cable. The line resistance can be compensated almost completely through the two measuring circuits of which one is used as a bridge or proportional circuit. The error of the line resistance is minimized in this way, so that temperature-dependent changes of the line resistances are taken into consideration as well through the additional loop. It is assumed that the line resistance changes due to temperature influences in the same way in all 3 wires.

$$R_{\text{Display}} = (R_{\text{Sensor}} + R_{\text{Connection cable}}) - R_{\text{Connection cable}}$$

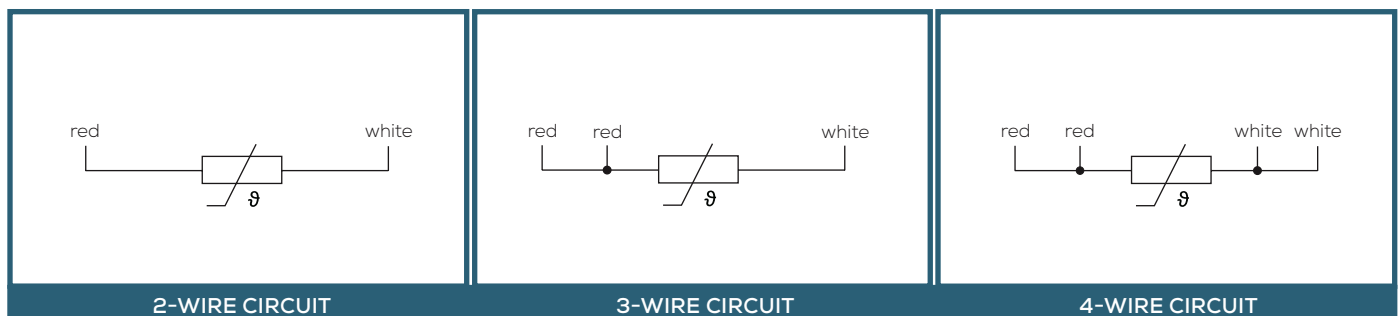
For this connection method no comparison of the line resistance is required anymore. It is therefore used most often in industrial temperature measuring technology.

4-WIRE CIRCUIT

This is the optimum connection method since the resistance thermometer is connected with 4 wires. In this variant the measured current is supplied via two conductors and the voltage drop is tapped at the other two conductors. This way the influence of the line resistance is eliminated completely.

$$R_{\text{Display}} = R_{\text{Sensor}}$$

This connection variant is used wherever very precise temperature measurements are required.



BASIC VALUES ACCORDING TO IEC 751 OR DIN EN 60751

The basic values are standardized for the measuring resistor Pt100 and listed in 1 °C steps. All values are specified in Ohm, calculated on the basis of the International Temperature Scale ITS 90, and listed for the temperature range of -200 °C to 850 °C.

°C	0	-1	-2	-3	-4	-5	-6	-7	-8	-9
-200	18.52									
-190	22.83	22.40	21.97	21.54	21.11	20.68	20.25	19.82	19.38	18.95
-180	27.10	26.67	26.24	25.82	25.39	24.97	24.54	24.11	23.68	23.25
-170	31.34	30.91	30.49	30.07	29.64	29.22	28.80	28.37	27.95	27.52
-160	35.54	35.12	34.70	34.28	33.86	33.44	33.02	32.60	32.18	31.76
-150	39.72	39.31	38.89	38.47	38.05	37.64	37.22	36.80	36.38	35.96
-140	43.88	43.46	43.05	42.63	42.22	41.80	41.39	40.97	40.56	40.14
-130	48.00	47.59	47.18	46.77	46.36	45.94	45.53	45.12	44.70	44.29
-120	52.11	51.70	51.29	50.88	50.47	50.06	49.65	49.24	48.83	48.42
-110	56.19	55.79	55.38	54.97	54.56	54.15	53.75	53.34	52.93	52.52
-100	60.26	59.85	59.44	59.04	58.63	58.23	57.82	57.41	57.01	56.60
-90	64.30	63.90	63.49	63.09	62.68	62.28	61.88	61.47	61.07	60.66
-80	68.33	67.92	67.52	67.12	66.72	66.31	65.91	65.51	65.11	64.70
-70	72.33	71.93	71.53	71.13	70.73	70.33	69.93	69.53	69.13	68.73
-60	76.33	75.93	75.53	75.13	74.73	74.33	73.93	73.53	73.13	72.73
-50	80.31	79.91	79.51	79.11	78.72	78.32	77.92	77.52	77.12	76.73
-40	84.27	83.87	83.48	83.08	82.69	82.29	81.89	81.50	81.10	80.70
-30	88.22	87.83	87.43	87.04	86.64	86.25	85.85	85.46	85.06	84.67
-20	92.16	91.77	91.37	90.98	90.59	90.19	89.80	89.40	89.01	88.62
-10	96.09	95.69	95.30	94.91	94.52	94.12	93.73	93.34	92.95	92.55
0	100.00	99.61	99.22	98.83	98.44	98.04	97.65	97.26	96.87	96.48

BASIC VALUES ACCORDING TO IEC 751 OR DIN EN 60751

°C	0	+1	+2	+3	+4	+5	+6	+7	+8	+9
0	100.00	100.39	100.78	101.17	101.56	101.95	102.34	102.73	103.12	103.51
10	103.90	104.29	104.68	105.07	105.46	105.85	106.24	106.63	107.02	107.40
20	107.79	108.18	108.57	108.96	109.35	109.73	110.12	110.51	110.90	111.29
30	111.67	112.06	112.45	112.83	113.22	113.61	114.00	114.38	114.77	115.15
40	115.54	115.93	116.31	116.70	117.08	117.47	117.86	118.24	118.63	119.01
50	119.40	119.78	120.17	120.55	120.94	121.32	121.71	122.09	122.47	122.86
60	123.24	123.63	124.01	124.39	124.78	125.16	125.54	125.93	126.31	126.69
70	127.08	127.46	127.84	128.22	128.61	128.99	129.37	129.75	130.13	130.52
80	130.90	131.28	131.66	132.04	132.42	132.80	133.18	133.57	133.95	134.33
90	134.71	135.09	135.47	135.85	136.23	136.61	136.99	137.37	137.75	138.13
100	138.51	138.88	139.26	139.64	140.02	140.40	140.78	141.16	141.54	141.91
110	142.29	142.67	143.05	143.43	143.80	144.18	144.56	144.94	145.31	145.69
120	146.07	146.44	146.82	147.20	147.57	147.95	148.33	148.70	149.08	149.46
130	149.83	150.21	150.58	150.96	151.33	151.71	152.08	152.46	152.83	153.21
140	153.58	153.96	154.33	154.71	155.08	155.46	155.83	156.20	156.58	156.95
150	157.33	157.70	158.07	158.45	158.82	159.19	159.56	159.94	160.31	160.68
160	161.05	161.43	161.80	162.17	162.54	162.91	163.29	163.66	164.03	164.40
170	164.77	165.14	165.51	165.89	166.26	166.63	167.00	167.37	167.74	168.11
180	168.48	168.85	169.22	169.59	169.96	170.33	170.70	171.07	171.43	171.80
190	172.17	172.54	172.91	173.28	173.65	174.02	174.38	174.75	175.12	175.49
200	175.86	176.22	176.59	176.96	177.33	177.69	178.06	178.43	178.79	179.16
210	179.53	179.89	180.26	180.63	180.99	181.36	181.72	182.09	182.46	182.82
220	183.19	183.55	183.92	184.28	184.65	185.01	185.38	185.74	186.11	186.47
230	186.84	187.20	187.56	187.93	188.29	188.66	189.02	189.38	189.75	190.11
240	190.47	190.84	191.20	191.56	191.92	192.29	192.65	193.01	193.37	193.74
250	194.10	194.46	194.82	195.18	195.55	195.91	196.27	196.63	196.99	197.35
260	197.71	198.07	198.43	198.79	199.15	199.51	199.87	200.23	200.59	200.95
270	201.31	201.67	202.03	202.39	202.75	203.11	203.47	203.83	204.19	204.55
280	204.90	205.26	205.62	205.98	206.34	206.70	207.05	207.41	207.77	208.13
290	208.48	208.84	209.20	209.56	209.91	210.27	210.63	210.98	211.34	211.70
300	212.05	212.41	212.76	213.12	213.48	213.83	214.19	214.54	214.90	215.25
310	215.61	215.96	216.32	216.67	217.03	217.38	217.74	218.09	218.44	218.80
320	219.15	219.51	219.86	220.21	220.57	220.92	221.27	221.63	221.98	222.33
330	222.68	223.04	223.39	223.74	224.09	224.45	224.80	225.15	225.50	225.85
340	226.21	226.56	226.91	227.26	227.61	227.96	228.31	228.66	229.02	229.37
350	229.72	230.07	230.42	230.77	231.12	231.47	231.82	232.17	232.52	232.87
360	233.21	233.56	233.91	234.26	234.61	234.96	235.31	235.66	236.00	236.35
370	236.70	237.05	237.40	237.74	238.09	238.44	238.79	239.13	239.48	239.83
380	240.18	240.52	240.87	241.22	241.56	241.91	242.26	242.60	242.95	243.29
390	243.64	243.99	244.33	244.68	245.02	245.37	245.71	246.06	246.40	246.75
400	247.09	247.44	247.78	248.13	248.47	248.81	249.16	249.50	249.85	250.19
410	250.53	250.88	251.22	251.56	251.91	252.25	252.59	252.93	253.28	253.62
420	253.96	254.30	254.65	254.99	255.33	255.67	256.01	256.35	256.70	257.04

