Cables

Catalog

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SensyMIC – Mineral Insulated Cables

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SensyHeat – Heaters

SensyMIC – Mineral Insulated Cables

General Information

Mineral insulated cables have an outer sheath of metal with 2 to 8 inner conductors. The insulation material is made from a highly compressed metal-oxide powder (preferably MgO or Al_2O_3).

Mineral insulated thermocouple cables have inner conductors of thermocouple base material. Mineral insulated cables for RTDs have inner conductors of copper, copper-nickel alloys, nickel, nickel-chromium or nickel-plated copper.

Mineral insulated cables are designed for high-temperature applications and are used wherever there are particularly strict requirements with regard to mechanical, chemical and electrical stability.

On account of their good flexibility, the use of mineral insulated cables is preferred in areas where mounting is difficult and where a high degree of flexibility is required (for example, laboratories or pilot manufacturing plants).The minimum bending radius is 3 times the outer diameter of the mineral insulated cable.

Innovations in technology and manufacturing have made it possible for these cables to be used increasingly frequently as a material in the manufacture of standardized thermocouples and RTDs, in particular in industrial measuring and control technology and in automotive sensor technology.

Delivery Program

SENSYCON offers a wide range of mineral insulated cables for the production of mineral insulated thermocouples and mineral insulated RTDs.

All standardized thermocouples type K, J, L, T, U, E and N and the precious metal thermocouples type R, S and B are available as mineral insulated thermocouple cables. Various mineral insulated cables with copper, copper-nickel, nickel and nickel-chromium inner conductors are also available ex stock.

However, not all combinations of sheath material and thermocouple are possible as, for example, for high-temperature-resistant sheath materials some of the necessary heat treatments considerably exceed the maximum permissible temperatures for the leads.

The following steels and alloys are available as sheath materials:

1.4301	complies with	AISI 304
1.4306	complies with	AISI 304 L
1.4404	complies with	AISI 316 L
1.4541	complies with	AISI 321
1.4571	complies with	AISI 316 TI
1.4749	complies with	AISI 446
1.4841	complies with	AISI 314
1.4845	complies with	AISI 310 S
1.4876	complies with	INCOLOY 800
2.4816	complies with	INCONEL 600
2.4851	complies with	INCONEL 601
2.4951	complies with	Nimonic 75
Platinum 10 % Rhodium		

Special Materials

Special manufactures can be produced for special applications, for example using special materials and insulation materials or designed within specific tolerances.

Standard Types

The catalog numbers printed in bold are standard types and can be delivered at short notice.

Special Manufactures

The catalog numbers printed normally are special manufactures and are not available ex stock. However, they can be produced with a minimum order quantity (one production length) and a minimum production time.

Production Lengths

The production lengths of mineral insulated cables depend on the length of the available tubes.

The following lengths can be delivered:

Outer ∅ (mm)	Production length (approx.)
0.5	500 m
1.0	600/1.000 m
1.5	310/1.500 m
1.6	250/1.300 m
2.0	700 m
3.0	420/530 m
3.2	365/460 m
4.5	180 m
4.8	160 m
6.0	105 m
6.4	88 m
8.0	58 m
10.0	35 m

Minimum Order Value

The minimum order value is DEM 300.00/Euro 150.00.
For order values less than DEM 300.00/Euro 150.00 and quantities less than one production length, a surcharge of 25% is added.

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Technical Data

Insulation Ceramics

SENSYCON supplies MgO as the standard insulator with a purity of ≥ 96 % as well as MgO with a purity of ≥ 99.4 % and Al_2O_3.

Insulation Resistance

The insulation resistance depends on the purity of the insulation ceramics used as well as the manufacturing process and the humidity content of the insulation. The cables are supplied fully dried with ends that are hermetically sealed. The following values of the insulation resistance are guaranteed upon delivery (see table 1).

The insulation resistance also depends on the length of the cable. Therefore, it is listed as a length-related resistance in Ω × m.
Example: L = 100 m; R_{is} = 10 MΩ
R_{is} = 10 MΩ × 100 m = 1000 MΩ × m

The minimum value at room temperature is
1000 MΩ × m acc. to DIN EN 61515.

DIN EN 61515 provides for the minimum requirements stated in table 1.

