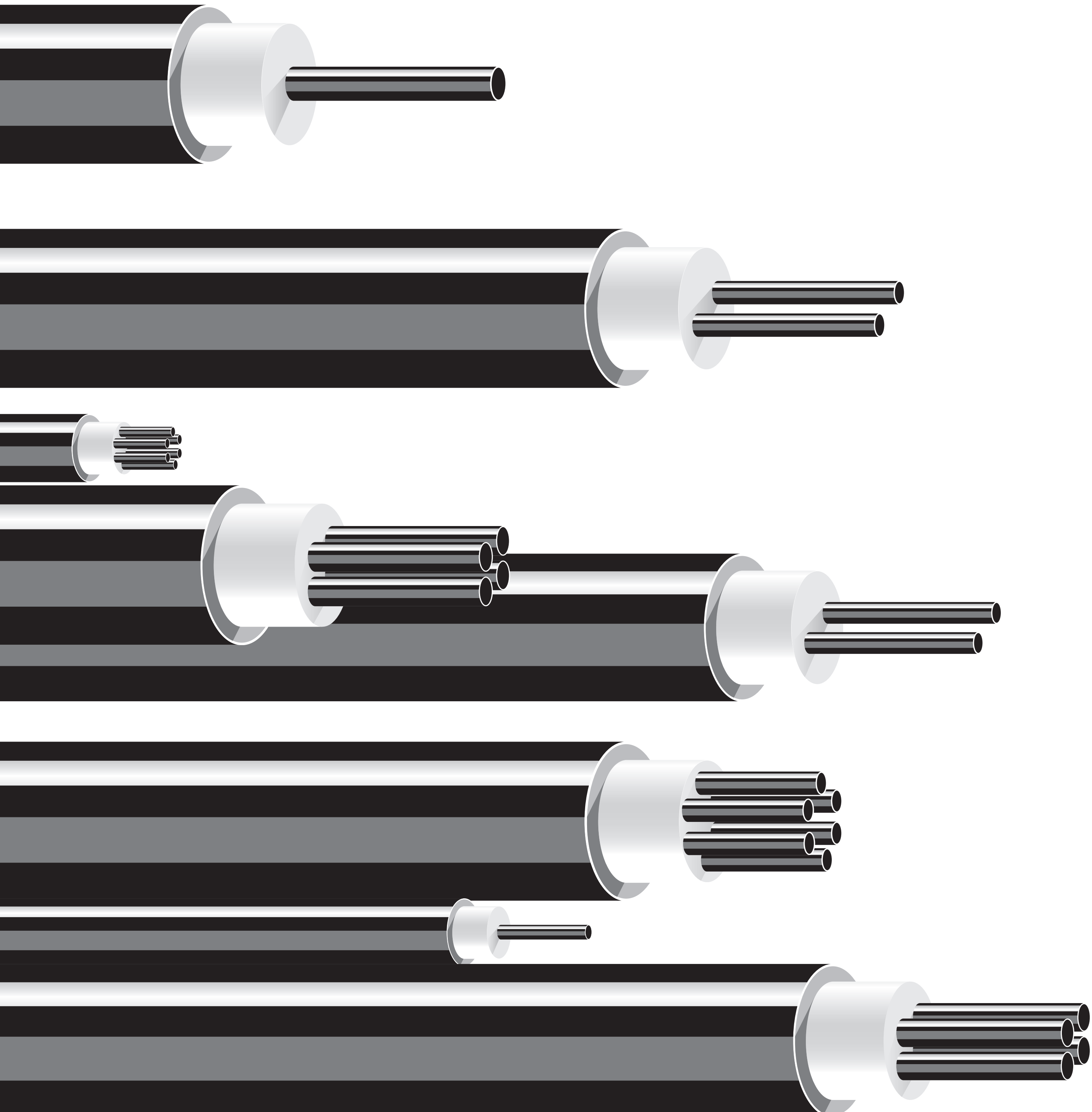
ISOMIL®

MINERAL INSULATED CABLES



MIL GmbH


Norbert Baumann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World-wide increasing precision, reliability, and safety requirements in Temperature, Control and Measurement Engineering can no longer be satisfied by conventional cables causing a rising need for mineral insulated lines. Applications cover everything from the simple building of furnaces to the production of nuclear power plants.

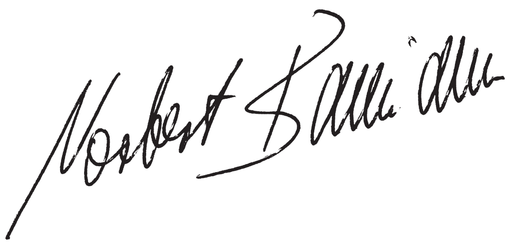
Our product catalogue will guide you through a selection of state-of-the-art mineral insulated thermocouples and heating cables. We can offer thereby 35 years of experience.

The close collaboration with leading customers - world-wide - is the guarantor for a broadly varied offer, with a maximum flexibility and highest reliability. Our head office is in the city of Hanau, Germany. From here we service our national and international customers.

The MiL GmbH is both a manufacturer and a service provider. We offer to our customers everything from professional consultation to custom-made products.

Yours sincerely

Norbert Baumann



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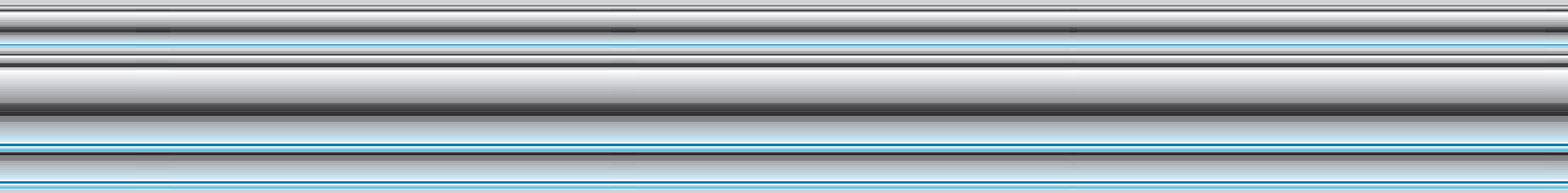
CONTENTS



ISOMIL - T

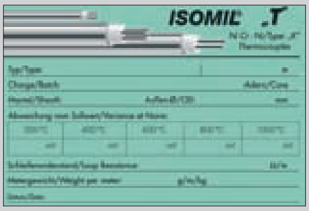
Mineral Insulated
Thermocouple Cables

The construction of a mineral insulated cable is as follows: - one or more wire-like conductors (cores) are embedded in a high insulation quality mineral powder and pressed into a metal tube (sheath) made of oxidation and corrosion resistant material. The entire material combination is then processed using suitable forming steps to obtain the final dimensions.

These mineral insulated cables are available under the name ISOMIL®.
There are two groups:

ISOMIL-T
Mineral Insulated Cables

ISOMIL-M
Mineral Insulated
Measurement Cables



Label sample for a finished cable coil of ISOMIL-T

The inner conductors consist of one or more thermocouples for temperature measurement. There, we are dealing with a sheathed thermocouple conductor. The compensation conductor which extends the thermocouple from the point of connection to the reference junction can also be insulated in the same manner.

In ISOMIL-T the thermoelectric voltages of the thermocouples are in accordance with the basic standard values within the usual tolerance range. For NiCr-Ni the basic values of the thermoelectric voltage are identical in the German and international standards. For both Fe-CuNi (Thermoiron-Thermoconstantan) and Cu-CuNi (Thermocopper-Thermoconstantan) they differ. These thermocouples are available in ISOMIL-T in accordance with the German Standard Norm DIN 43710 and with the International Thermoelectric Voltage Series (IEC 584).

The limit deviation of the thermocouple voltage is available according the following norm:

• DIN IEC 584-2

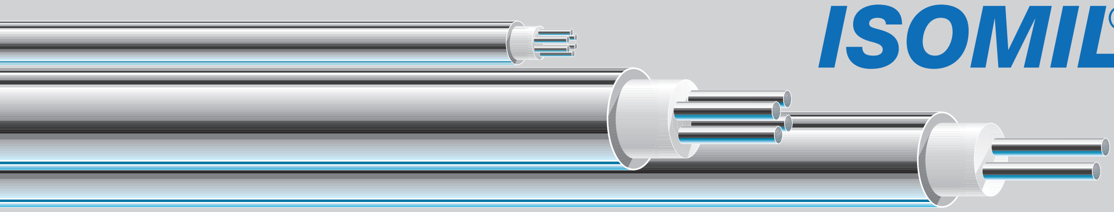
• ASTM E 230-93 / ANSI.MC.96.1

Other norms, e.g. GOST on request.

Type denotation ISOMIL-T

Example: The type Denotation 2K2A30 designates a cable coil with 2 cores, inner conductors made of NiCrNi, insulation made of MgO (≥ 97%), the sheath material 1.4541 and an outer diameter of 3 mm.

Number of conductors	Inner conductor	Insulation	Sheath material	Outer diameter (1/10 mm)
2 2 cores	**K** NiCrNi	**1** $Al^{2}O^{3}$ (97%)	**A** 1.4541	
4 4 cores	**E** NiCr-CuNi	**2** MgO (≥ 97%)	**F** 1.4571	
6 6 cores	**J** Fe-CuNi	**3** MgO (99,4%)	**L** 2.4816	
8 8 cores	**T** Cu-CuNi		**C** 2.4851	
	U Cu-CuNi		**G** 2.4858	
	S PtRh10%-Rh		**P** 2.4951	
	R PtRh13%-Rh		**Q** 1.4845	
	N Nicrosil-Nisil		**R** 1.4301	
			S 1.4404	
			X 1.4876	
			NC IncothermTG	



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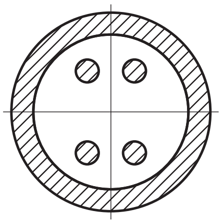
The inner conductor is generally a low resistive wire (in some cases several wires) which transmits the electrical signal. Conductors of this type are used in measurement and control techniques and thus referred to as sheathed measurement conductors.