(Continued from Page 23)

°C	0	+1	+2	+3	+4	+5	+6	+7	+8	+9
430	257.38	257.72	258.06	258.40	258.74	259.08	259.42	259.76	260.10	260.44
440	260.78	261.12	261.46	261.80	262.14	262.48	262.82	263.16	263.50	263.84
450	264.18	264.52	264.86	265.20	265.53	265.87	266.21	266.55	266.89	267.22
460	267.56	267.90	268.24	268.57	268.91	269.25	269.59	269.92	270.26	270.60
470	270.93	271.27	271.61	271.94	272.28	272.61	272.95	273.29	273.62	273.96
480	274.29	274.63	274.96	275.30	275.63	275.97	276.30	276.64	276.97	277.31
490	277.64	277.98	278.31	278.64	278.98	279.31	279.64	279.98	280.31	280.64
500	280.98	281.31	281.64	281.98	282.31	282.64	282.97	283.31	283.64	283.97
510	284.30	284.63	284.97	285.30	285.63	285.96	286.29	286.62	286.95	287.29
520	287.62	287.95	288.28	288.61	288.94	289.27	289.60	289.93	290.26	290.59
530	290.92	291.25	291.58	291.91	292.24	292.56	292.89	293.22	293.55	293.88
540	294.21	294.54	294.86	295.19	295.52	295.85	296.18	296.50	296.83	297.16
550	297.49	297.81	298.14	298.47	298.80	299.12	299.45	299.78	300.10	300.43
560	300.75	301.08	301.41	301.73	302.06	302.38	302.71	303.03	303.36	303.69
570	304.01	304.34	304.66	304.98	305.31	305.63	305.96	306.28	306.61	306.93
580	307.25	307.58	307.90	308.23	308.55	308.87	309.20	309.52	309.84	310.16
590	310.49	310.81	311.13	311.45	311.78	312.10	312.42	312.74	313.06	313.39
600	313.71	314.03	314.35	314.67	314.99	315.31	315.64	315.96	316.28	316.60
610	316.92	317.24	317.56	317.88	318.20	318.52	318.84	319.16	319.48	319.80
620	320.12	320.43	320.75	321.07	321.39	321.71	322.03	322.35	322.67	322.98
630	323.30	323.62	323.94	324.26	324.57	324.89	325.21	325.53	325.84	326.16
640	326.48	326.79	327.11	327.43	327.74	328.06	328.38	328.69	329.01	329.32
650	329.64	329.96	330.27	330.59	330.90	331.22	331.53	331.85	332.16	332.48
660	332.79	333.11	333.42	333.74	334.05	334.36	334.68	334.99	335.31	335.62
670	335.93	336.25	336.56	336.87	337.18	337.50	337.81	338.12	338.44	338.75
680	339.06	339.37	339.69	340.00	340.31	340.62	340.93	341.24	341.56	341.87
690	342.18	342.49	342.80	343.11	343.42	343.73	344.04	344.35	344.66	344.97
700	345.28	345.59	345.90	346.21	346.52	346.83	347.14	347.45	347.76	348.07
710	348.38	348.69	348.99	349.30	349.61	349.92	350.23	350.54	350.84	351.15
720	351.46	351.77	352.08	352.38	352.69	353.00	353.30	353.61	353.92	354.22
730	354.53	354.84	355.14	355.45	355.76	356.06	356.37	356.67	356.98	357.28
740	357.59	357.90	358.20	358.51	358.81	359.12	359.42	359.72	360.03	360.33
750	360.64	360.94	361.25	361.55	361.85	362.16	362.46	362.76	363.07	363.37
760	363.67	363.98	364.28	364.58	364.89	365.19	365.49	365.79	366.10	366.40
770	366.70	367.00	367.30	367.60	367.91	368.21	368.51	368.81	369.11	369.41
780	369.71	370.01	370.31	370.61	370.91	371.21	371.51	371.81	372.11	372.41
790	372.71	373.01	373.31	373.61	373.91	374.21	374.51	374.81	375.11	375.41
800	375.70	376.00	376.30	376.60	376.90	377.19	377.49	377.79	378.09	378.39
810	378.68	378.98	379.28	379.57	379.87	380.17	380.46	380.76	381.06	381.35
820	381.65	381.95	382.24	382.54	382.83	383.13	383.42	383.72	384.01	384.31
830	384.60	384.90	385.19	385.49	385.78	386.08	386.37	386.67	386.96	387.25
840	387.55	387.84	388.14	388.43	388.72	389.02	389.31	389.60	389.90	390.19
850	390.48									

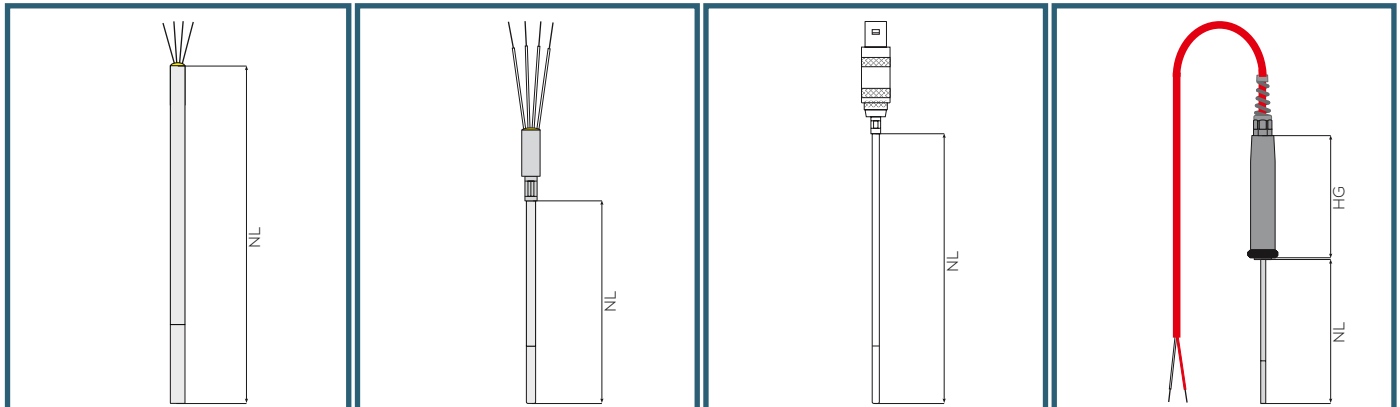
LIMIT DEVIATIONS ACCORDING TO IEC 751 OR DIN EN 60751

The limit deviations for classes B, A and AA are standardized for the measuring resistor Pt100. In addition we have defined limit deviations for the restricted classes 1/5 B and 1/10 B. The values were calculated and specified in Ohm and °C.