Test voltages
Outer diameter ≤ 1.5 mm: 75 V ± 25 V DC
Outer diameter > 1.5 mm: 500 V ± 50 V DC

The minimum values at higher temperatures can be confirmed on request.

Loop Resistance (resistance of inner conductors)

In order to assess measuring errors, the loop resistance is an important parameter in addition to the insulation resistance. The lower the loop resistance, the lower its influence on the measuring accuracy.
The maximum loop resistance of the various MI cables is shown in table 2.

Processing

It is absolutely necessary that the cable is sufficiently dried after the seal is opened or after the mineral insulated cable is cut into the lengths required. Immediately after drying, the cable must be sealed. The cable must not be stored with open ends.

Table 1: Insulation Resistance Values at Ambient and Elevated Temperatures
(The values are intended to specify the minimum requirements for operations but not for manufacturer's quality control tests)

	Minimum immersed length at test temperature m	Test temperature °C	Minimum insulation resistance MΩm
Ambient temperature	1	20 ± 15	1000
Elevated temperature type J, E, K and N	0.5	500 ± 15	5
Elevated temperature Type T	0.5	300 ± 10	500

Note – The insulant of a mineral insulated thermocouple cable or thermocouple has a finite conductivity and therefore the insulation resistance decreases as the length of the cable or thermocouple increases. The conductance of a specific cable or thermocouple is therefore expressed in Sm^{-1} (equivalent to $\Omega^{-1} \cdot m^{-1}$) and hence the minimum specified insulation resistance is expressed in Ωm or MΩm for cables or thermocouples longer than 1 m. For shorter lengths, it is expressed in MΩ.

Table 2: Loop Resistance for 1 Thermocouple at 20 °C in Ω/m (approx. values)

Thermocouple (TP = Thermocouple)	Outer ∅ mm											
	0.5	1.0	1.5	1.6	2.0	3.0	3.2	4.5	4.8	6.0	6.4	8.0
1 TP NiCr-Ni	150	32/44	15/19	13/18	10.5	6.4	5.3	2.8	2.5	1.6	1.4	0.9
2 TP NiCr-Ni						6.2		3.1		1.6		0.8
1 TP Fe-CuNi	130	34	15	13	8.6	4.2	3.0	1.7	1.4	1.0	0.7	0.5
2 TP Fe-CuNi						3.7		1.8		1.0		0.5

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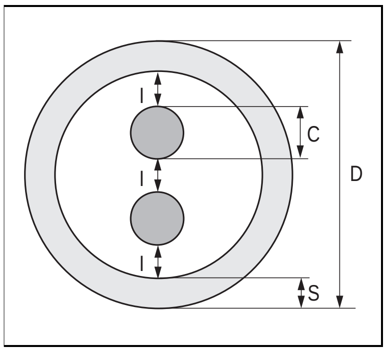
Dimensions

The following table shows the tolerances of the outer diameter, minimum wall thickness, minimum conductor diameter and thickness of the insulation according to DIN EN 61515.

Outer diameter of the cable (D) Nominal value ± tolerance, mm	Minimum wall thickness (S), mm	Minimum diameter of the inner conductor (C), mm	Minimum thickness (I) of the insulation, mm
0.5 ± 0.025	0.05	0.08	0.04
1.0 ± 0.025	0.10	0.15	0.08
1.5 ± 0.025	0.15	0.23	0.12
1.6 ± 0.025	0.16	0.24	0.13
2.0 ± 0.025	0.20	0.30	0.16
3.0 ± 0.030	0.30	0.45	0.24
3.2 ± 0.030	0.32	0.48	0.26
4.0 ± 0.045	0.40	0.60	0.32
4.5 ± 0.045	0.45	0.68	0.36
4.8 ± 0.045	0.48	0.72	0.38
6.0 ± 0.060	0.60	0.90	0.48
6.4 ± 0.060	0.64	0.96	0.51
8.0 ± 0.080	0.80	1.20	0.64
10.0 ± 0.100	1.00	1.50	0.80



D = Outer diameter
C = Conductor diameter
S = Wall thickness
I = Insulation thickness