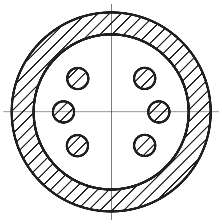
Type denotation ISOMIL-M

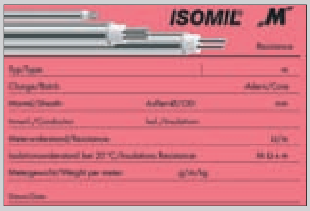
Example: The type Denotation 2C2A60 designates a cable coil with 2 cores, inner conductors made of cooper, insulation made of MgO (97%), the sheath material 1.4541 and an outer diameter of 6 mm.

Number of conductors	Inner conductor	Insulation	Sheath material	Outer diameter (1/10 mm)
1 1 core	**C** Cooper	**1** $Al^{2}O^{3}$ (97%)	**A** 1.4541	
2 2 cores	**Ni** Nickel	**2** MgO (97%)	**F** 1.4571	
4 4 cores	**CN** Cooper-Nickel	**3** MgO (99,4%)	**L** 2.4816	
6 6 cores	**CNi** Nickel plated copper		**P** 2.4951	
			Q 1.4845	
			R 1.4301	
			S 1.4404	
			X further Qualities	

Further types are available on request e.g. „wide space".





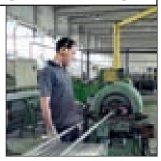


Label sample for a finished cable coil of ISOMIL-M

Processing of Mineral Insulated Cables

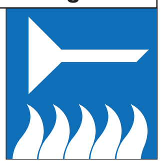
See the individual steps from the raw material to the finished product.

Swaging & Rolling



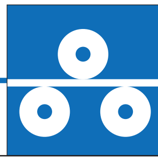
Swaging is the optimum forming method for certain types of our mineral insulated cables, naturally special equipment must be employed. The inner conductors are best protected when processed on a continuous calibre mill. However, the tolerances generally required for the sheath wall limit the use of this method to a few special designs.

Hot filling

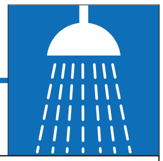


To avoid humidity being absorbed by the hygroscopic insulation material the components are dried thoroughly and filled at an elevated temperature.

Drying



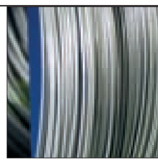
Straightening



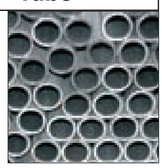
Cleaning

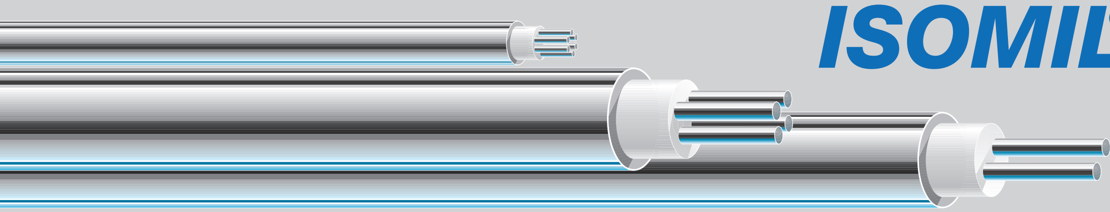
Insulation material

Wire



Tube





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The production of a flawless mineral insulated cable right down to the smallest dimensions requires a considerable number of intermediate annealing processes.

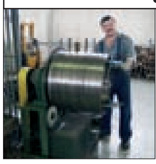
Annealing

Pickling removes all discolouration which occurs in spite of the protective gas used during the annealing process.

Pickling

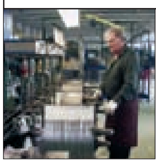
The cross-section of the compound sheath / insulation / conductor can be reduced with hard metal or wire drawing dies like a solid wire. The greatest care and technical know-how are required to establish the correct reduction steps.

Drawing



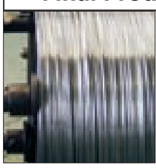
Final annealing is conducted under protective gas in a continuous process to attain a smooth, bright surface.

Final Annealing



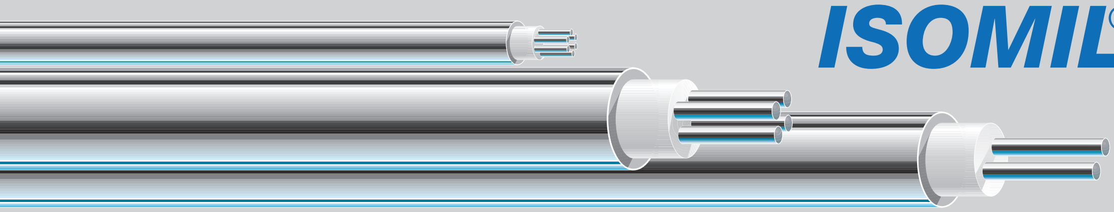
Each drawn batch undergoes quality assurance tests - as cable coils of long length - before dispatch.

Final Product



Properties and Advantages of Mineral Insulated Cables

High Insulation Resistance Conductor / Sheath and Conductor / Conductor	At room temperature and up to the more common application temperatures mineral powder insulates so well that the sheath can be considered to be entirely separated from the inner conductor. Consequently, there are no adverse effects if the conductor touches other metal parts of the equipment or is connected to them.
Long Life	The construction of the cable guarantees a long conductor life and thus the function of the conductor because the sheath and the insulating powder protect the conductors (cores) against environmental conditions such as corrosion or scaling.
Easy Installation	The cables are pliable, easy to handle and can be installed easily in a limited space or in locations where access is difficult. No additional insulation is required.
Mechanical Strength	The compact construction with densely packed mineral powder and the robust metal sheath ensure the position of the conductors in the compound and thus the function of the cable even when exposed to mechanical stresses such as bending, twisting or flattening. The cable can also be used in pressure or vacuum equipment.
Safety	Since the insulation is attained exclusively from powders on a mineral base the cables are fire-proof and can thus be exposed to considerably higher temperatures than cables with synthetic sheaths (e.g. PVC, teflon or textile fibres etc.).
Rapid Response	The high density of the mineral powder effects rapid transmission of heat between conductor and sheath: This factor makes the cable highly suitable for temperature measurement and control techniques.



Dielectric Strength

Despite its small size the compact construction allows an amazingly high dielectric strength conductor/conductor or conductor/sheath, respectively, which means the cables can be used in power supply systems at 220 V and above.

Radiation Resistance

The correct choice of component ensures radiation resistance making possible the use of these cables in primary circuits as well as in the incore area, i.e. inside the actual reactor core.

Corrosion and Scaling Resistance

The vast array of materials included in our standard programme and the possibility to make materials to specification has put us in a position to supply suitable sheath materials even for unfavourable environmental conditions in a corrosive atmosphere and at high temperatures. Depending on the choice of component the maximum application temperatures are between 500°C and 1000°C.

Long Lengths

Long lengths of cable can be obtained due to the initial measurements before drawing and the production method.

Small Cable Diameter

The relatively small diameter (compared with conventional cables) which is a result of the construction has many advantages for both customer and construction engineer.

Components and Common Properties

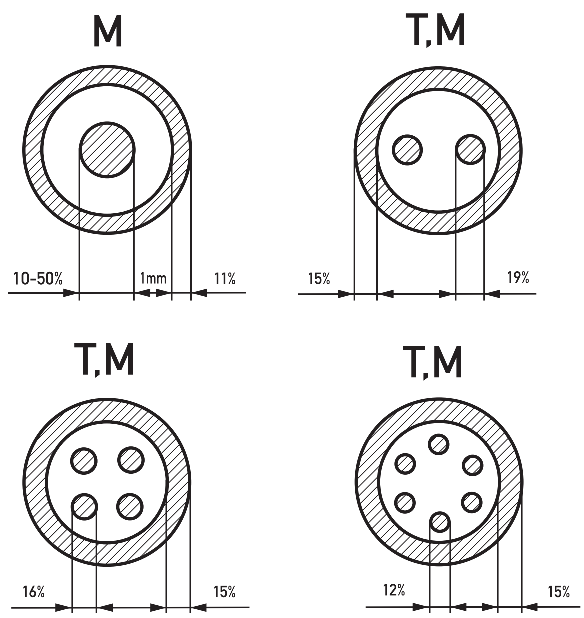
Construction of the Cable

The conductor or conductors are embedded in high density mineral powder which is hermetically sealed by a metal sheath. Dimensioning, namely the ratio of wall thickness, insulation layer thickness and conductor diameter, is of significance for the electrical and mechanical properties. Consequently, in the following we present cross-sections of a number of our standard cables as well as some of those made to customer specifications.

Standard Production

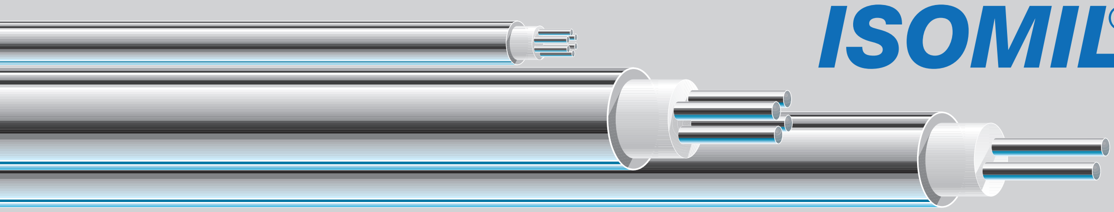
The more common cables have diameters between 0.5 and 10 mm. The choice of diameter is primarily determined by the requirements of the technical application in question.