°C	Ω	B		A		AA		1/5 B		1/10 B	
		±Ω	±°C	±Ω	±°C	±Ω	±°C	±Ω	±°C	±Ω	±°C
-200	18.520	0.562	1.30								
-150	39.723	0.438	1.05								
-100	60.256	0.324	0.80	0.142	0.35						
-50	80.306	0.218	0.55	0.099	0.25	0.073	0.18	0.044	0.11		
-40	84.271	0.198	0.50	0.091	0.23	0.066	0.17	0.040	0.10		
-30	88.222	0.178	0.45	0.083	0.21	0.059	0.15	0.036	0.09	0.018	0.045
-20	92.160	0.157	0.40	0.075	0.19	0.052	0.13	0.031	0.08	0.016	0.040
-10	96.086	0.137	0.35	0.067	0.17	0.046	0.12	0.027	0.07	0.014	0.035
0	100.000	0.117	0.30	0.059	0.15	0.039	0.10	0.023	0.06	0.012	0.030
10	103.903	0.136	0.35	0.066	0.17	0.045	0.12	0.027	0.07	0.014	0.035
20	107.794	0.155	0.40	0.074	0.19	0.052	0.13	0.031	0.08	0.016	0.040
30	111.673	0.174	0.45	0.081	0.21	0.058	0.15	0.035	0.09	0.017	0.045
40	115.541	0.193	0.50	0.089	0.23	0.064	0.17	0.039	0.10	0.019	0.050
50	119.397	0.212	0.55	0.096	0.25	0.071	0.18	0.042	0.11	0.021	0.055
60	123.242	0.230	0.60	0.104	0.27	0.077	0.20	0.046	0.12	0.023	0.060
70	127.075	0.249	0.65	0.111	0.29	0.083	0.22	0.050	0.13	0.025	0.065
80	130.897	0.267	0.70	0.118	0.31	0.089	0.23	0.053	0.14	0.027	0.070
90	134.707	0.285	0.75	0.125	0.33	0.095	0.25	0.057	0.15	0.029	0.075
100	138.506	0.303	0.80	0.133	0.35	0.101	0.27	0.061	0.16	0.030	0.080
110	142.293	0.321	0.85	0.140	0.37	0.107	0.28	0.064	0.17	0.032	0.085
120	146.068	0.339	0.90	0.147	0.39	0.113	0.30	0.068	0.18	0.034	0.090
130	149.832	0.357	0.95	0.154	0.41	0.119	0.32	0.071	0.19	0.036	0.095
140	153.584	0.374	1.00	0.161	0.43	0.125	0.33	0.075	0.20	0.037	0.100
150	157.325	0.392	1.05	0.168	0.45	0.131	0.35	0.078	0.21	0.039	0.105
160	161.054	0.409	1.10	0.175	0.47	0.136	0.37	0.082	0.22	0.041	0.110
170	164.772	0.427	1.15	0.182	0.49	0.142	0.38	0.085	0.23	0.043	0.115
180	168.478	0.444	1.20	0.189	0.51	0.148	0.40	0.089	0.24	0.044	0.120
190	172.173	0.461	1.25	0.195	0.53	0.154	0.42	0.092	0.25	0.046	0.125
200	175.856	0.478	1.30	0.202	0.55	0.159	0.43	0.096	0.26	0.048	0.130
210	179.528	0.495	1.35	0.209	0.57	0.165	0.45	0.099	0.27	0.049	0.135
220	183.188	0.511	1.40	0.215	0.59	0.170	0.47	0.102	0.28	0.051	0.140
230	186.836	0.528	1.45	0.222	0.61	0.176	0.48	0.106	0.29	0.053	0.145
240	190.473	0.544	1.50	0.229	0.63	0.181	0.50	0.109	0.30	0.054	0.150
250	194.098	0.561	1.55	0.235	0.65	0.187	0.52	0.112	0.31	0.056	0.155
260	197.712	0.577	1.60	0.242	0.67						
270	201.314	0.593	1.65	0.248	0.69						
280	204.905	0.609	1.70	0.254	0.71						
290	208.484	0.625	1.75	0.261	0.73						
300	212.052	0.641	1.80	0.267	0.75						

°C	Ω	B		A		AA		1/5 B		1/10 B	
		±Ω	±°C	±Ω	±°C	±Ω	±°C	±Ω	±°C	±Ω	±°C
310	215.608	0.656	1.85	0.273	0.77						
320	219.152	0.672	1.90	0.279	0.79						
330	222.685	0.687	1.95	0.285	0.81						
340	226.206	0.703	2.00	0.292	0.83						
350	229.716	0.718	2.05	0.298	0.85						
360	233.214	0.733	2.10	0.304	0.87						
370	236.701	0.748	2.15	0.310	0.89						
380	240.176	0.763	2.20	0.315	0.91						
390	243.640	0.777	2.25	0.321	0.93						
400	247.092	0.792	2.30	0.327	0.95						
410	250.533	0.806	2.35	0.333	0.97						
420	253.962	0.821	2.40	0.339	0.99						
430	257.379	0.835	2.45	0.344	1.01						
440	260.785	0.849	2.50	0.350	1.03						
450	264.179	0.863	2.55	0.355	1.05						
460	267.562	0.877	2.60								
470	270.933	0.891	2.65								
480	274.293	0.905	2.70								
490	277.641	0.918	2.75								
500	280.978	0.932	2.80								
550	297.487	0.997	3.05								
600	313.708	1.060	3.30								