Excerpt from the Tolerances and Temperature Ranges for Thermocouples

Thermocouple Type	Temperature Range °C	Tolerance
Thermocouples according to DIN EN 60584		
Class 1		
E	- 40 to + 800	± 1.5 °C or ± 0.004 × |t|
J	- 40 to + 750	± 1.5 °C or ± 0.004 × |t|
K/N	- 40 to + 1000	± 1.5 °C or ± 0.004 × |t|
Class 2		
E	- 40 to + 900	± 2.5 °C or ± 0.0075 × |t|
J	- 40 to + 750	± 2.5 °C or ± 0.0075 × |t|
K/N	- 40 to + 1200	± 2.5 °C or ± 0.0075 × |t|
T	- 40 to + 350	± 1.0 °C or ± 0.0075 × |t|
R/S	± 0 to + 1600	± 1.5 °C or ± 0.0025 × |t|
Class 3		
B	+ 600 to + 1700	± 4.0 °C or ± 0.005 × |t|
Thermocouples according to DIN 43 710		
U	- 200 to + 600	from 0 to + 400 °C ± 3 °C from + 400 to + 600 °C ± 0.0075 × |t|
L	- 200 to + 900	from 0 to + 400 °C ± 3 °C from + 400 to + 900 °C ± 0.0075 × |t|

The short-range ordered state in NiCr-Ni thermocouples (type K)

Type K thermocouples are the most widely used thermocouples in process measuring technology, and not only there.
Why?

- Their wide temperature range from – 200 to 1200 °C
- Their excellent long-term stability under oxidizing conditions
- Their high sensitivity of 40 µV/°C
- Their superior suitability within mineral insulated thermocouples
- Their moderate price compared to precious metals

make these thermocouples an optimal solution both technically and financially.

From time to time arguments come up denying the suitability of this thermocouple type for the accuracy required in industrial measuring and control technology because these alloys are subject to the short-range ordered state.

What is the short-range ordered state?

The short-range ordered state is a phenomenon which occurs with nickel-chromium alloys and predominantly affects their thermoelectric properties. It is a magnetic ordering state of the individual elements of the matrix.

A distinction is made between
- the ordered state, the so-called **K state,** and
- the disordered state, which will be called **U state.**

One can imagine that in the K state the matrix elements stand in rank and file, whereas in the U state there is no order to their positions.
These states can be produced by certain temperature treatments and can easily be reversed.

In addition, transition states between the above states often occur.

What is the effect of the ordering states?

The electromotive force (e.m.f.) of a nickel-chromium wire in the K state may differ from an identical wire in the U state by the equivalent of 2 to 3 °C depending on the temperature and test method. In the transition states this value is lower.

How are the ordering states created?

Above 600 °C nickel-chromium alloys are always in the disordered or U state. After reaching this temperature the U state is formed very quickly.

If the alloy is cooled rapidly (in a few minutes) to room temperature, the U state will be kept as long as the temperature of the alloy is not raised above room temperature. The U state is "frozen in".

If the alloy is cooled slowly (in a few hours) to room temperature, a transition state between K and U generally appears.

If the alloy is kept for an extended period (one or two days) within a temperature range of 250 to 500 °C, the K state will be formed and sustained until the alloy is heated to 600 °C or above again.

What heat treatment is applied to mineral insulated thermocouples before delivery?

All manufacturers apply annealing after the last drawing step to reduce any hardening of the sheath and wires caused by plastic deformation, i.e. to make the mineral insulated thermocouple soft and thus flexible and to reverse major changes in e.m.f.

This annealing is applied at temperatures above 600 °C, i.e. the wires are in the U state.

After annealing, the cables are usually cooled as quickly as possible in order to avoid precipitation processes, for example in sheaths of austenitic stainless steels (1.4571 or similar), which would impair the weld ability. This results in a more or less undefined transition state between K and U in the wires; it is possible to achieve such rapid cooling that the U state is frozen in in small cable cross-sections only in some continuous cooling plants.

What is the behaviour of thermocouples in the different modes of delivery?

The majority of thermocouples are installed so that the measuring junction is at an elevated temperature and so that the temperature along the length of the thermocouple decreases with various slopes down to room temperature.

With a perfectly homogeneous thermocouple, i.e. the individual wires are completely identical over their whole length and do not have any local impurities or irregularities in their matrix, the e.m.f. will depend exclusively on the difference between the measuring junction and the reference junction.

