

# Mineral Insulated Cables



- Thermocouple Mineral Insulated Cables
- RTD Extension Mineral Insulated Cables
- Heater Mineral Insulated Cables
- Mineral Insulated Power Cable

# ABOUT THE COMPANY



Tempsens Instruments (I) Pvt. Ltd. is a part of Pyrotech Group which was established by four technocrats in 1976 at Udaipur, with their first product as Thermocouples and RTDs.

Today Tempsens is one of the largest manufacturers of Temperature Sensors in India.

We are ISO 9001:2008 certified company with NABL accredited Lab. Tempsens Instruments (I) Pvt. Ltd. U # II was started in 2009 to produce quality cables with high standard of manufacturing process conforming to national & international specifications.

We manufacture wide range of cables for Temperature sensors and Instrumentation in various insulations as PTFE, Kapton, Silicon, Fiber Glass, Ceramic Fiber, Refrasil/Nextel, PVC etc. in variety of configurations. These cables are available in temperature range -60°C to 1200°C.

All our products are manufactured under strict ISO - 9001 quality control system. We also provide Calibration Certificates with all cables. We stock almost all types of cables which enable us for fast delivery of goods. Our engineers are capable of custom design solution for any application as per customer need. We are dedicated to provide the highest quality products that meet our customer's specifications for various applications. We continuously focus on improving our manufacturing processes and competitiveness in the industry.

We introduce our latest addition in the cable line- the mineral insulated, metal sheathed cable products. The applications of MI Cable in blast furnace, atomic research, nuclear reactors, Kilns, etc. Our product catalogue will help you in understanding and selecting MI cables for your application requirements. We provide our customers from standard as well as custom made products according to the needs of the customer, our lines are flexible and ready to meet the demand.

We manufacture cables in four distinct product lines:

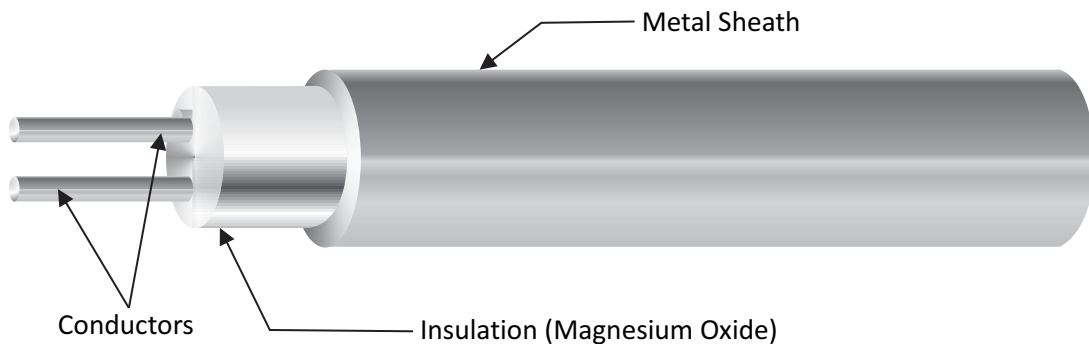
- Thermocouple cables for measuring temperature.
- RTD extension cables for use with resistance temperature devices.
- Micro – Heater cables for unique industrial heating applications.
- Mineral Insulated Power Cable
- Any Special Cable which requires high temperature and rugged insulation.

# BASICS OF MINERAL INSULATED CABLES

## GENERAL INFORMATION

One or more wire like conductors (cores) are embedded in a high insulation quality MgO and pressed into a metal tube (sheath) made of oxidation and corrosion resistant material. The entire combination is then processed using suitable forming steps to obtain the final dimensions.

In other words, Mineral Insulated Cable comprises a metal sheath in which the conductors are embedded in highly compressed magnesium oxide insulation.



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

On account of their good flexibility, the use of mineral insulated cables are 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 2 times the outer diameter of the mineral insulated cable.

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

## Mineral Insulated Cables

- 1) Mineral Insulated Thermocouple Cable.
- 2) Mineral Insulated RTD Cable.
- 3) Mineral Insulated Heater Cable.
- 4) Mineral Insulated Power Cable/Mineral Insulated Copper Cable
- 5) Coaxial/Triaxial Cable
- 6) Self Powered Neutron Detectors (SPNDs)

Thermocouple cables are manufactured to meet the requirements specified in ASTM E585/E585M & ASTM E 839 & IEC1515, Internationally recognized standards which specify the base metal thermocouple types.