Some Examples



The construction of several standard cables of ISOMIL-T, -M cross sections.

Not all our stock can be supplied in maximum production lengths. When ordering please state the required minimum length, e.g. „1500 m in lengths not under 70 m“.



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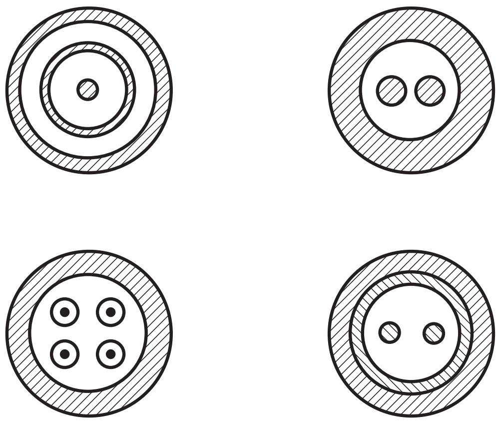
Special orders are accepted in appropriate amounts. These special requests can be deviations from the standard production such as dimensions (sheath thickness, insulation thickness, conductor diameter), the number and design of the conductors, the material combination sheath / insulation / inner conductor or special electrical or other physical properties.

As a general rule, special orders are more involved and have as prerequisites a minimum production quantity; in some cases trial runs are required to clarify the position. Moreover the acquisition of materials which are not in stock must be considered.

Discussions with the customers prior to ordering are essential.



Examples of customer specials

Protection against the absorption of humidity

The insulation materials are so highly hygroscopic that the mineral powder when exposed through an open end can absorb so much moisture from the atmosphere in a few minutes that the insulation voltage conductor / conductor or conductor / sheath drops by several orders of magnitude.

Consequently, it is vital that the cable ends are kept hermetically sealed at all times, i.e. not only during production but also during further processing and usage. On dispatch both cable ends are moisture sealed with plastic, whereby the inner conductor/conductors are led out so that the insulation voltage can be checked at all times.

However, should moisture penetrate the cable in spite of all the preventive measures, it can be forced out by heating the cable end concerned e.g. with a flame, from the middle to the end. Experience shows that even in a cable which has lain open for several days the moisture does not penetrate more than 50 cm of the cable. It follows that if a cable end lies open over a shorter period then the penetration depth of the humidity is correspondingly less, e.g. a few cms. When drying out the reduction in humidity increases with rising temperature - at 450°C suddenly (MgO). It follows that heating above 500°C has no noteworthy advantages.

Insulation Materials and Dielectric Strength

Insulation Material

Typical Composition of the Standard Quality MgO and the High Purity Qualities MgO and Al_2O_3.

	MgO (97%) (Standard)	MgO (High Purity)	Al_2O_3 (High Purity)
MgO	>97,0	>99,4	0,08
Al_2O_3	0,15	0,019	99,8
CaO	0,7	0,02	0,004
Fe_2O_3	0,09	0,018	0,009
$5iO2_2$	2,0	0,02	0,08
B, Cd, S	<10 ppm	<10 ppm	<10 ppm
C *	10 ppm	50 ppm	20 ppm

*) can be reduced further if necessary (exposure to radiation) before use.

Physical Properties of Insulation Materials:

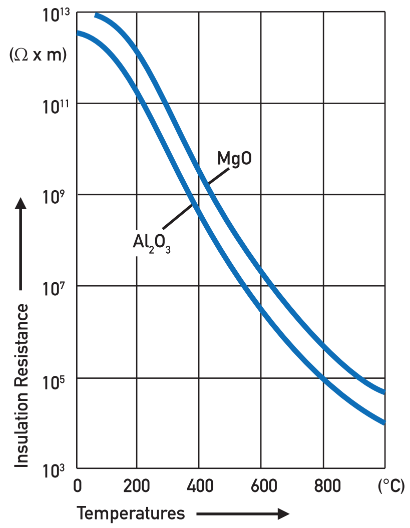
	MgO	Al_2O_3	Unit
Density (crystal)	3,65	3,98	g/cm³
Density in MIC	3,0	2,9	g/cm³
Melting Point	2800	3000	°C
Specific Heat (20-300°C)	1,03	0,95	J/gK
Coefficient of Exp. 20-200°C	11,3	6,55	10^{-6}/K
Coefficient of Exp. 20-600°C	13,2	7,62	10^{-6}/K
Resistivity 20°C	$5x10^{16}$	$1x10^{14}$	Ω x m
Resistivity 400°C	$1x10^{13}$	$1x10^{12}$	Ω x m
Resistivity 800°C	$5x10^{8}$	$2x10^{8}$	Ω x m
Dielectric Constant 20°C	5	9	-
Knoop Hardness	3700	21000	N/mm²
Modulus of Elasticity 20°C	$3x10^{5}$	$3,6x10^{5}$	N/mm²

Insulation Resistance

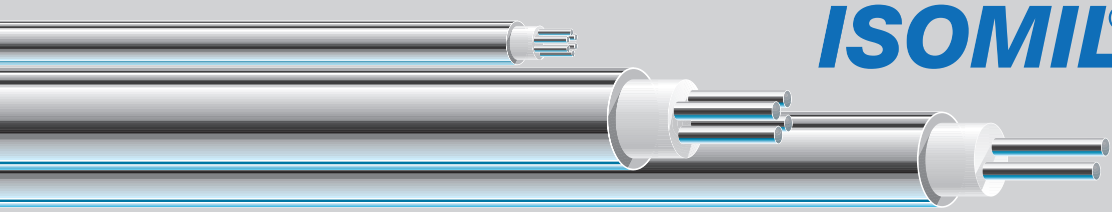
The two figures show typical curves for the insulation resistance.

DC Voltage

For both mineral insulated thermocouples and mineral insulated heating cables the standards (e.g. DIN 43721, ASTM E 420/71, VDE 0284) lay down dc measurements. Since polarization currents are accompanied by a time dependent increase of the insulation resistance after applying dc voltage, the measurement value is read off after 60 ± 3s.



Insulation resistance of ISOMIL measured with 20V DC.



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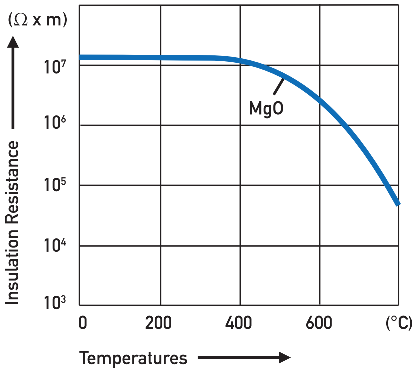
AC Voltage



Insulation resistance of ISOMIL measured with 500V ~ AC / 50Hz.

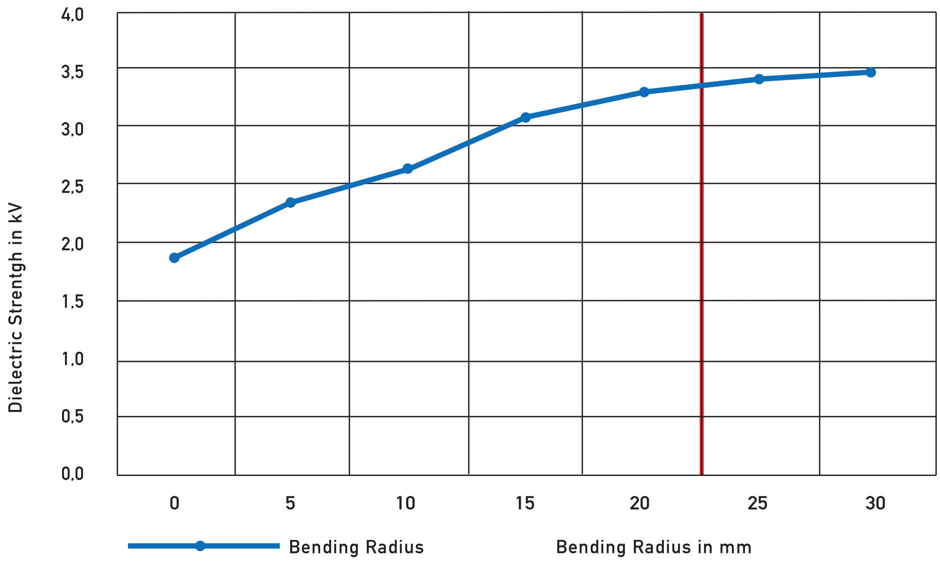
The displacement currents lead to considerably lower insulation resistances especially in the temperature range below 600°C. When considering an FI switch as a protective measure, the above must be given careful consideration when designing the circuitry in equipment with mineral insulated heating cables.

Dielectric Strength - Bending Radius

Mineral insulated cables can easily be wound into a spiral. The minimum bending radius varies according to the width of the sheath and is three to five fold the outer diameter.

Bending causes a reduction in density in the insulation material under the outer edge of the sheath, this reduction increases the smaller the bending radius. The associated reduction in dielectric strength conductor/sheath is of significance especially for ISOMIL-H.

ISOMIL-H in spiral form



Dielectric strength as a function of bending radius-measured on ISOMIL-H at alternating voltage (50 Hz).

Measurements have shown that the dielectric strength is virtually temperature independent up to 800°C.