However, if the thermocouple is not homogeneous, deviations from the original e.m.f. will occur, which depend on the nature and amount of the inhomogeneity and the temperature profile along the thermocouple.

Every thermocouple type K, regardless of the mode of delivery, will change after installation and when first used because it is always led through a temperature range in which the K state is formed after an extended period of time.

It is important to consider that the K state will also be formed at temperatures slightly below 250 °C, but much more slowly, it may take weeks.

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What happens when first heated to 600 °C and above?

The following is based on a "regular" installation of the thermocouple as it is common in process control:
The insertion length of the thermocouple is fixed and the operating temperature does not vary significantly.

1. Delivery in the U state
At the measuring junction, nothing happens because the U state is already present. In the so-called temperature gradient, i.e. where the temperature decreases towards the end of the thermocouple, the K state will gradually be formed over weeks (see above). During this period, the deviation from true e.m.f. changes continuously. Reliable temperature measurement and control are not possible. At the cold end of the thermocouple, a local transition from the K state to the U state appears, another inhomogeneity with additional influence on the e.m.f.

2. Delivery in the transition state
At the measuring junction, the U state is formed relatively quickly. In the temperature gradient a creeping transition into the K state occurs and at the cold end a local transition from the K state to the transition state is formed as an additional source of errors.

3. Delivery in the K state
At the measuring junction the U state develops very quickly. In the temperature gradient and at the cold end, nothing happens as the K state is already present everywhere here, i.e. this mode of delivery offers immediate stable and reliable temperature indication.

How are mineral insulated thermocouples tested?

For a reliable e.m.f. test, the samples are transferred to the K state. If this is not done, the effects shown above for the first two delivery modes occur during calibration.

When can reliable temperature measurement be expected?

Reliable temperature measurement which also corresponds to the e.m.f. determined in the test can only be expected if the mineral insulated thermocouples are delivered in the stable K state. Therefore, mineral insulated thermocouples should only be delivered in the stable K state.

SENSYCON is the only manufacturer to apply expensive second final annealing which ensures that all cables are delivered in the stable K state.

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Standard Sheath Materials

Mineral Insulated Cables

Mineral insulated thermocouples can be manufactured from all ductile sheath materials, especially from the full range of austenitic stainless steels. Nickel-alloy materials can also be used for certain applications. Special sheath materials can also be supplied.

Max. operating temperature	Sheath material	**Material properties**	**Applications**
800 °C	1.4301 **AISI 304** 1.4306 **AISI 304 L**	Materials 1.4301 and 1.4306 have different low carbon contents and differ, in particular, in their resistance to intercrystalline corrosion. Good resistance to organic acids at moderate temperatures, saline solutions, such as sulphates, sulphides and sulphites, and alkaline solutions at moderate temperatures. Good welding properties. Welding retreatment is generally not necessary, in particular with 1.4306.	Chemical apparatus engineering, nuclear power, textile and paper industry, grease and soap industry, food processing industry, dairies and breweries, nitric acid industry.
800 °C	1.4404 **AISI 316 L**	As a result of the addition of molybdenum, this material has higher corrosion resistance in non-oxidizing acids such as ethanolic acid, tartaric acid, phosphoric acid, sulphuric acid and others. Increased pitting resistance. Good welding properties. Heat treatment is generally not necessary.	Sulphite, pulp, textile, dyeing, fatty acid, soap and pharmaceutical industries.
800 °C	1.4541 **AISI 321**	Good resistance to intercrystalline corrosion, also after welding. Good resistance to heavy oil products, steam and exhaust gases. Good oxidation resistance. Can be used continuously up to approximately 800 °C. Good welding properties in all standard welding processes without the need for welding retreatment. Good ductility.	Nuclear power and reactor construction, chemical apparatus engineering, annealing furnaces, heat exchangers, paper and textile industry, petrochemical and crude oil industry, grease and soap industry, food processing industry.
800 °C	1.4571 **AISI 316 TI**	Increased resistance against corrosion from certain acids due to the addition of molybdenum. Resistant against pitting, salt water and aggressive industrial influences. Can be used continuously up to approximately 800 °C. Good welding properties in all standard welding processes without the need for welding retreatment. Good ductility.	Nuclear power and reactor construction, chemical apparatus engineering, furnace construction, chemical and pharmaceutical industries.
1150 °C	1.4749 **AISI 446**	Extremely good resistance to reducing, sulphurous atmospheres. Very good resistance to oxidation and air. Good resistance to corrosion caused by incinerator slag and copper, lead and tin smelts. Good welding properties in arc welding and WIG welding. Preheating to 200 - 400 °C is recommended. Retreatment is not necessary.	Petrochemical industry, metallurgy, power technology, recuperators, heat treatment kilns, vortex firing installations, waste incinerators.