TYPE OVERVIEW OF THE SHEATH RESISTANCE THERMOMETERS AND CABLE RESISTANCE THERMOMETERS



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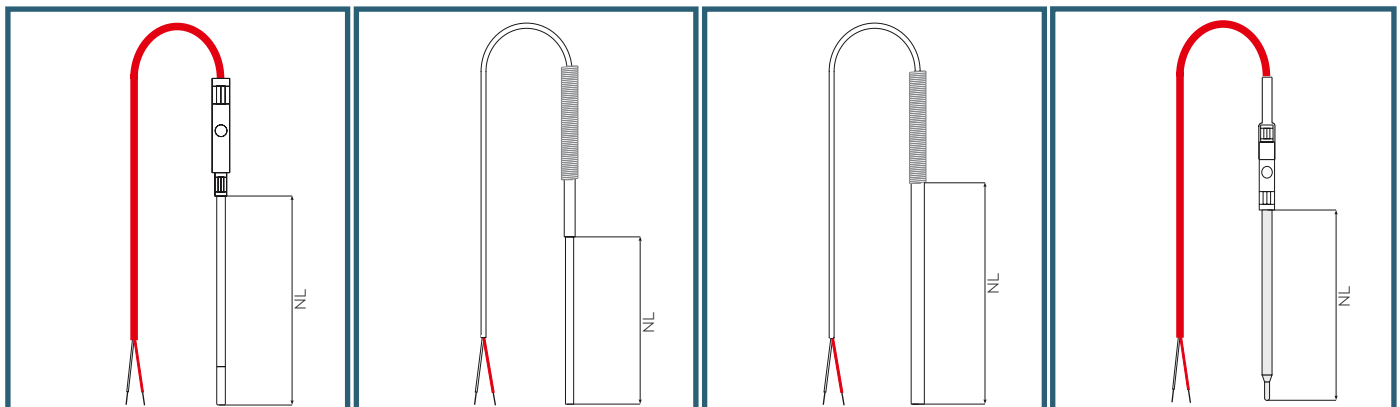
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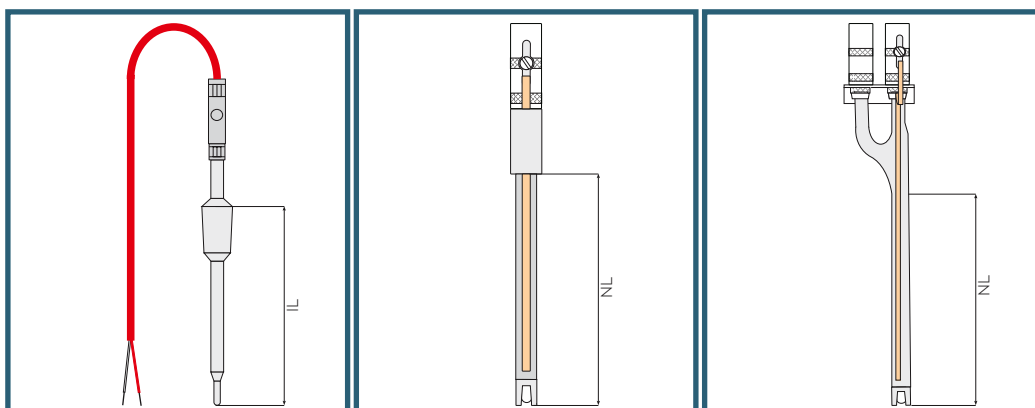
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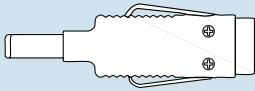
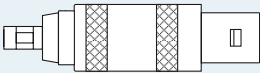
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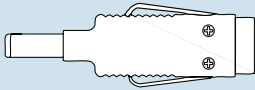
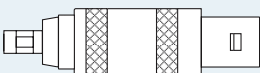
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NL = Nominal length, IL = Installation length

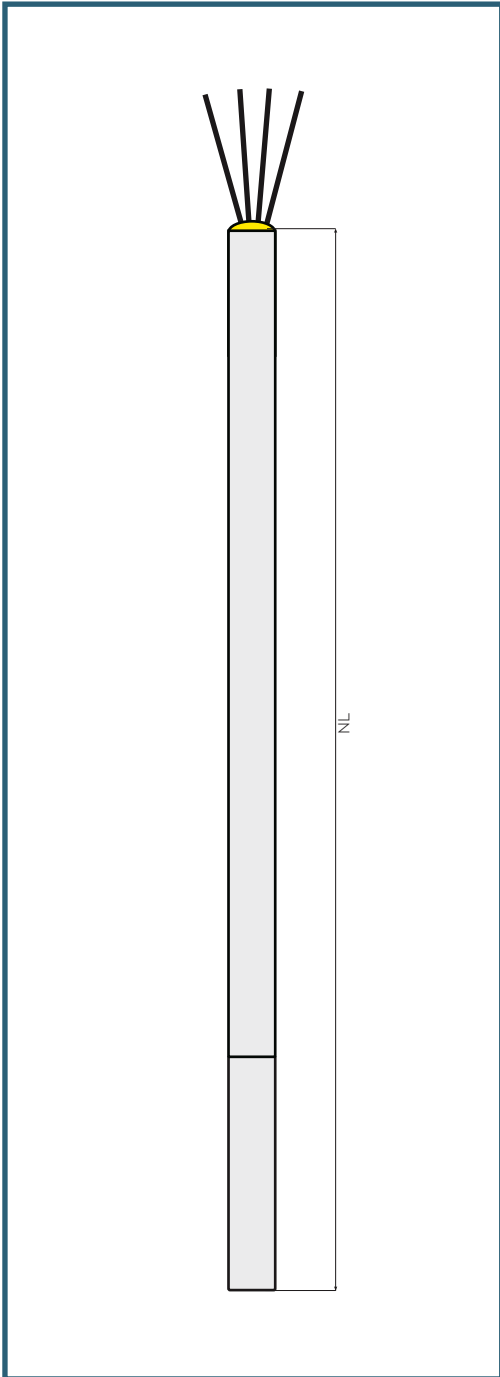
TYPE OVERVIEW OF STANDARD-PLUG CONNECTIONS

Plug connection	Specifications	Ref.-Nr.	WT-MI-306	WT-MI-303-HG	WT-MI-303	WT-ME-303	WT-K
Plug PHYSICS 	Resolution 0.1 °C	31862		x	x	x	x
	Resolution 0.01 °C	31861		x	x	x	x
	Resolution 0.001 °C	64995		x	x	x	x
Plug LEMO, (couplers) 	0S, MIL-Diameter 0.5 up to 1.5 mm		x				
	1S, MIL-Diameter 1.5 up to 6 mm		x	x	x	x	x
	1S, MIL-Diameter 1.5 up to 6 mm		x	x	x	x	x
	LEMO couplers are optionally available		x	x	x	x	x

Plug connection	Specifications	Ref.-Nr.	WT-GL-3/6-303	WT-GL-NS14-303	WT-GL-8-306	WT-GL-9,5-306
Plug PHYSICS 	Resolution 0.1 °C	31862	x	x		
	Resolution 0.01 °C	31861	x	x		
	Resolution 0.001 °C	64995	x	x		
Plug LEMO, (couplers) 	0S, MIL-Diameter 0.5 up to 1.5 mm					
	1S, MIL-Diameter 1.5 up to 6 mm		x	x	x	x
	2S, MIL-Diameter 4.5 mm or 6 mm		x	x		
	LEMO couplers are optionally available		x	x	x	x

WT-MI-301

MINERAL INSULATED RESISTANCE THERMOMETER FLEXIBLE WITH FREE WIRE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Flexible mineral insulated resistance thermometer
- + Nominal length up to 500 mm – diameter up to 6.0 mm
- + MI cable sheath made of stainless steel 1.4541
- + Diameter for MI-wire and protective tube consistent
- + Pt100 in wounded glass design (vibration resistant) to EN 60751 Class A with 4-wire circuit
- + Connection via free wire ends (20 mm length)
- + Measuring range $-100\text{ }^{\circ}\text{C}$ to $400\text{ }^{\circ}\text{C}$

OPTIONS:

- + Version with Pt100 – Class A (wound ceramic version – not vibration-resistant)
- + Variant with rigid, protective tube placed on the tip
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Diameter change