Sheath Materials

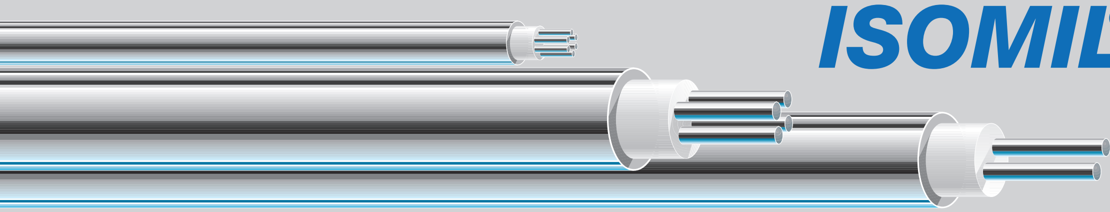
Supply and demand on the mineral insulated cable market comprise a vast array of sheath qualities with the main emphasis on materials suitable for certain applications and those with a historical basis. To limit this choice to an acceptable range as far as production and stock are concerned we are obliged, in particular with high grade stainless steels, to carry out a selective process for our standard production programme . A number of other sheath material qualities are available, and can be used for customer specials.

The following table and explanations are intended as an aid. By comparing the qualities available the customer is in a position to select the most suitable sheath material for his own purpose from the ISOMIL qualities available.

Common Sheath Materials

Material Designation / short description - Standards

Material No.	Short Description	AISI (USA)	BS (GB)	AFNOR (FR)	UNI (IT)
1.4301	(X5CrNi 18-9)	304	304S	Z6CN 18-09	X5CrNi 1810
1.4306	(X5CrNi 19-11)	304L	304S	Z2CN 18-10	X3CrNi 1811
1.4401	(X5CrNiMo 18-10)	316	316S	Z6CND 17-11	X5CrNi MO1712
1.4404	(X2CrNiMo 18-10)	316L	316S	Z2CND 17-12	X2CrNiMo 1712
1.4541	(X6CrNiTi 18-10)	321	321S	Z6CNT 18-11	X6CrNiTi 1811
1.4550	(X6CrNiNb18-10)		347S	Z6CNNb 18-11	X6CrNiNb 1811
1.4571	(X6CrNiMoTi 17-12-2)	316TI	320 S31	Z6CNDT 17-12	X6CrNiMoTi 1712
1.4845	(X12CrNi 25-21)	310S	310S	Z12CN 25-20	X6CrNi 2521
					ASTM
2.4816	Alloy 600	600		NC15Fe	B163. 166-168
2.4851	Alloy 601	601			
1.4876	Alloy 800	800	NA15	Z10NG32-21	
2.4858	Alloy 825	825	NA16	NFe 32C20DU	
Incotherm TG	Nicromil		3072-3074		
					Roy. Swed.
2.4951	Nimonic 75		HR 203, 504	NC20T	MH. 05



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Composition and Physical Properties
(Composition of Sheath Material wt.-%)

Material No.	Ni	Cr	C max.	Si max.	Mn max.	Fe	Mo*	Others**
1.4301	8,0-10,5	17,0-20,0	0,07	1,0	2,0	Rest		
1.4306	10,0-12,0	18,0-20,0	0,03	1,0	2,0	Rest		
1.4401	10,5-13,5	16,5-18,5	0,07	1,0	2,0	Rest	2,0-2,5	
1.4404	10,0-13,0	16,5-18,5	0,03	1,0	2,0	Rest	2,0-2,5	
1.4541	9,0-12,0	17,0-19,0	0,08	1,0	2,0	Rest		Ti > 5xC
1.4550	9,0-12,0	17,0-19,0	0,08	1,0	2,0	Rest		Nb > 8xC
1.4571	10,5-13,5	16,5-18,5	0,08	1,0	2,0	Rest	2,0-2,5	Ti > 5xC
1.4845	19,0-22,0	24,0-26,0	0,08	1,0	2,0	Rest		N < 0,11
1.4876	30,0-34,0	19,0-23,0	0,12	1,0	2,0	Rest		Ti und Al 0,15-0,60
2.4858	38,0-46,0	19,5-23,5	0,05	0,5	1,0		2,5-3,5	Ti 0,6-1,2 Cu 1,5-3,0
2.4816	>72,0	14,0-17,0	0,15	0,5	1,0	6,0-10,0		
2.4851	58,0-63,0	21,0-25,0	0,10	0,5	1,0			Ti < 0,5 Al 1,0-1,7
Incotherm TG	73,6	22,0		1,4			3,0	
2.4951	Rest	18,0-21,0	0,08-0,15	1,0	1,0	<5,0		Ti 0,2-0,6

*) Molybdenum can be used - depending of the alloy - to improve corrosion resistance to a number of acids and resistance to pitting.

**) Niobium and Titanium bind the carbon (as carbide formers) thus preventing the formation of Cr carbides on the grain boundaries during welding which could lead to embrittlement in the welding zone.

Selection of Suitable Sheath Quality

AISI 321

Corrosion and heat resistance: This material possesses excellent resistance to a number of aggressive media including hot crude oil products, steam and combustion gases. When operated in air it is oxidation resistant up to 900°C and with temperature variation resistant up to 800°C. It is resistant to carbon dioxide up to 650°C.

Welding and mechanical properties: Suitable for all the known welding techniques. It is alloyed with Ti, a carbide former, and is thus resistant to grain disintegration in accordance with DIN 50914. Consequently, irrespective of the cross-section no heat-treatment is required subsequent to welding. The material is highly ductile. Machine-cutting may only be performed with very sharp tools otherwise work hardening of the surface occurs making further processing difficult.

Field of application: Nuclear power (also liquid sodium), reactor instrumentation, construction of chemical instruments (highly resistant), e.g. in the production of acetyl acid and nitric acids, heat exchangers, annealing furnaces, paper and textile industry, crude oil refinement and petrochemistry, fat and soap industry, food processing, dairy and fermentation works.

AISI 316 Ti
AISI 316

Corrosion and heat resistance: Additions of molybdenum make these steels superior to molybdenum-free types as regards increased corrosion resistance to certain acids such as acetic acid, phosphoric acid, sulphuric acid, and other similar acids. Furthermore, these steels are more or less insensitive to pitting corrosion and withstand salt-water and aggressive industrial media. They can be used in continuous operation in air up to approx. 900°C and with temperature variation up to 800°C.

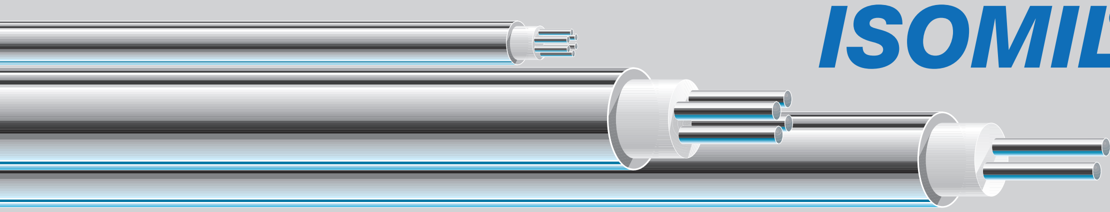
Welding and mechanical properties: Suitable for all the known welding techniques. Heat-treatment subsequent to welding is generally not necessary. In special circumstances when stresses from welding should be reduced to avoid stress-corrosion-cracking heat-treatment should be conducted (e.g. 1/2 h at 900°C). Highly ductile. As with 1.4541 only very sharp tools should be used for machine cutting. The steels can be polished.

Field of application: Due to its high level of resistance to corrosion and pitting corrosion this alloy is ideally suited to applications in the field of chemical instrument construction. Other fields are: nuclear power plants, reactor instrumentation, furnace construction, sulphite, chemical pulp, textile, dye, fatty acid, photochemical and pharmaceutical industries.

AISI 304L

Corrosion and heat resistance: This steel is also highly resistant to a number of aggressive media e.g. crude oil products, steam, combustion gases, colouring agents and liquid sodium. In contrast to alloys such as 1.4301, it is less prone to intercrystalline corrosion due to the lower carbon content. It can be subjected to continuous operation in air up to 900°C and under temperature variation up to 800°C.

Welding and mechanical properties: Suitable for all the known welding techniques. Heat-treatment subsequent to welding is generally not necessary. In special circumstances when stresses from welding should be reduced to avoid stress-corrosion-cracking heat-treatment should be conducted (e.g. 1/2h at 900°C). Highly ductile. As with 1.4541 only very sharp tools should be used for machine-cutting. The steels can be polished.



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Field of application: Nuclear power plants, construction of chemical equipment, textile and paper industry, fat, soap and nitric acid industries, food processing, dairy and brewery works.

AISI 310

Corrosion and heat resistance: Excellent corrosion resistance. Can be operated in an atmosphere with carbon dioxide content up to 900°C. Resistant to concentrated nitric acid at 200°C and molten nitrates up to 420°C. Continuous operation in air up to approx. 1150°C and with temperature variation up to approx. 1000°C. Not recommended - the use of the material in continuous operation between 550°C and 850°C, because the material has a tendency to aphase precipitation and is consequently brittle after cooling to room temperature.

Welding and mechanical properties: Arc-welding techniques are used on this material. Neither pre-heating nor heat-treatment subsequent to welding are required. Perfect for hot and cold working processes. Following hot or cold work heat-treatment is recommended (1050°C - 1100°C, cooling in water or in air). Machine-cutting can be performed providing high quality tools are used and the correct cutting conditions are selected. Hard metal tools are recommended.

Field of application: In all fields where excellent scaling resistance and simultaneous hot tensile strength are of advantage. The high Ni content results in sensitivity to furnace gases with a sulphur content, in particular in reducing atmospheres. Particularly in: nuclear power plants, crude oil and petrochemistry, furnace construction, heat exchangers, air preheaters, cement kilns, brick kilns and glass works.