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Max. operating temperature	**Sheath material**	Material properties	**Applications**
1150 °C	1.4841 **AISI 314**	Excellent resistance to corrosion, also at high temperatures. Also suitable in atmospheres containing carbon and sulphur. Resistant to oxidation in air up to 1000 °C (interrupted service) or 1150 °C (continuous service) . Well suited with high thermal cycling. Recommended for long-term continuous use in the temperature range from 425 to 850 °C. Good welding properties in arc welding processes. Thermal retreatment is not necessary. The material has good ductility on delivery. After a long period of use, however, the material can become slightly brittle.	Boilers and blast furnaces, cement and brick kilns, glass production, crude oil and petrochemical industries, furnace construction and power stations.
1100 °C	1.4845 **AISI 310 S**	Good resistance to oxidation and sulphidisation. Due to the high content of chromium, the material is resistant to oxidizing hydrous solutions and has good resistance to chlorine-induced tension crack corrosion. Good resistance in cyanide smelts and neutral salt melts at high temperatures. Not susceptible to green mould. Good welding properties. It is recommended to weld with low heat impact. Apply solution annealing after welding to avoid the danger of intercrystalline corrosion.	As 1.4841
1100 °C in air	1.4876 **Incoloy 800** ™ *	This material provides superior thermal stability due to the addition of titanium and aluminium. Suitable for applications requiring maximum stability under load in addition to scaling resistance. Excellent resistance to carburisation and nitrogenisation. The material has good welding properties in arc and WIG welding processes. Heat treatment is not necessary after welding.	Power stations, crude oil and petrochemical industries, furnace construction.
1100 °C	2.4816 **Inconel 600** ™ *	Good general resistance to corrosion, resistant to tension crack corrosion. Excellent resistance to oxidation. Not recommended with gases containing CO_2 and sulphur above 550 °C and sodium above 750 °C. In air, resistant up to 1100 °C. Good welding properties for all types of welding processes. Excellent ductility even after long-term use.	PWR, nuclear power, furnace construction, plastics industry, heat treatment, paper and food processing industries, boilers, aircraft engines.
1100 °C	2.4951 **Nimonic 75** ™ *	Excellent high-temperature stability and resistance to oxidation and carburisation. Due to the combination of nickel and chromium, the material has very good resistance to hot, gaseous media. Resistance to thermal fatigue and thermal shock. Good welding properties for all types of welding processes. Excellent ductility even after long-term use.	Space travel, aircraft construction, nuclear reactors, mechanical engineering, metal working, thermal materials processing.
1300 °C	Pt 10 % Rh	High-temperature resistance up to 1300 °C under oxidizing conditions. High heat resistance up to 1200 °C in the presence of oxygen, sulphur and silicon. Especially resistant to halogens, ethanolic acids, NaHCl-solutions, etc. Can become brittle through the absorption of silicon from armouring ceramics. Sulphur eutectics possible at temperatures over 1000 °C. Sensitive to phosphorus.	Glass, electrochemical and catalytic technology, chemical industry, laboratories, melting and annealing furnaces and other furnaces, final storage of nuclear power products.