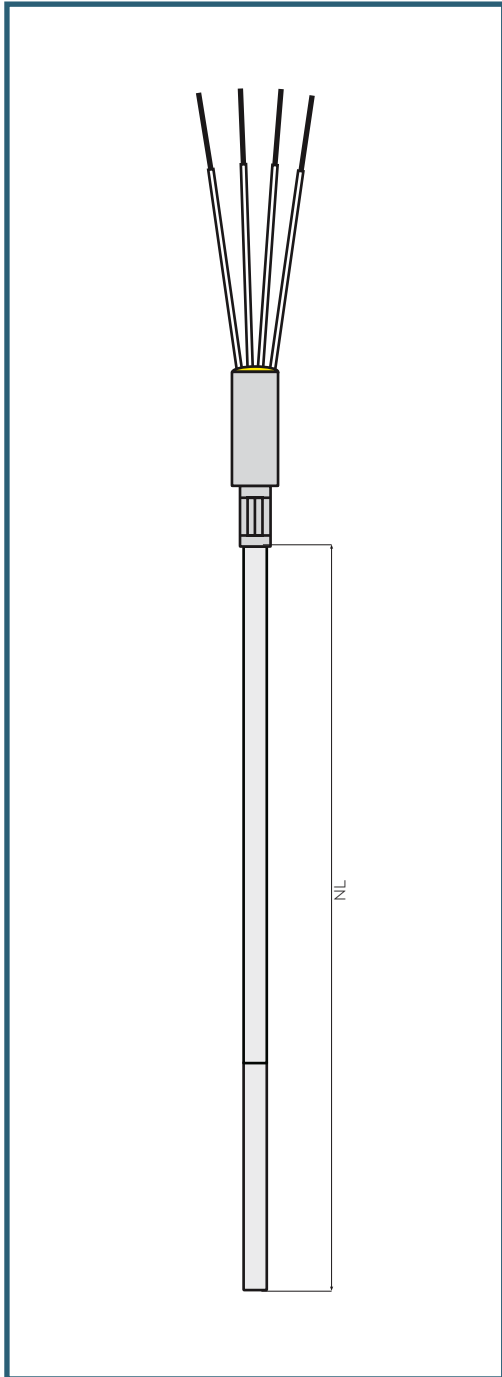


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

WT-MI-302

MINERAL INSULATED RESISTANCE THERMOMETER FLEXIBLE WITH REINFORCED WIRE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Flexible mineral insulated resistance thermometer
- + Nominal length up to 500 mm – diameter up to 6.0 mm
- + With adapter sleeve made of stainless steel
- + MI cable sheath made of stainless steel 1.4541
- + Diameter for MI-wire and protective tube consistent
- + Pt100 in thin film design
to EN 60751 Class A with 4-wire circuit
- + FEP-insulated connection strands – length 50 mm
- + 10 mm stripped and tin-plated
- + Measuring range -50 °C to 300 °C

OPTIONS:

- + Version with Pt100 – Class B (thin film design)
- + Vibration resistant version with Pt100 – Class A
(wound glass design – sensor diameter 6 mm)
- + Version rigid protective tube placed onto the tip
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Diameter change
- + Length change of the connection wires/strands

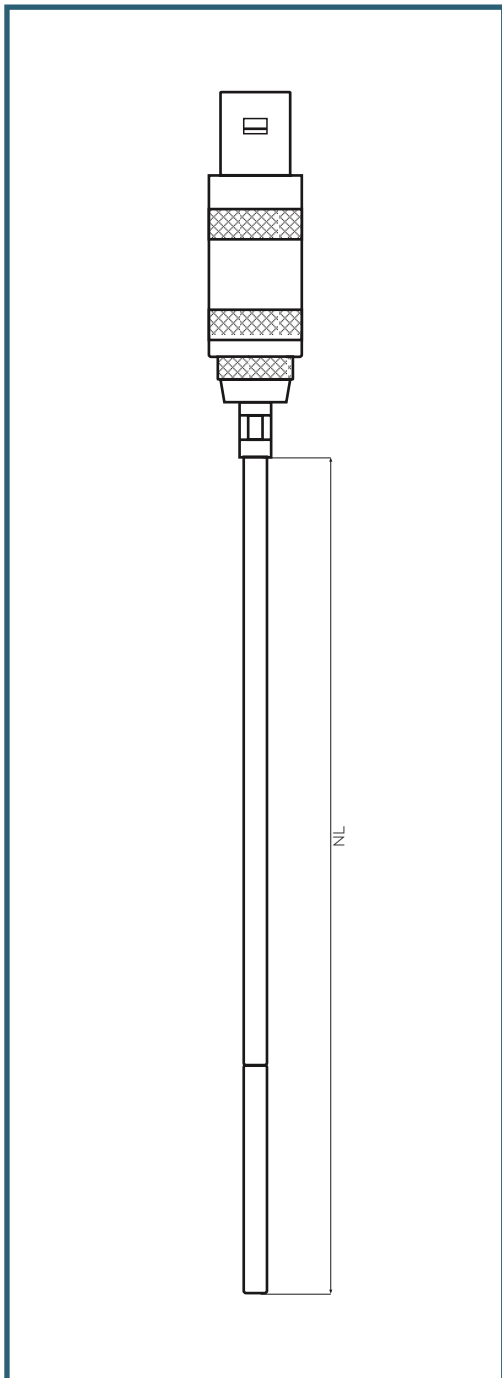


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

WT-MI-306

MINERAL INSULATED RESISTANCE THERMOMETER FLEXIBLE WITH DIRECT PLUG CONNECTION LEMO



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Flexible mineral insulated resistance thermometer
- + Nominal length up to 500 mm – diameter up to 6.0 mm
- + With directly mounted plug LEMO
- + MI cable sheath made of stainless steel 1.4541
- + Diameter for MI-wire and protective tube consistent
- + Pt100 in wounded ceramic design to EN 60751
Class A in 4-wire connection
- + Measuring range $-100\text{ }^{\circ}\text{C}$ to $400\text{ }^{\circ}\text{C}$

OPTIONS:

- + Connector mounting at customer request
e.g. plug LEMO and couplers (see page 29)
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Diameter change
- + Variant with rigid, protective tube placed on the tip

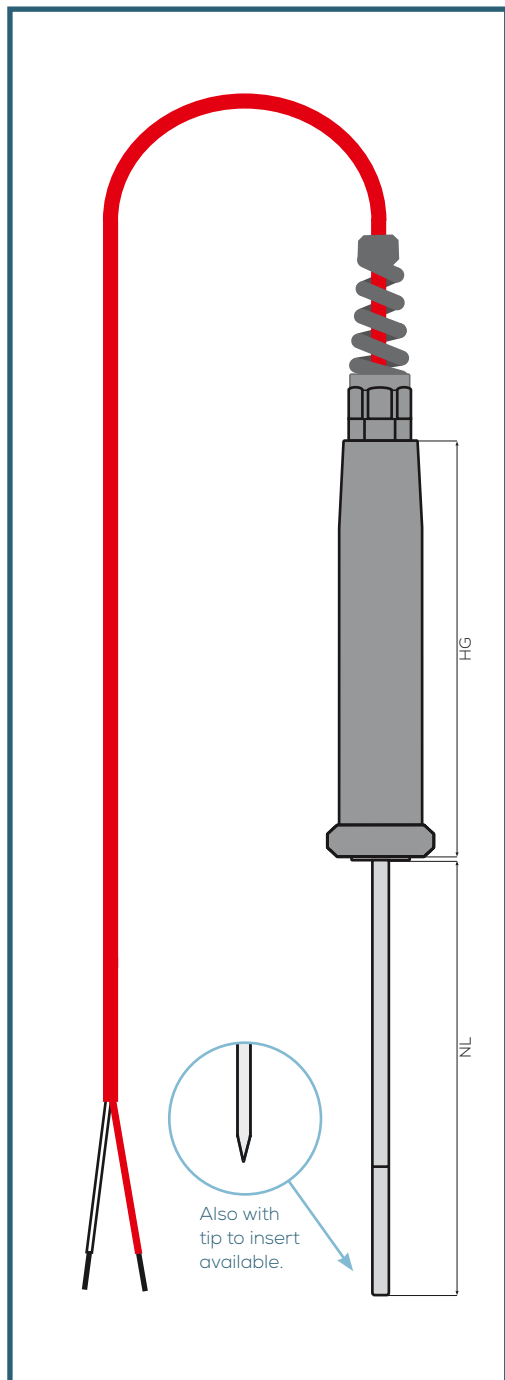


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

WT-MI-303-HG

RESISTANCE THERMOMETER WITH HANDLE, CONNECTION CABLE AND FREE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Resistance thermometer to immerse or insert with handle
- + Nominal length up to 500 mm – diameter up to 6.0 mm
- + MI cable sheath made of stainless steel 1.4541
- + Diameter for MI-wire and protective tube consistent
- + Pt100 in wounded ceramic design to EN 60751
Class A in 4-wire circuit
- + With handle made of PA6 – \varnothing 20 mm
- + Cable outlet secured with bend protection and strain relief
- + Fixed connection compensating cable
- + Cable length 2–5 m
- + FEP/silicone insulated
- + Connection end 50/10 mm stripped with free ends (tin-plated)
- + Measuring range -100 °C to 300 °C

OPTIONS:

- + Connector mounting at customer request
e.g. plug PHYSICS or LEMO (see page 29)
- + Nominal length change with possible adjustment of the measuring range
- + Cable length change
- + Diameter change