Inconel 600

Corrosion and heat resistance: Highly resistant to general corrosion and stress-corrosion-cracking. The limit for use in carbon dioxide is around 500°C, as from 650°C corrosion increases drastically. Inconel 600 should not be used in liquid sodium above 750°C because higher temperatures cause material disintegration. Excellent oxidation resistance up to 1150°C. Not for application above 550°C in a S-containing atmosphere. Can be operated in water free of Cl up to 590°C.

Welding and mechanical properties: Suitable for all known welding techniques. Annealing should precede welding. Suitable for brazing and soldering. Very highly ductile. Inconel 600 is a high nickel content alloy thus exhibiting excellent mechanical properties at higher temperatures. The material is soft and robust and facilitates machining-cutting providing it is not machined in the annealed condition but in the rolled condition.

Field of application: Standard material for the construction of PWR plants, nuclear power plants, furnace construction, man-made fibre production, synthetic material production, paper industry, food processing, steam boilers, column stills, aircraft engines.

Comparison of the Standards

Thermoelectric Voltages for temperatures in steps of 100°C
(reference temperature 0°C)

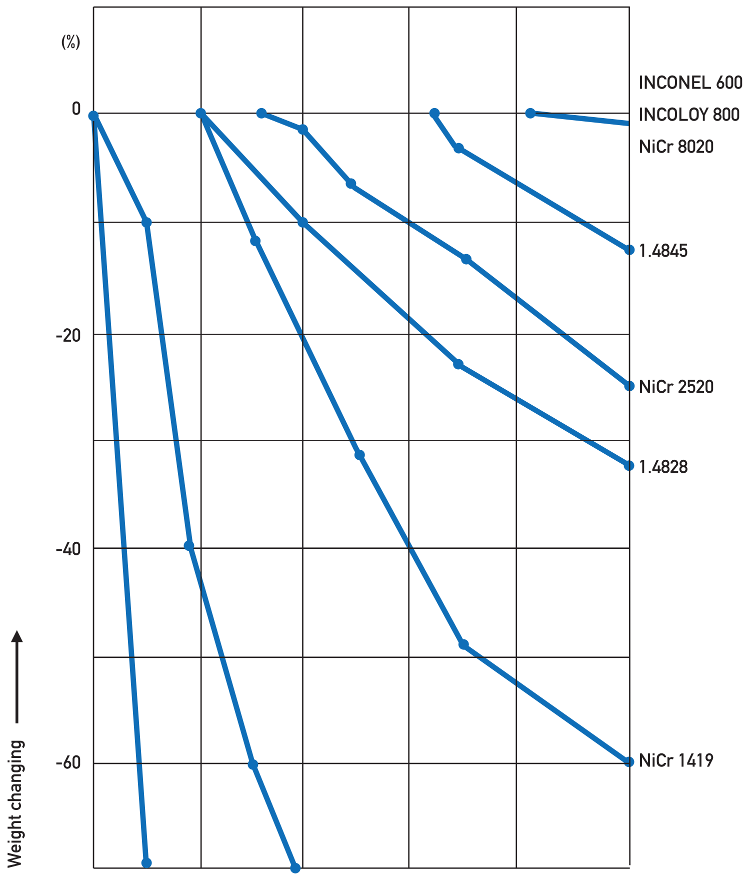
Basic values to:	IEC 584 (BRD)	ASTM E230-93 (USA)*	BS 4937/4 (UK)*	NFC 42-321 (FR)*	GOST (GUS)
Temperature °C	Basic values in mV				
NiCr-Ni					
20	0.798	0.798	0.798	0.798	0.80
100	4.095	4.095	4.095	4.095	4.10
200	8.137	8.137	8.137	8.137	813
300	12.207	12.207	12.207	12.207	1.221
400	16.395	16.395	16.395	16.395	1.640
500	20.640	20.640	20.640	20.640	2.065
600	24.902	24.902	24.902	24.902	24.91
700	29.128	29.128	29.128	29.128	29.15
800	33.277	33.277	33.277	33.277	33.32
900	37.325	37.325	37.325	37.325	37.37
1000	41.269	41.269	41.269	41.269	41.32
1100	45.108	45.108	45.108	45.108	45.16
Fe-CuNi (Typ J)					
20	1.019	1.019	1.019	1.019	
100	5.268	5.268	5.268	5.268	
200	10.777	10.777	10.777	10.777	
300	16.325	16.325	16.325	16.325	
400	21.846	21.846	21.846	21.846	
500	27.388	27.388	27.388	27.388	
600	33.096	33.096	33.096	33.096	
700	39.130	39.130	39.130	39.130	
800	45.498	45.498	45.498	45.498	
Cu-CuNi					
20	0.789	0.789	0.789	0.789	
100	4.277	4.277	4.277	4.277	
200	9.286	9.286	9.286	9.286	
300	14.860	14.860	14.860	14.860	
400	20.869	20.869	20.869	20.869	

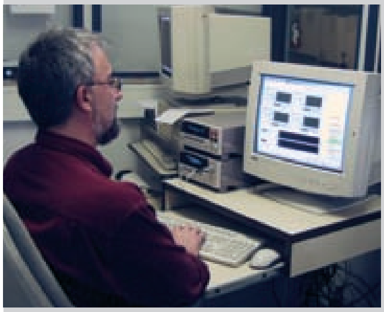
*) Corresponds to IEC 584
New NFC 42-321 is equivalent to IEC 584

Scaling Resistance

Different sheath materials were heated in air in a cycle as follows: 15 min up to 980°C (indirect heating), 5 mins cooling to room temperature, 15 mins up to 980°C and so on.

The diagram below shows the loss in weight (in %) of the specimen versus the test duration (in hours) as a result of the flaking layers of oxide. It is clear that the scaling resistance of the alloys increases with the sum of nickel and chromium, at 980°C with temperature variation it is excellent in INCONEL 600 (2,4816) and still good in 1.4841. On the other hand 18-9 steels are not suitable for applications at this temperature.





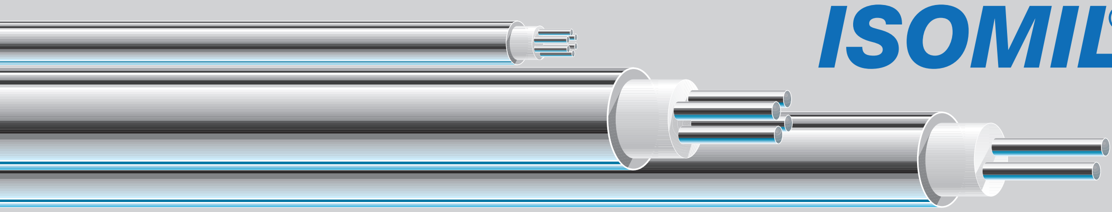
Composition and Physical Properties

(Composition weighting-%)

	Material No.	Ni	Cr	C max.	Si max.	Mn max.	Fe	Mo*	Others**
1	**1.4301**	8,0-10,5	17,0-20,0	0,07	1,0	2,0	Rest	–	–
2	**1.4303**	10,5-12,0	17,0-20,0	0,07	1,0	2,0	Rest	–	–
3	**1.4305**	8,0-10,0	17,0-19,0	0,15	1,0	2,0	Rest	–	S 0,15-0,35
4	**1.4306**	10,0-12,5	17,0-20,0	0,03	1,0	2,0	Rest	–	–
5	**1.4310**	6,5-9,0	16,0-18,0	0,08-0,14	1,5	2,0	Rest	≤ 0,80	–
6	**1.4401**	10,5-13,5	16,5-18,5	0,07	1,0	2,0	Rest	2,0-2,5	–
7	**1.4404**	11,0-14,0	16,5-18,5	0,03	1,0	2,0	Rest	2,0-2,5	–
8	**1.4435**	12,5-15,0	16,5-18,5	0,03	1,0	2,0	Rest	2,5-3,0	–
9	**1.4436**	11,5-14,0	16,5-18,5	0,07	1,0	2,0	Rest	2,5-3,0	–
10	**1.4541**	9,0-11,5	17,0-19,0	0,10	1,0	2,0	Rest	–	Ti ≥ 5 x C
11	**1.4550**	9,0-11,5	17,0-19,0	0,10	1,0	2,0	Rest	–	Nb ≥ 8 x C
12	**1.4571**	10,5-13,5	16,5-18,5	0,10	1,0	2,0	Rest	2,0-2,5	Ti ≥ 5 x C
13	**1.4828**	11,0-13,0	19,0-21,0	0,20	1,5-2,5	2,0	Rest	–	–
14	**1.4845**	19,0-22,0	24,0-26,0	0,08	1,0	2,0	Rest	–	–
15	**1.4981**	15,5-17,5	15,5-17,5	0,10	0,3-0,6	1,0-1,5	Rest	1,6-2,0	Nb ≥ 10 x C
16	**1.4876**	30,0-34,0	19,0-23,0	0,12	1,0	2,0	Rest	–	Ti und Al 0,15-0,60
17	**2.4816**	≥ 72,0	14,0-17,0	0,15	0,5	1,0	6,0-10,0	–	–
18	**2.4951**	Rest	18,0-21,0	0,08-0,15	1,0	1,0	≤ 5,0	–	Ti 0,2-0,6
19	**2.4952**	Rest	18,0-21,0	0,10	1,0	1,0	≤ 3,0	–	Ti 1,8-2,7 Al 1,0-1,8
20	**2.4969**	Rest	18,0-21,0	0,13	1,0	1,0	≤ 1,5	–	Co 15-21 Ti 2,0-3,0 Al 1,0-2,0
21	**2.5869**	≥ 75,0	19,0-21,0	0,15	0,5-2,0	1,0	≤ 1,0	–	–

*) Molybdenum can be used - depending on the alloy - to improve corrosion resistance to a number of acids and resistance to pitting.