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Mineral Insulated Thermocouple Cables

Type		K (NiCr-Ni)		J (Fe-CuNi)		L (Fe-CuNi)		E (NiCr-CuNi)		N (NiCrSi-NiSi)		T (Cu-CuNi)	
Sheath material	∅ mm	1 TP	2 TP	1 TP	2 TP	1 TP	2 TP	1 TP	2 TP	1 TP	2 TP	1 TP	2 TP
1.4301 AISI 304	3.0								7963328				
	4.5		7963404										
	6.0	7963532	7963441						7963359				
1.4306 AISI 304 L	4.5		7963502										
1.4404 AISI 316 L	1.5	7963424											
	2.0	7963416											
	3.2	7963473											
	6.0	7963425	7963426										
1.4541 AISI 321	1.0			7961457		7963301		7960340				7963371	
	1.5	**7960336**		**7960376**								7963304	
	2.0			**7960377**	7960384	7963321							
	2.4	7963341											
	3.0	**7960351**	**7960352**	**7960379**	7960385	**7960347**	7960348	7960391				7960388	
	4.0			**7960383**		7960360							
	4.5	**7960353**	7961453	7961460	7963347	7963349	7963348	7963498	7963499			7963346	
	4.8	7963526											
	6.0	**7960354**	7960355	**7960381**	**7960387**	**7960349**	7960350	7963360	7963450			**7960390**	7963517
	6.35								7963403				
	9.5				7963475								
1.4571 AISI 316 TI	1.0	**7960312**		**7963494**		**7960308**						**7963386**	
	1.5	7960313		**7963307**	7963524	**7960309**		7963306				7963308	
	1.6	**7961469**											
	2.0	**7963490**				7963449							
	3.0	**7960314**	**7960315**	7961458	7963525	7960310	7963330	7963331				7960389	
	3.2	**7960361**	7963535									7963461	
	4.5	7963467	7963351	7961461		7963353	7963352						
	4.8	7960372	7963438										
	6.0	7960316	**7960317**	**7960382**	7963436		7960311						7963365
	6.4	7960373	7963519										
	8.0	**7960318**	7963397										
1.4749 AISI 449	1.5	7963309									7963446		
	3.0	7963332									7963333		
	6.0	7963367	7963366							7963448	7963447		
	12.7	7963329											
Double sheath	12.7	**7963311**											
1.4841 AISI 314	1.0	**7960358**											
	1.5	**7960345**											
	2.0	7963410											
	3.0	**7960346**	**7960341**										
	4.0	7961452	**7960342**										
	4.5	7963355											
	6.0	**7960337**	7960356										
	8.0	7963378											

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Mineral Insulated Thermocouple Cables

Type		K (NiCr-Ni)		J (Fe-CuNi)		L (Fe-CuNi)		E (NiCr-CuNi)		N (NiCrSi-NiSi)		T (Cu-CuNi)	
Sheath material	∅ mm	1 TP	2 TP	1 TP	2 TP	1 TP	2 TP	1 TP	2 TP	1 TP	2 TP	1 TP	2 TP
1.4845 AISI 310 S	3.0	**7960368**											
	4.5	7960369											
	6.0	**7960370**	7960371										
1.4876 Incoloy 800™	1.5	7963310											
	1.8	7963316											
	3.0	**7960357**	7963413										
	4.5	7963395											
	6.0	**7960344**	7963368			**7963369**							
	8.0	7963379	7963419										
	9.5	7963523	7963444										
	10.0	7963382	7961454										
	12.0	7963383											
1.4893	3.0										7963442		
2.4816 Inconel 600™	0.25	7963538											
	0.5	**7960325**											
	0.8	7963539											
	1.0	**7960326**		7963303		7960359				7963302			
	1.5	**7960327**	7960362	7960375	7963305	7960319	7963312			7960364			
	1.6	**7960338**		7963315									
	2.0	**7960339**	**7963325**	7963417			7963324						
	2.3	**7963396**											
	2.5	7963326											
	3.0	**7960328**	**7960329**	7960378	7961462	**7960320**	7963340	**7963431**	7963339	7960365	7963336		
	3.2	**7960343**	7963536							7963527			
	4.5	**7960330**	**7960331**	7961459	7963439	7960321	7960322			7960572	7963356		
Double sheath	4.5	7963433											
	4.8	**7961455**											
	6.0	**7960332**	**7960333**	**7960380**	**7960386**	7960323	7960324	7963375	7960586	7960366	7963372		
	6.4	**7960363**	7960367										
Double sheath	6.5	7963509	7963492										
	7.8	7963455	7963456			7963377							
	8.0	**7960334**	**7960335**	7963430		7963380				7963381			
	9.0		7963334										
	9.5	7963454	7963453										
2.4951 Nimonic 75™	1.8	7963317											
	3.0	7963342											
Double sheath	3.0	7963412											
Double sheath	6.0	7963435											
	8.0	7963489											
	10.0	7963443											