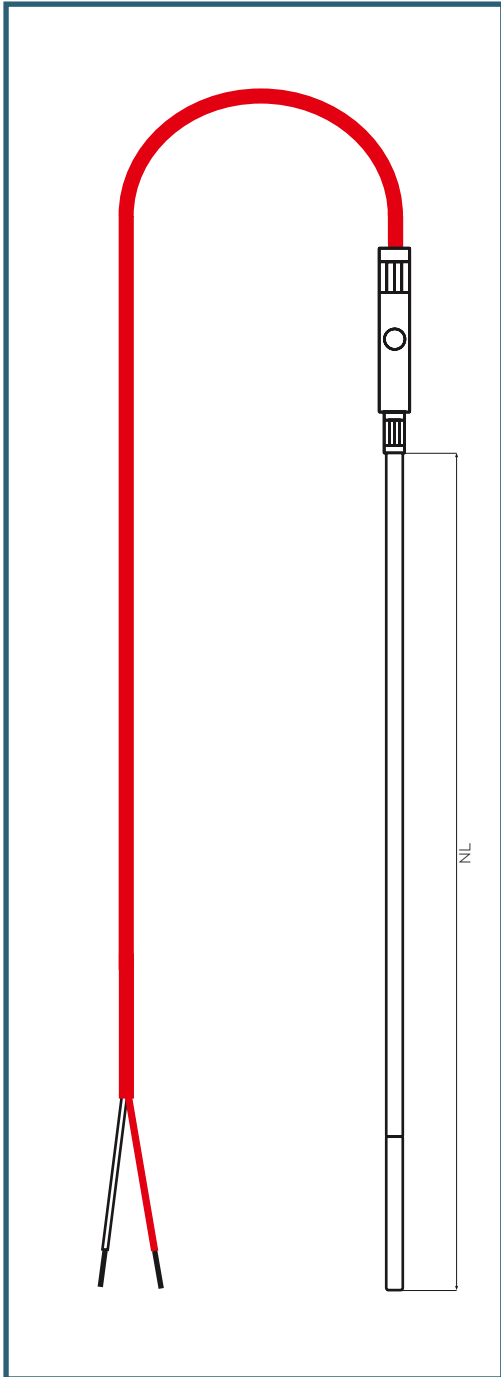


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

WT-MI-303

MINERAL INSULATED RESISTANCE THERMOMETER FLEXIBLE WITH CONNECTION CABLE AND FREE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Mineral insulated resistance thermometer
- + Nominal length up to 500 mm – diameter up to 6.0 mm
- + MI cable sheath made of stainless steel 1.4541
- + Diameter for MI-wire and protective tube consistent
- + Pt100 in wounded ceramic design to EN 60751 Class A in 4-wire circuit
- + With adapter sleeve made of stainless steel
- + Fixed connection compensating cable
- + Cable length 2-5 m
- + FEP/silicone insulated
- + Connection end 50/10 mm stripped with free ends (tin-plated)
- + Measuring range -100 °C to 400 °C

OPTIONS:

- + Connector mounting at customer request e.g. plug PHYSICS or LEMO (see page 29)
- + Nominal length change
- + Cable length change
- + Diameter change
- + Adapter sleeve made of brass
- + Cable outlet secured with heat-shrinking tubing (approx. 60 mm length)
- + With mounted anti-kink spring (approx. 60 mm length)
- + Sensor with PTFE heat-shrink tubing complete shrinking (operating temperature max. 200 °C)
- + With adjustable screw fitting (ø 3.0 to 6.0 mm)



- + With screw-in thread M8 x 1
- + With screw-in thread M10 x 1
- + With screw-in thread G¼
- + With PTFE clamp ring
- + With steel cutting ring

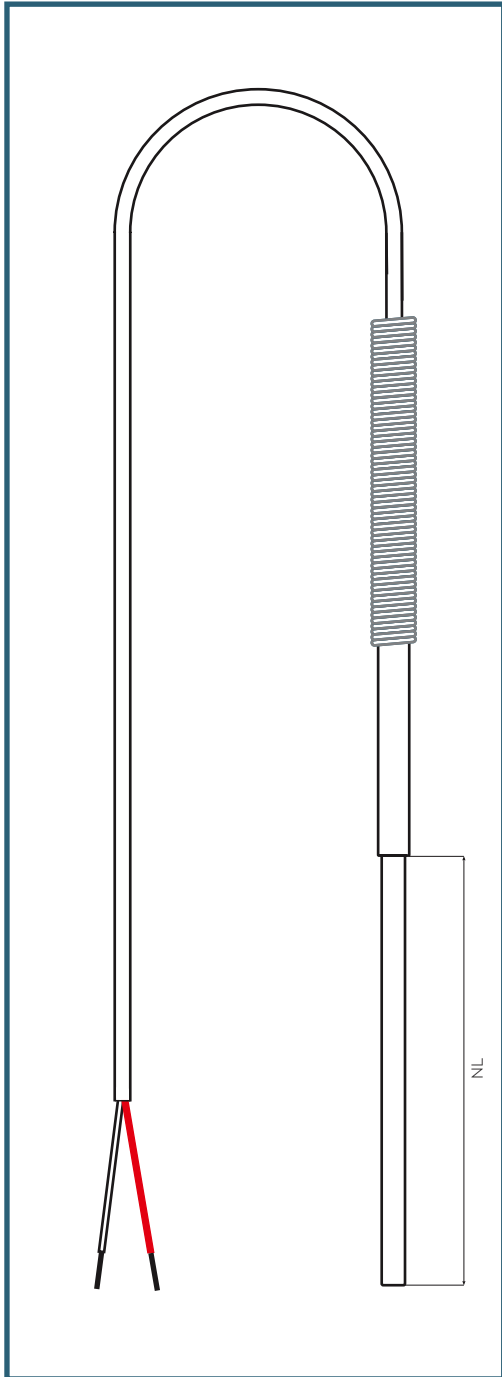


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

WT-ME-303

IMMERSION RESISTANCE THERMOMETER WITH CONNECTION CABLE AND FREE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Immersion resistance thermometer
- + Protective tube \varnothing up to 6.0 mm made of stainless steel 1.4571
- + Nominal length up to 500 mm
- + Directly installed Pt100 in wounded ceramic design to EN 60751 Class A in 4-wire circuit
- + With transition piece \varnothing 5 x 60 mm made of stainless steel 1.4571
- + Firmly connected connection cable 4 x 0.22 mm²
- + Cable length 2 -5 m
- + FEP/stainless steel braiding screen/FEP
- + Cable outlet with anti-kink spring, approx. 60 mm length, secured
- + Connection end 50/10 with free ends (tin-plated)
- + Measuring range -100 °C to 250 °C

OPTIONS:

- + Connector mounting at customer request
e.g. plug PHYSICS or LEMO (see page 29)
- + Sensor with PTFE heat-shrink tubing complete shrinking
- + Nominal length change
- + Cable length change
- + Diameter change
- + Adapter sleeve made of brass