**) Niobium and Titanium bind the carbon (as carbide formers) thus preventing the formation of Cr carbides on the grain boundaries during welding which could lead to embrittlement in the welding zone.



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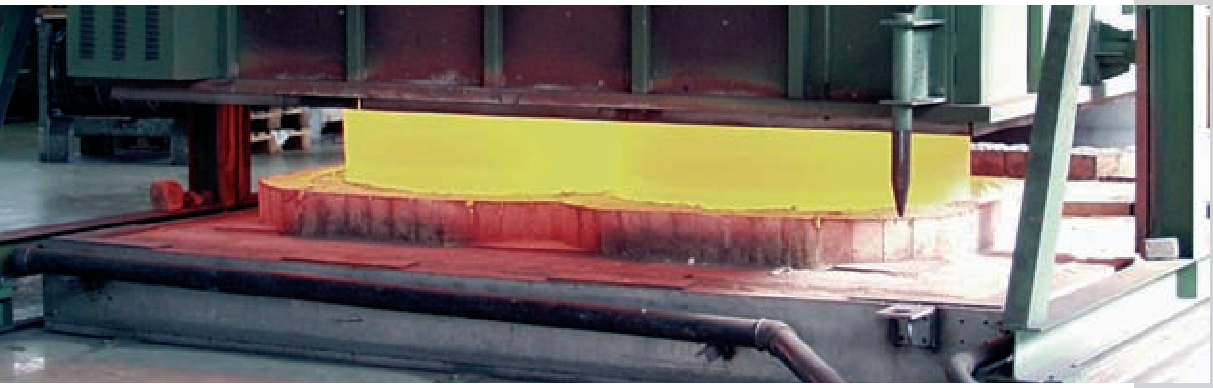
Physical Properties of the Sheath Materials

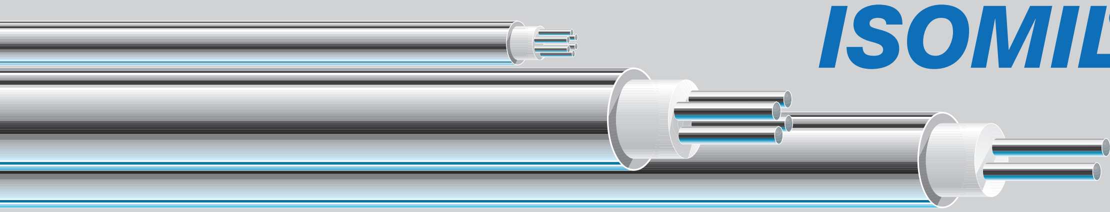
No.	Melting Point (°C)	spez. Resistivity (Ohm.mm^2/m)	Thermal cond. 20°C (W/mK)	Density (g/cm^3)	Specific heat (J/g.K)	Tens. strength annealed (N/mm^2)	Therm. exp. 20-300°C (10^{-6}/K)	Hardness HV annealed (HV)	Mag. behaviour
1-12	ca. 1400	0,73	14,7	7,90	0,50	500-700	17,0	130-180	non-mag. *
13	ca. 1400	0,85	15,0	7,90	0,50	500-750	17,0	ca. 200	non-mag.
14	ca. 1400	0,96	14,7	7,90	0,50	550-800	16,5	ca. 200	non-mag.
15	ca. 1400	0,86	15,0	7,90	0,50	530-690	18,1	ca. 180	non-mag.
16	ca. 1400	1,00	11,5	8,00	0,55	450-700	16,6	ca. 180	non-mag.
17+21	ca. 1400	1,03	14,8	8,40	0,45	550-750	13,3	ca. 150	non-mag.
18	ca. 1350	1,09	11,7	8,37	0,46	ca. 800	13,4	180-280**	non-mag.
19	ca. 1350	1,24	11,2	8,19	0,46	ca. 1200	13,7	180-280**	non-mag.
20	ca. 1350	1,18	11,5	8,18	0,45	ca. 1200	13,7	180-280**	non-mag.

*) Can become magnetic with increasing cold work
**) Annealed and aged approx. 70 HV units higher



Corrosion Resistance of Sheath Materials

Corrosive Media	Meterial No. in accordance with AISI				
	304	305	303	304 L	301
Tap water, 20°C	0	0	0	0	0
Saltwater, 20°C	0*)	0*)	0*)	0*)	0*)
Steam (water vapour), 400°C	0	0	0	0	0
Steam + SO_2	1	1	2	1	1
Air, 20°C	0	0	0	0	0
Hydrogen chloride, 20°C	1*)	1*)	–*)	1*)	1*)
Hydrogen chloride, 100°C	2*)	2*)	–*)	2*)	2*)
Sulphuric acid, 5%, 20°C	1	1	–	1	1
Sulphuric acid, 5%, 100°C	3	3	–	3	3
Hydrochloric acid, 1%, 20°C	1	1	–	1	1
Hydrochloric acid, 1%, 100°C	3	3	–	3	3
Lactic acid, 10%, 20°C	0	0	–	0	0
Lactic acid, 10%, 100°C	0	0	–	0	0
Nitric acid, 10%, 20°C	0	0	0	0	0
Nitric acid, 10%, 100°C	0	0	0	0	0
Lubricating oil, 50°C	0	0	0	0	0
Household washing powder	0	0	0	0	0
Sodium chloride, saturated, 20°C	0*)	0*)	0*)	0*)	0*)
Sodium chloride, saturated, 100°C	1*)	1*)	1*)	1*)	1*)
Petrol, 20°C	0	–	0	0	0
Petrol + methanol, 15%	0	–	0	0	0
Sodium hydroxide, 25%, 20°C	0	0	–	0	0
Sodium hydroxide, 25%, 100°C	1	1	–	1	1
Sodium hydroxide, 320°C	3	3	–	3	3
Ammonia, 20°C	0	0	–	0	0
Lime, 10%, 20°C	0	0	–	0	0



316	316 L	317	D 319	321	347	316 Ti	600
0	0	0	0	0	0	0	0
0*)	0*)	0*)	0*)	0*)	0*)	0*)	0*)
0	0	0	0	0	0	0	0
0	0	0	0	1	1	0	–
0	0	0	0	0	0	0	0
1*)	1*)	1*)	1*)	1*)	1*)	1*)	1*)
1*)	1*)	1*)	1*)	2*)	2*)	1*)	1*)
0	0	0	0	1	1	0	1
2	2	2	2	3	3	2	3
1	1	1	1	1	1	1	1
3	3	3	3	3	3	3	3
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0*)	0*)	0*)	0*)	0*)	0*)	0*)	0*)
1*)	1*)	1*)	1*)	1*)	1*)	1*)	1*)
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	0
3	3	3	3	3	3	3	2
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Thermoelectric Voltages in mV

NiCr-Ni

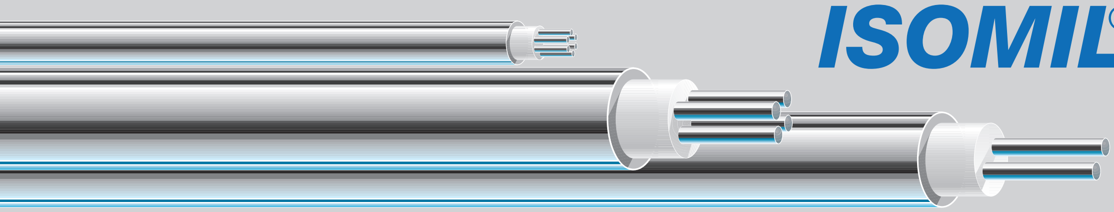
°C	0	-10	-20	-30	-40	-50
-100	-3,553	-3,852	-4,138	-4,410	-4,669	-4,912
0	0	-0,392	-0,777	-1,156	-1,527	-1,889
°C	0	10	20	30	40	50
0	0	0,397	0,798	1,203	1,611	2,022
100	4,095	4,508	4,919	5,327	5,733	6,137
200	8,137	8,537	8,938	9,341	9,745	10,151
300	12,207	12,623	13,039	13,456	13,874	14,292
400	16,395	16,818	17,241	17,664	18,088	18,513
500	20,640	21,066	21,493	21,919	22,346	22,772
600	24,902	25,327	25,751	26,176	26,599	27,022
700	29,128	29,547	29,965	30,383	30,799	31,214
800	33,277	33,686	34,095	34,502	34,909	35,314
900	37,325	37,724	38,122	38,519	38,915	39,310
1000	41,269	41,657	42,045	42,432	42,817	43,202

Fe-CuNi

°C	0	-10	-20	-30	-40	-50
-100	-4,75	-5,15	-5,53	-5,90	-6,26	-6,60
0	0	-0,51	-1,02	-1,53	-2,03	-2,51
°C	0	10	20	30	40	50
0	0	0,52	1,05	1,58	2,11	2,65
100	5,37	5,92	6,47	7,03	7,59	8,15
200	10,95	11,51	12,07	12,63	13,19	13,75
300	16,56	17,12	17,68	18,24	18,80	19,36
400	22,16	22,72	23,29	23,86	24,43	25,00
500	27,85	28,43	29,01	29,59	30,17	30,75
600	33,67	34,26	34,85	35,44	36,04	36,64
700	39,72	40,35	40,98	41,62	42,27	42,92
800	46,22	46,89	47,57	48,25	48,94	49,63

Cu-CuNi

°C	0	-10	-20	-30	-40	-50
-100	-3,40	-3,68	-3,95	-4,21	-4,46	-4,69
0	0	-0,39	-0,77	-1,14	-1,50	-1,85
°C	0	10	20	30	40	50
0	0	0,40	0,80	1,21	1,63	2,05
100	4,25	4,71	5,18	5,65	6,13	6,62
200	9,20	9,74	10,29	10,85	11,41	11,98
300	14,90	15,50	16,10	16,70	17,31	17,92
400	21,00	21,62	22,25	22,88	23,51	24,15
500	27,41	28,08	28,75	29,43	30,11	30,80