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Mineral Insulated Cables

Con-ductors	Ø mm	Material			
		1.4404	1.4541	1.4571	2.4816
2 x Cu	1.50		7963414		
	1.60		7963313	7963314	
	2.00		7963320		
	3.00		**7960400**	7961464	
	4.50			7963496	
	4.78	7963415		7963521	
	6.00		**7960401**	**7960395**	
3 x Cu	1.60			7963459	
	2.00		7963319		
	3.00				7963338
	4.78	7963471		**7961467**	
4 x Cu	1.00 S		7963506		
	1.30 S		7963507		
	2.00		7963318		
	2.80		7963389		
	3.00		**7960399**	**7960396**	7963337
	4.00		7963343	7963344	
	4.50	7963357	7963350	**7960404**	
	4.78	7963460		7961468	
	4.80		7963387		
	5.00		7963385	7963358	
	5.00 S		7963495		
	6.00		**7960402**	**7960397**	7963373
	6.00 S		7963364		
	6.40			7960588	
	8.00			7963451	
6 x Cu	4.50			7963409	
	4.80		7963388		
	5.00		7963508	7963502	
	6.00		**7960403**	7961465	
	6.00 S		7963491		
	8.00			7963362	

Mineral Insulated Cables

Con-ductors	Ø mm	Material			
		1.4404	1.4541	1.4571	2.4816
8 x Cu	3.00			7963539	
	6.00		7963420		
3 x CuNi	6.00		7963402		
4 x CuNi	6.00		7963280		
6 x CuNi	6.00		7963281		
2 x Ni	3.00		7963354		
3 x Ni	2.40			7963411	
	3.00		7963501		
	4.50	7963466			
	6.00	7963408			
4 x Ni	3.20 S			7963398	
	3.50 S	7963445			
	4.50			7963695	
	4.80 S		7963694	7963399	
	6.00	7963465			
	6.40 S			7963400	
	8.00			7963401	
6 x Ni	6.00	7963423			
2 x NiCr	2.50				7963327
	3.00		7961463		
	6.00		7963361		
4 x NiCr	2.00				7963323
	3.00		7960392	7963468	
	4.50		7963345		
	6.00		7960393	7963469	
	6.00 S		**7961466**		
6 x NiCr	6.00		**7960394**	7963470	
	8.00		7963457		
8 x NiCr	6.00		7960398		
2 x 2.4816	6.00				7963374

S = Special manufacture

SensyMIC – Mineral Insulated Cables

Mineral Insulated Thermocouple Cables with Precious Metal Thermocouples

Precious metal thermocouples are exceptionally suited for high-temperature applications under oxidizing conditions. They are used in chemical plants when absolute resistance to all kinds of acids is required.

Resistance of Precious Metal Mineral Insulated Thermocouples in different Atmospheres

Sheath material	Thermo-couple	Max. operating temperature	Oxygen	Nitrogen	Hydrogen	Carbon	Chlorine	Sulphur	Class of tolerance
2.4816	Type S	1100 °C *	good	good	good	good	good	condi-tional	2
	Type R	1100 °C *	good	good	good	good	good	condi-tional	2
	Type B	1100 °C *	good	good	good	good	good	condi-tional	3
Pt10%Rh	Type S	1300 °C *	good	good	conditional	conditional	conditional	condi-tional	2
	Type R	1300 °C *	good	good	conditional	conditional	conditional	condi-tional	2
	Type B	1300 °C *	good	good	conditional	conditional	conditional	condi-tional	3

* Because of the drift behaviour at high temperatures, the recommended maximum temperature is 900 °C.

Application

When using precious metal thermocouples, it is necessary to be aware that the insulation resistance of the insulation ceramics used decreases very much at high temperatures (over 1000 °C). If big lengths of the sheath material are exposed to high temperatures, measuring errors can occur as a result of a mean value being taken over the installation length.