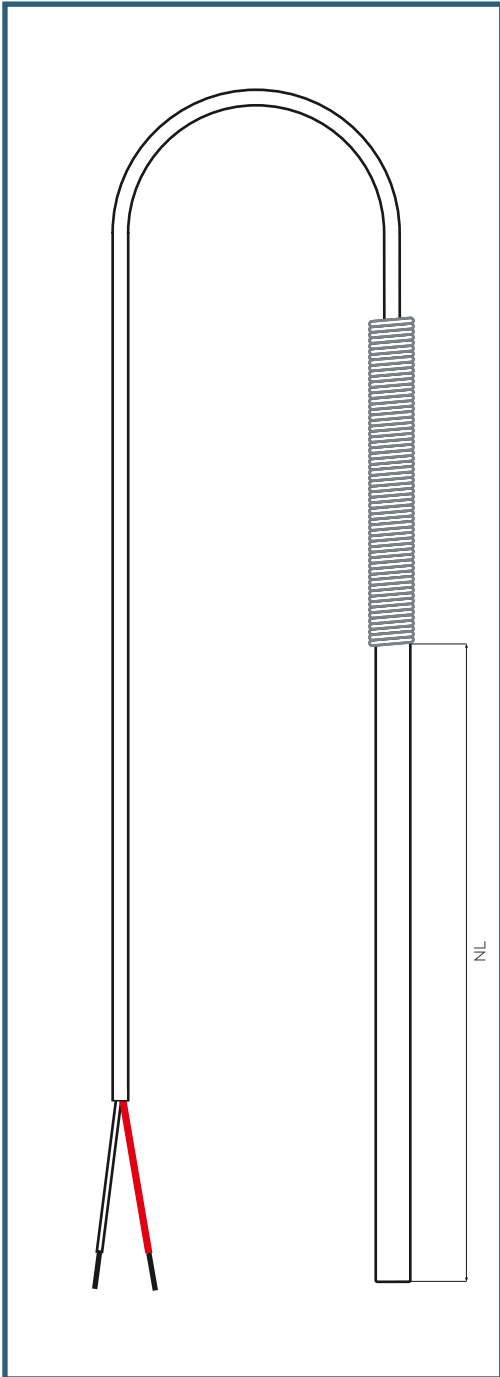


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

WT-K

CABLE RESISTANCE THERMOMETER WITH CONNECTION CABLE AND FREE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Cable resistance thermometer
- + Protective tube diameter up to 6.0 mm - nominal length up to 500 mm
- + Made of stainless steel 1.4571
- + Directly installed Pt100 in wounded ceramic design to EN 60751 Class A in 4-wire circuit
- + Directly connected connection cable
- + Cable length 2-5 m
- + FEP/stainless steel braiding screen/FEP insulated
- + Cable outlet with anti-kink spring, approx. 60 mm length, secured
- + Connection end 50/10 mm stripped with free ends (tin-plated)
- + Measuring range -100 °C to 400 °C

OPTIONS:

- + Connector mounting at customer request e.g. plug PHYSICS or LEMO (see page 29)
- + Nominal length change
- + Cable length change
- + Diameter change
- + Adapter sleeve made of brass
- + Cable outlet secured with heat-shrinking tubing (approx. 60 mm length)
- + Sensor with PTFE heat-shrink tubing complete shrinking (operating temperature max. 200 °C)
- + With adjustable screw fitting (\varnothing 3.0 to 6.0 mm)



- + With screw-in thread M10 x 1
- + With screw-in thread G $\frac{1}{4}$
- + With PTFE clamp ring
- + With steel cutting ring

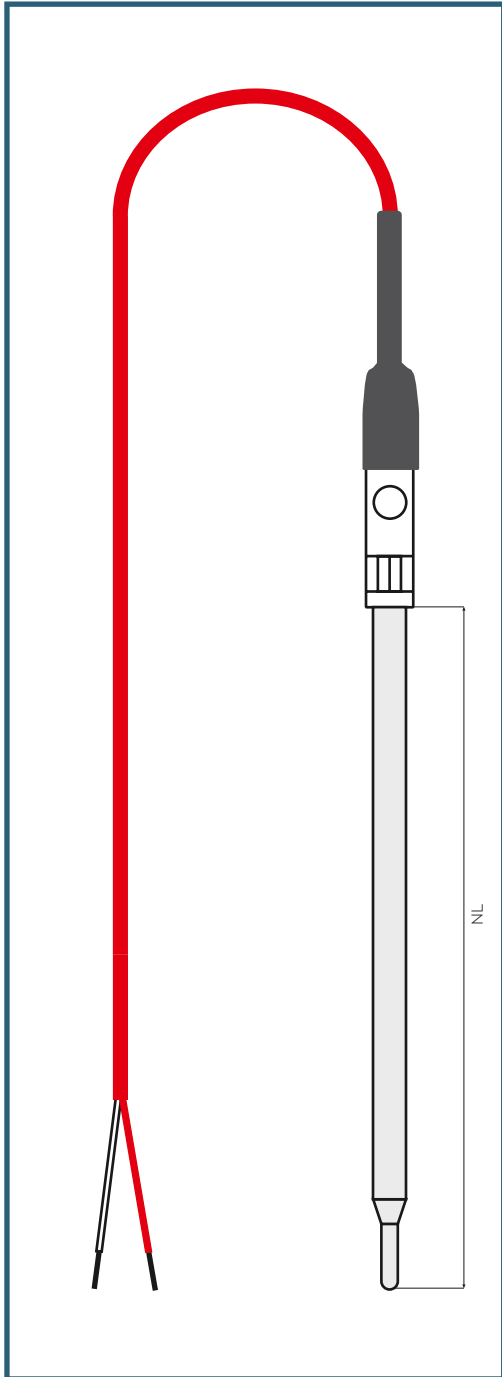


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

WT-GL-3/6-303

LABORATORY RESISTANCE THERMOMETER IN GLASS DESIGN WITH CONNECTION CABLE AND FREE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Laboratory resistance thermometer in glass version
- + Nominal length up to 500 mm – diameter 3/6 mm
- + Glass sensor \varnothing 3 mm, 12 mm length with glass shaft \varnothing 6 mm
- + Pt100 in wounded glass design to EN 60751
Class A in 4-wire circuit
- + With adapter sleeve made of stainless steel
- + Fixed connection compensating cable
- + Cable outlet via heat-shrink tubing approx. 60 mm
- + Cable length 2-5 m
- + FEP/silicone insulated
- + Connection end with free ends 50/10 mm (tin-plated)
- + Measuring range $-100\text{ }^{\circ}\text{C}$ to $250\text{ }^{\circ}\text{C}$

OPTIONS:

- + Connector mounting at customer request
e.g. plug PHYSICS or LEMO (see page 29)
- + Nominal length change
- + Cable length change
- + Adapter sleeve made of brass

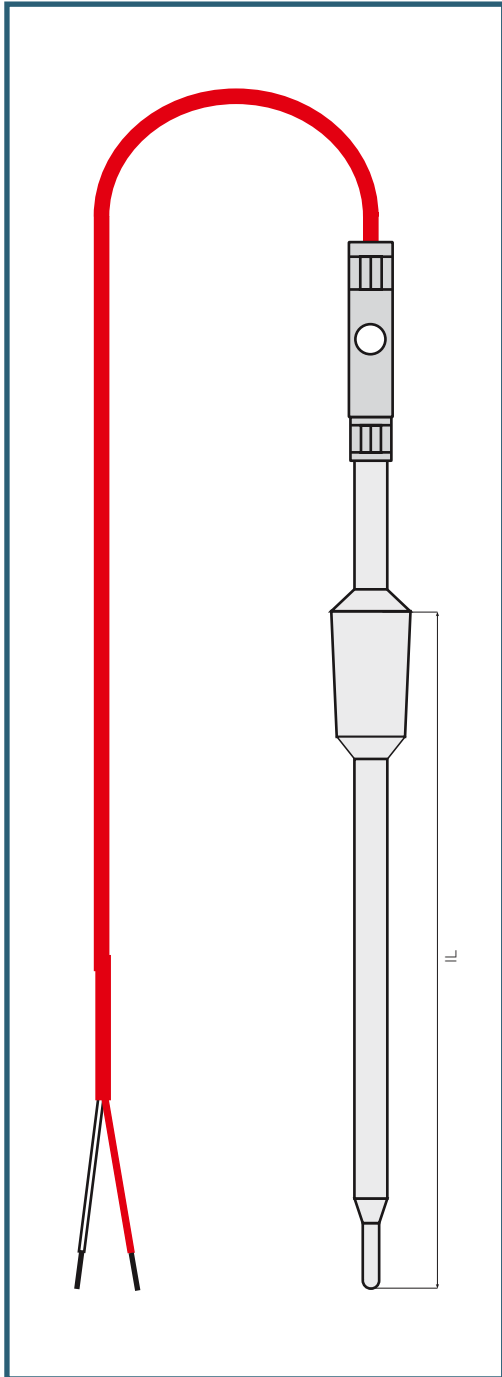


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

WT-GL-NS14-303

LABORATORY GROUND JOINT THERMOMETER IN GLASS DESIGN WITH CONNECTION CABLE AND FREE ENDS



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Laboratory ground joint thermometer in glass version
- + Installation length incl. ground joint: 300 mm
- + Glass sensor \varnothing 3 mm, 12 mm length with glass shaft \varnothing 6 mm and ground joint NS 14.5/23
- + With adapter sleeve made of stainless steel
- + Pt100 in wounded glass design to EN 60751 Class A in 4-wire circuit (from adapter sleeve)
- + Fixed connection compensating cable
- + Cable length 2-5 m
- + FEP/silicone insulated
- + Connection end with free ends 50/10 mm (tin-plated)
- + Measuring range -50 °C to 250 °C