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-60	-70	-80	-90	-100	mV/K*)
-5,141	-5,354	-5,550	-5,730	-5,891	
-2,243	-2,586	-2,920	-3,242	-3,553	
60	70	80	90	100	
2,436	2,850	3,266	3,681	4,095	0,041
6,539	6,939	7,338	7,737	8,137	0,040
10,560	10,969	11,381	11,793	12,207	0,041
14,712	15,132	15,552	15,974	16,395	0,042
18,938	19,363	19,788	20,214	20,640	0,042
23,198	23,624	24,050	24,476	24,902	0,043
27,445	27,867	28,288	28,709	29,128	0,042
31,629	32,042	32,455	32,866	33,277	0,042
35,718	36,121	36,524	36,925	37,325	0,041
39,703	40,096	40,488	40,879	41,269	0,040
43,585	43,968	44,349	44,729	45,108	0,039

Thermoelectric Voltages
in mV for Temperatures
in steps of 10°C
(reference temperature 0°C)

IEC 584

*) mean value of the
100°C range

-60	-70	-80	-90	-100	mV/K*)
-6,93	-7,25	-7,56	-7,86	-8,15	0,034
-2,98	-3,44	-3,89	-4,33	-4,75	0,048
60	70	80	90	100	
3,19	3,73	4,27	4,82	5,37	0,054
8,71	9,27	9,83	10,39	10,95	0,056
14,31	14,88	15,44	16,00	16,56	0,056
19,92	20,48	21,04	21,60	22,16	0,056
25,57	26,14	26,71	27,28	27,85	0,057
31,33	31,91	32,49	33,08	33,67	0,058
37,25	37,85	38,47	39,09	39,72	0,061
43,57	44,23	44,89	45,55	46,22	0,065
50,32	51,02	51,72	52,43	53,14	0,069

Thermoelectric Voltages
in mV for Temperatures
in steps of 10°C
(reference temperature 0°C)

IEC 584

*) mean value of the
100°C range

-60	-70	-80	-90	-100	mV/K*)
-4,91	-5,12	-5,32	-5,51	-5,70	0,023
-2,18	-2,50	-2,81	-3,11	-3,40	0,034
60	70	80	90	100	
2,48	2,91	3,35	3,80	4,25	0,043
7,12	7,63	8,15	8,67	9,20	0,050
12,55	13,13	13,71	14,30	14,90	0,057
18,53	19,14	19,76	20,38	21,00	0,061
24,79	25,44	26,09	26,75	27,41	0,064
31,49	32,19	32,89	33,6	34,31	0,069

Thermoelectric Voltages
in mV for Temperatures
in steps of 10°C
(reference temperature 0°C)

IEC 584

*) mean value of the
100°C range

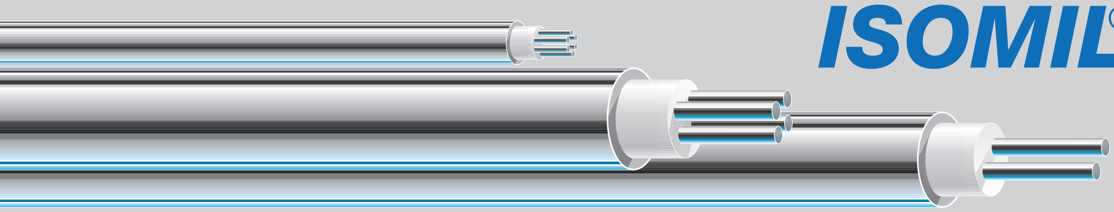
Standard Program
ISOMIL - T

Properties

2-core Thermo cable
NiCr-Ni

Code No.	Thermocouple		Sheath Material	Outer ø	Wall thick-ness	Weight approx. kg/m	max. length m
	Inner cond. ø approx. mm	Loop resis-tance Ohm/m		approx. mm	approx. mm		
2 K 2 L 10	0,18	37,5	Alloy 600 2.4816	1,0	0,14	0,004	7000
2 K 2 L 15	0,27	16,5		1,5	0,20	0,010	3500
2 K 2 L 16	0,29	14,6		1,6	0,22	0,011	3000
2 K 2 L 20	0,36	9,6		2,0	0,28	0,018	2000
2 K 2 L 30	0,54	4,3		3,0	0,42	0,041	900
2 K 2 L 32	0,57	3,78		3,2	0,44	0,047	750
2 K 2 L 45	0,72	2,4		4,5	0,56	0,076	380
2 K 2 L 48	0,86	1,66		4,8	0,67	0,118	300
2 K 2 L 60	1,08	1,1		6,0	0,84	0.164	220
2 K 2 L 64	1,15	0,96		6,4	0,88	0,186	175
2 K 2 L 80	1,44	0,60		8,0	1,12	0,291	110
2 K 2 L 100	1,80	0,38		10,0	1,40	0,455	70
2 K 2 A 10	0,18	37,5	stainless steel AISI 321	1,0	0,14	0,004	7000
2 K 2 A 15	0,27	16,5		1,5	0,20	0,010	3500
2 K 2 A 16	0,29	14,6		1,6	0,22	0,011	3000
2 K 2 A 20	0,36	9,6		2,0	0,28	0,018	2000
2 K 2 A 30	0,54	4,3		3,0	0,42	0,039	900
2 K 2 A 32	0,57	3,78		3,2	0,44	0,045	750
2 K 2 A 40	0,72	2,4		4,0	0,56	0,070	380
2 K 2 A 48	0,86	1,66		4,8	0,67	0,108	300
2 K 2 A 60	1,08	1,1		6,0	0,84	0,157	220
2 K 2 A 64	1,15	0,96		6,4	0,88	0,182	175
2 K 2 A 80	1,44	0,60		8,0	1,12	0,279	110
2 K 2 A 100	1,80	0,38		10,0	1,4	0,436	70
2 K 2 S 15	0,27	16,5	stainless steel AISI 316	1,5	0,20	0,010	3500
2 K 2 S 16	0,29	14,6		1,6	0,22	0,011	3000
2 K 2 S 32	0,57	3,78		3,2	0,44	0,045	750
2 K 2 S 48	0,86	1,66		4,8	0,67	0,108	300
2 K 2 S 64	1,15	0,96		6,4	0,88	0,182	175

Further dimensions are on request available



ISOMIL®

Standard Program
ISOMIL - T

Properties

2-core Thermo cable Fe-CuNi

Code No.	Thermocouple: Inner cond. ø approx. mm	Thermocouple: Loop resistance Ohm/m	Sheath Material	Outer ø approx. mm	Wall thickness approx. mm	Weight approx. kg/m	max. length m
2 J 2 L 10	0,18	21,5	Alloy 600 2.4816	1,0	0,14	0,004	7000
2 J 2 L 20	0,36	6,0		2,0	0,28	0,018	2000
2 J 2 L 30	0,54	2,7		3,0	0,42	0,041	900
2 J 2 L 40	0,72	1,45		4,0	0,56	0,072	440
2 J 2 L 60	1,08	0,66		6,0	0,84	0,163	220
2 J 2 L 80	1,44	0,37		8,0	1,12	0,290	110
2 J 2 A 10	0,18	21,5	stainless steel AISI 321	1,0	0,14	0,004	7000
2 J 2 A 20	0,36	6,0		2,0	0,28	0,018	2000
2 J 2 A 30	0,54	2,7		3,0	0,42	0,039	900
2 J 2 A 40	0,72	1,45		4,0	0,56	0,070	440
2 J 2 A 60	1,08	0,66		6,0	0,84	0,156	220
2 J 2 A 80	1,44	0,37		8,0	1,12	0,278	110

4-core Thermo cable NiCr-Ni

Code No.	Thermocouple: Inner cond. ø approx. mm	Thermocouple: Loop resistance Ohm/m	Sheath Material	Outer ø approx. mm	Wall thickness approx. mm	Weight approx. kg/m	max. length m
4 K 2 L 15	0,24	2,22	Alloy 600 2.4816	1,5	0,20	0,010	3500
4 K 2 L 16	0,25	19,5		1,6	0,22	0,011	3000
4 K 2 L 20	0,32	12,5		2,0	0,28	0,018	2000
4 K 2 L 30	0,48	5,5		3,0	0,42	0,043	900
4 K 2 L 32	0,51	4,9		3,2	0,44	0,049	750
4 K 2 L 40	0,65	3,0		4,0	0,56	0,077	440
4 K 2 L 48	0,76	2,1		4,8	0,67	0,112	300
4 K 2 L 60	0,95	1,4		6,0	0,84	0,172	220
4 K 2 L 64	1,02	1,23		6,4	0,88	0,190	175
4 K 2 L 80	1,28	0,77		8,0	1,12	0,307	110
4 K 2 A 15	0,24	2,22	stainless steel AISI 321	1,5	0,20	0,010	3500
4 K 2 A 16	0,25	19,5		1,6	0,22	0,011	3000
4 K 2 A 20	0,32	12,5		2,0	0,28	0,018	2000
4 K 2 A 30	0,48	5,5		3,0	0,42	0,041	900
4 K 2 A 32	0,51	4,9		3,2	0,44	0,047	750
4 K 2 A 40	0,65	3,0		4,0	0,56	0,073	440
4 K 2 A 48	0,76	2,1		4,8	0,67	0,110	300
4 K 2 A 60	0,95	1,4		6,0	0,84	0,166	220
4 K 2 A 64	1,02	1,23		6,4	0,88	0,186	175
4 K 2 A 80	1,28	0,77		8,0	1,12	0,295	110