Standard Type

The standard mineral insulated cables have a 2.4816 sheath with diameter 1.5 mm and 3.0 mm in type S and diameter 1.6 mm and 3.2 mm in type R.

Product nos.

S 1.5	2.4816	7960435
S 3.0	2.4816	7960436
R 1.6	2.4816	7960456
R 3.2	2.4816	7960463

Mineral insulated cables with a Pt10%Rh sheath are available in type S with diameter 1.5 mm and 3.0 mm and in type R in 1.6 mm ex stock.

Product nos.

S 1.5	Pt10%Rh	7960445
S 3.0	Pt10%Rh	7960446
R 1.6	Pt10%Rh	7960459

Special Manufacture

Special manufactures are always possible in other dimensions on request. Sheath materials with other PtRh - alloys can be supplied.

The minimum production length is 1.5 m.
The following table provides an overview of the maximum production lengths of the most popular dimensions.
Bigger lengths are possible in special cases on request.

Maximum Production Lengths

Sheath	TP	∅ 1.0 mm	∅ 1.5 mm	∅ 1.6 mm	∅ 2.0 mm	∅ 3.0 mm	∅ 3.2 mm	∅ 4.5 mm	∅ 4.8 mm	∅ 6.0 mm	∅ 6.4 mm
Pt10%Rh	1 × S	20 m	20 m	18 m	9 m	6 m	5 m	6 m	5 m	3 m	
	2 × S	20 m	20 m	18 m	9 m	6 m	5 m	6 m	5 m	3 m	
	1 × R	20 m	20 m	18 m	9 m	6 m	5 m	6 m	5 m	3 m	
	2 × R	20 m	20 m	18 m	9 m	6 m	5 m	6 m	5 m	3 m	
2.4816	1 × S	35 m	310 m	265 m	155 m	90 m	80 m	18 m	7 m	10 m	8.5 m
	2 × S		14 m	265 m	155 m	90 m	80 m	18 m	7 m	10 m	8.5 m
	1 × R	35 m	14 m	265 m	155 m	90 m	80 m	18 m	7 m	10 m	8.5 m
	2 × R		14 m	265 m	155 m	90 m	80 m	18 m	7 m	10 m	8.5 m

SensyHeat – Heaters

SensyHeat

SensyHeat Mineral Insulated Heating Cable is an electrical metal sheath heating cable with high economic efficiency (specific heating capacity up to 300 W/m). It is the most rugged and durable type of heating cable. Mineral Insulated Heating Cable is applicable for operation in high temperatures and explosion-proof areas. It can have a very high watt output and is used for process heating applications at temperatures where plastics insulated heating cables are not suitable. When properly installed, it has a very high lifetime.

Mineral Insulated Heaters are applicable in the following industries:
Machinery, power generating industry, chemical and petrochemical industry as well as research and development.

Resistance Wire	Sheath Material	Operating Temperature up to
NiCr alloy CuNi alloy	2.4816 (Inconel) 1.4541 (AISI 321)	800 °C 500 °C

Technical Data – Standard program

Outer ∅ mm	Resistance at 20 °C Ω/m	Conductor ∅ mm	Wall thickness mm	Length m
Conductors NiCr 8020, applicable for temperatures up to 800 °C				
3.2	10.00	0.38	0.34	100
3.2	6.30	0.48	0.34	360
3.2	4.00	0.61	0.34	360
3.6	2.50	0.77	0.38	270
3.8	1.60	0.96	0.40	240
4.1	1.00	1.21	0.43	200
4.5	0.63	1.52	0.48	170
5.0	0.40	1.91	0.53	140
5.6	0.25	2.42	0.59	110
6.5	0.16	3.03	0.69	80
Conductors CuNi, applicable for temperatures up to 500 °C				
3.5	1.3	0.70	0.37	280
3.7	0.8	0.88	0.39	250
4.0	0.5	1.12	0.42	220
4.4	0.3	1.44	0.47	180
4.9	0.2	1.77	0.52	150
5.8	0.1	2.50	0.61	100

Tolerance for the resistance per m: ± 10 %
Tolerance for the outer diameter: according to DIN EN 61515

In order to assure a sufficient electrical strength between conductor and sheath, the insulation thickness is specified with 1.0 mm for all types of the standard program.