OPTIONS:

- + Connector mounting at customer request e.g. plug PHYSICS or LEMO (see page 29)
- + Further ground joints variants possible
- + Installation length change
- + Cable length change
- + Adapter sleeve made of brass

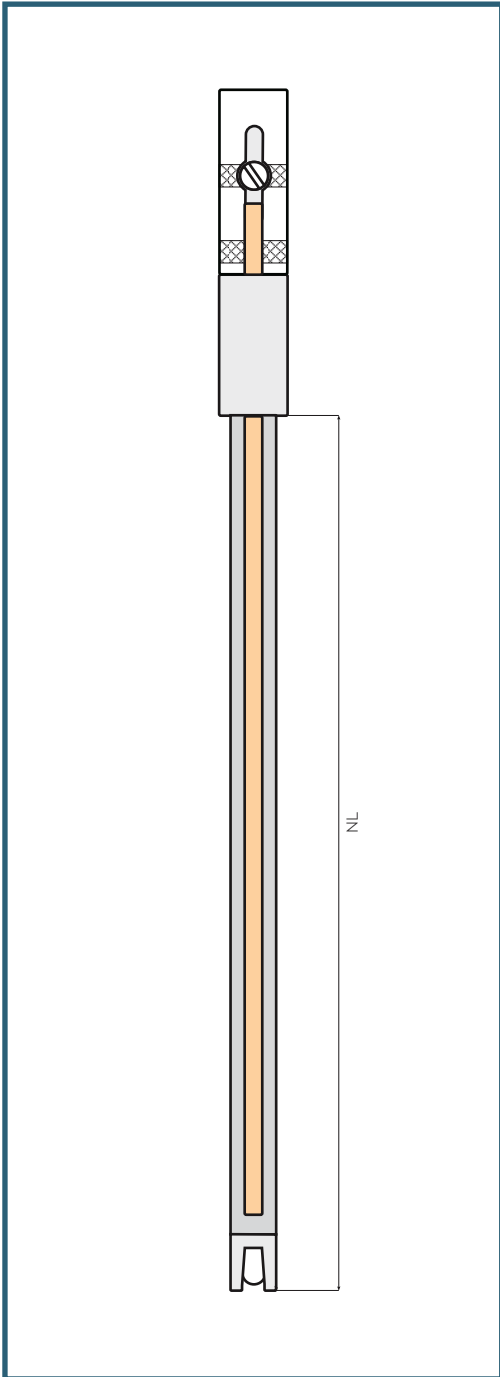


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

You find further information online: www.ludwig-schneider.com

WT-GL-8-306

LABORATORY RESISTANCE THERMOMETER IN GLASS DESIGN WITH DIRECTLY MOUNTED LEMO COUPLING



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Glass resistance thermometer
- + Nominal length up to 500 mm – diameter 8 mm
- + Measuring tip approx. 8 mm, ground two-sided
- + 1 x Pt100 (thin film – glazed) to EN 60751
Class A in 4-wire circuit
- + Connection via LEMO couplers
- + 4-pole with gold-plated contacts
- + Break and grounding strap firmly connected to LEMO couplers
- + Measuring range -30 °C to 350 °C

OPTIONS:

- + Connector mounting at customer request
e.g. plug LEMO and couplers (see page 29)
- + Nominal length change

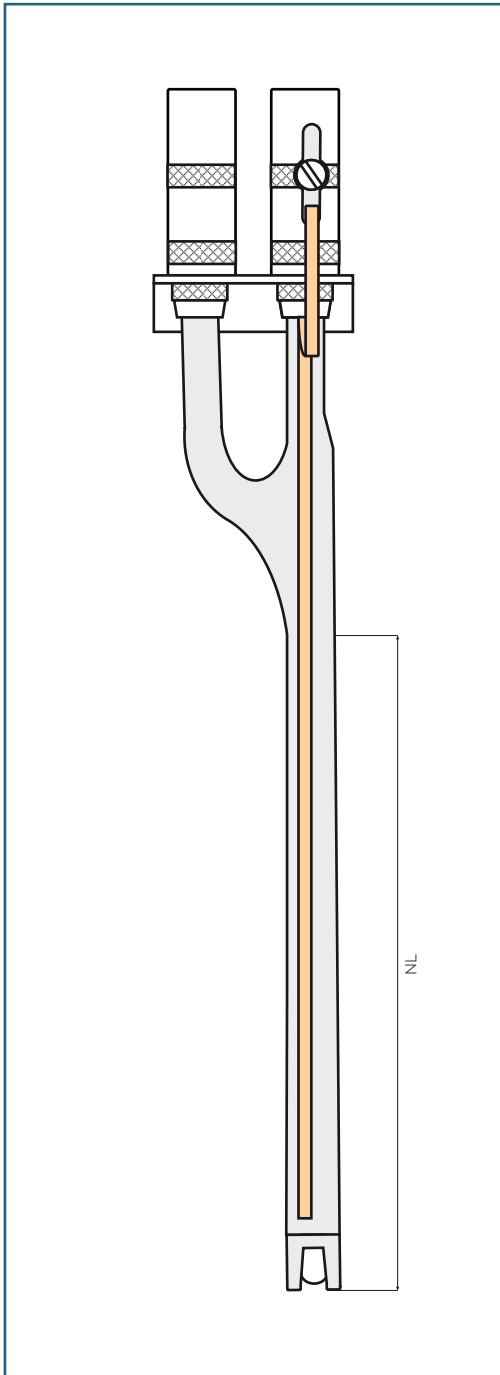


ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

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WT-GL-9,5-306

LABORATORY RESISTANCE THERMOMETER IN GLASS DESIGN WITH DIRECTLY MOUNTED LEMO COUPLING



COMPLETE INSTRUMENTS

DESCRIPTION OF THE STANDARD VERSION:

- + Glass resistance thermometer (duplex)
- + Nominal length up to 500 mm - diameter 9.5 mm
- + Measuring tip approx. 9.5 mm, ground two-sided
- + 2 x Pt100 (thin film - glazed) to EN 60751
Class A in 4-wire circuit
- + Connection via 2 x LEMO couplers, 4-pole with gold-plated contacts
- + With retaining bridge made of aluminum
- + Break and grounding strap firmly connected to LEMO couplers
- + Measuring range -30 °C to 350 °C

OPTIONS:

- + Connector mounting at customer request
e.g. plug LEMO and couplers (see page 29)
- + Nominal length change



ORDER: Please specify the desired options. Apart from standard sensors we also offer application-specific special versions. Please contact us when necessary.

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NOTES

NOTES

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PRODUCT SUMMARY

- Catalogue PRECISION LABORATORY THERMOMETERS /
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- Catalogue GENERAL PURPOSE THERMOMETERS /
THERMOMETERS FOR SPECIAL APPLICATION
- Catalogue TEMPERATURE PROBES THERMOCOUPLES
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