Standard Program
ISOMIL - T

Properties

Code No.	Thermocouple Inner cond. ø approx. mm	Thermocouple Loop resistance Ohm/m	Sheath Material	Outer ø approx. mm	Wall thickness approx. mm	Weight approx. kg/m	max. length m

4-core Thermo cable
NiCr-Ni

Code No.	Inner cond. ø approx. mm	Loop resistance Ohm/m	Sheath Material	Outer ø approx. mm	Wall thickness approx. mm	Weight approx. kg/m	max. length m
4 K 2 S 15	0,24	2,22	stainless steel AISI 316	1,5	0,20	0,010	3500
4 K 2 S 16	0,25	19,5		1,6	0,22	0,011	3000
4 K 2 S 32	0,51	4,9		3,2	0,44	0,047	750
4 K 2 S 48	0,76	2,1		4,8	0,67	0,110	300
4 K 2 S 64	1,02	1,23		6,4	0,88	0,186	175

4-core Thermo cable
Fe-CuNi

Code No.	Inner cond. ø approx. mm	Loop resistance Ohm/m	Sheath Material	Outer ø approx. mm	Wall thickness approx. mm	Weight approx. kg/m	max. length m
4 J 2 L 20	0,32	7,7	Alloy 600 2.4816	2,0	0,28	0,019	400
4 J 2 L 30	0,4	3,5		3,0	0,42	0,043	400
4 J 2 L 40	0,65	1.9		4,0	0,56	0,076	250
4 J 2 L 60	0,95	0,85		6,0	0,84	0,171	100
4 J 2 L 80	1,28	0,49		8,0	1,12	0,304	60
4 J 2 A 15	0,24	13,6	stainless steel AISI 321	1,5	0,20	0,010	3500
4 J 2 A 16	0,25	12,0		1,6	0,22	0,011	3000
4 J 2 A 20	0,32	7,7		2,0	0,28	0,018	400
4 J 2 A 30	0,48	3,5		3,0	0,42	0,041	400
4 J 2 A 32	0,51	3,0		3,2	0,44	0,047	750
4 J 2 A 40	0,65	1,9		4,0	0,56	0,073	250
4 J 2 A 48	0,76	1,32		4,8	0,67	0,110	300
4 J 2 A 60	0,95	0,85		6,0	0,84	0,166	100
4 J 2 A 64	1,02	0,74		6,4	0,88	0,186	175
4 J 2 A 80	1,28	0,49		8,0	1,12	0,292	60
4 J 2 S 15	0,24	13,6	stainless steel AISI 316	1,5	0,20	0,010	3500
4 J 2 S 16	0,25	12,0		1,6	0,22	0,011	3000
4 J 2 S 32	0,51	3,0		3,2	0,44	0,047	750
4 J 2 S 48	0,76	1,32		4,8	0,67	0,110	300
4 J 2 S 64	1,02	0,74		6,4	0,88	0,186	175

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Properties

6-core Thermo cable
NiCr-Ni

Code No.	Thermocouple		Sheath Material	Outer ø	Wall thickness	Weight	max. length
	Inner cond. ø approx. mm	Loop resistance Ohm/m		approx. mm	approx. mm	approx. kg/m	m
6 K 2 L 30	0,39	8,1	Alloy 600 2.4816	3,0	0,42	0,044	900
6 K 2 L 40	0,51	4,8		4,0	0,56	0,077	440
6 K 2 L 60	0,76	2,2		6,0	0,84	0,174	220
6 K 2 L 80	1,02	1,2		8,0	1,12	0,310	110
6 K 2 A 30	0,39	8,1	stainless steel AISI 321	3,0	0,42	0,042	900
6 K 2 A 40	0,51	4,8		4,0	0,56	0,074	440
6 K 2 A 60	0,76	2,2		6,0	0,84	0,168	220
6 K 2 A 80	1,02	1,2		8,0	1,12	0,298	110

Standard Production Program ISOMIL- M

Dimensions and Properties

Outer diameter (mm)	No. of con-ductors	Resistance per meter at 20°C (Ohm/m)			Conductor diameter (mm)		Wall thickness of sheath (mm)	Weight
		Cu	CuNi	Ni	Cu CuNi	Ni		kg/m
1,0	1	0,20	5,6	0,91	0,33	0,33	0,14	0,004
2,0		0,05	1,4	0,23	0,67	0,67	0,29	0,016
3,0		0,022	0,62	0,10	1,0	1,0	0,43	0,037
4,0		0,013	0,35	0,057	1,3	1,3	0,58	0,065
5,0		0,008	0,22	0,037	1,7	1,7	0,72	0,102
6,0		0,0056	0,16	0,025	2,0	2,0	0,87	0,147
2,0	2	0,20	5,6	0,91	0,33	0,33	0,29	0,015
3,0		0,18	5,1	0,53	0,35	0,44	0,33	0,033
4,0		0,098	2,7	0,30	0,48	0,58	0,44	0,059
5,0		0,063	1,8	0,19	0,59	0,73	0,55	0,092
6,0		0,044	1,2	0,13	0,71	0,89	0,66	0,132
2,0	4	0,24	6,7	0,88	0,3	0,34	0,29	0,016
3,0		0,12	3,4	0,53	0,43	0,44	0,33	0,037
4,0		0,11	3,1	0,39	0,45	0,51	0,44	0,065
5,0		0,071	2,0	0,25	0,56	0,64	0,55	0,101
6,0		0,049	1,4	0,17	0,67	0,77	0,66	0,146
8,0		0,028	0,78	0,10	0,89	1,0	0,88	0,260
3,0	6	0,151	4,2	0,52	0,38	0,44	0,33	0,037
4,0		0,084	2,3	0,29	0,52	0,59	0,44	0,065
5,0		0,081	2,2	0,19	0,52	0,73	0,55	0,102
6,0		0,056	1,6	0,13	0,63	0,89	0,66	0,147
8,0		0,032	0,89	0,07	0,83	1,2	0,88	0,261

Tolerances apply to diameter: in accordance with DIN 177

Physical Properties of the Conductor Materials

Inner conductor material	El. resistivity Ohm mm²/m at					Highest permis-sible ap-plication tempera-ture °C
	20°C	200°C	400°C	600°C	800°C	
Cu	0,0175	0,030	0,045	0,059	–	600
CuNi 44	0,490	0,49	0,49	0,51	0,52	700
Ni	0,080	0,172	0,325	0,395	0,407	800

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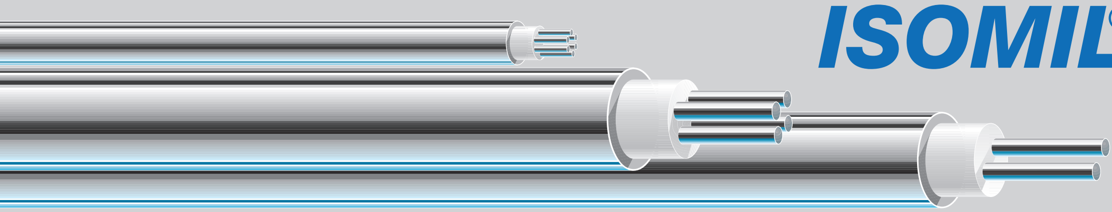

NOTES

Mistakes and
subject to change.

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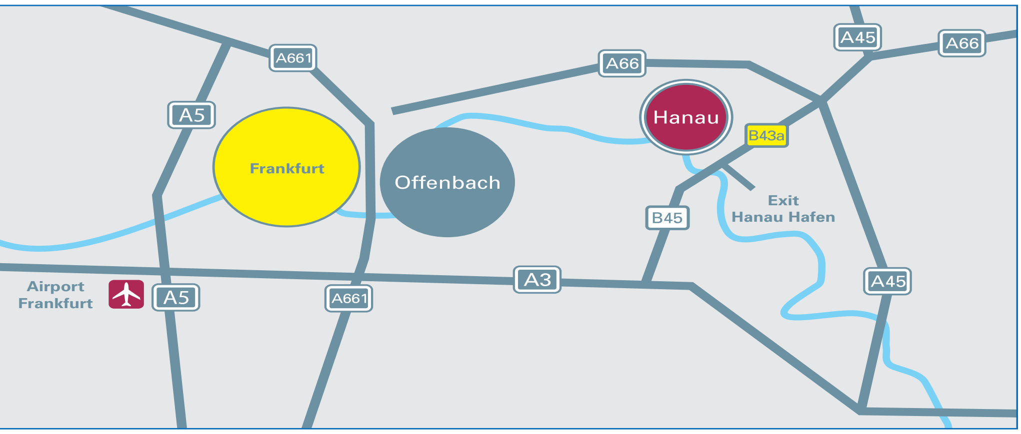
MINERAL INSULATED CABLES



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HOW TO FIND US

A3 Frankfurt

Main direction München / Würzburg / Hanau

Next: Direction B45 Hanau

Next: Direction B43a Fulda

Next: Exit Hanau - Hafen

A45 Giessen

Direction: Hanauer Kreuz

(Motorway junction Hanau)

Next: Direction B43a Dieburg

Next: Exit Hanau - Hafen

Now

Turn right direction Hanau-Hafen.

Next left, direction Industriegebiet (Industrial area)

Hafenstraße.

Next right, Ehrichstraße 10, Industriepark Gebäude 4

(Industrial park building No.4) on the left.

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کد پستی: ۱۹۴۱۷۱۵۴۷۶

تلفن: ۳ – ۲۶۶۰۰۱۱۲ ۲۱ ۹۸+

فکس: ۲۲۰۰۰۱۲۴ ۲۱ ۹۸+