Emf outputs comply with ASTM E230/E230M & IEC 584-2/ANSI MC 96.1

RTD extension cables adhere to ASTM E 2021 standards which ensure best performance of finished IPRT (RTD) sensors which are required to comply with ASTM E1137/E1137M.



# FEATURES

**Long Life** : The construction of the cable guarantees a long conductor life because the sheath and the insulating material protect the conductors (wire) against environmental conditions such as corrosion and scaling . This ensures accurate calibration throughout the life of the cable.

**Long Lengths** : Our unique manufacturing process results in lengths previously unheard of for mineral insulated cables.

**Rapid Response** : The small mass and high thermal conductivity promotes rapid heat transfer from the heat source to measuring junction.

**Mechanical Strength** : The Compact construction with densely packed MgO 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.

**Corrosion and Scaling Resistance** : The vast array of materials included in our standard inventory and the possibility of manufacturing to specification has put us in a position to supply suitable sheath materials, even for unfavorable environmental conditions in a corrosive atmosphere and at high temperatures.

**Radiation Resistance** : The correct choice of components 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.

**Moisture/Pressure** : The Homogeneous metal sheaths are impervious to most liquids and gases and will withstand high external pressures. Unless otherwise specified our sheaths are seamless.

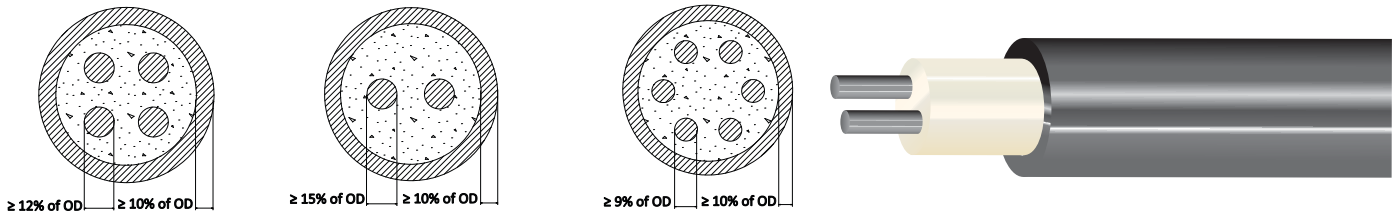
**Safety** : Since the materials used are MgO and metals, the cables are fire-proof and can thus be exposed to considerably higher temperatures than cables with synthetic sheaths.





# MINERAL INSULATED THERMOCOUPLE CABLE

Mineral Insulated Thermocouple cables have inner conductors of Thermocouple base material as per standard ASTM E 585/585M and ASTM E 839.



Number of Pair	Sheath Diameter (mm)	Nominal Wall Thickness (mm)	Element Diameter (mm)	Insulation Thickness (mm)	Insulation Resistance (MΩ)	Sheath Material	Conductor Type	Insulation	Calibration Accuracy
Simplex	1.50	≥ 0.15	≥ 0.23	≥ 0.11	≥ 1000 MΩ	SS316L SS321 SS310 SS446 SS304 Inconel 600 Inconel 601 and others	K Type J Type E Type N Type R Type S Type	MgO (Standard Purity ≥ 97%)  MgO (High Purity ≥ 99.4%)	Class 1 / Class 2 Accuracy as per IEC 584-2 / ANSI MC 96.1 / ASTM E 230
	2.00	≥ 0.20	≥ 0.30	≥ 0.14					
	2.50	≥ 0.25	≥ 0.38	≥ 0.18					
	3.00	≥ 0.30	≥ 0.45	≥ 0.21					
	4.50	≥ 0.45	≥ 0.68	≥ 0.32					
	6.00	≥ 0.60	≥ 0.90	≥ 0.42					
	6.40	≥ 0.64	≥ 0.96	≥ 0.45					
	8.00	≥ 0.80	≥ 1.20	≥ 0.56					
	9.50	≥ 0.95	≥ 1.43	≥ 0.67					
	10.00	≥ 1.00	≥ 1.50	≥ 0.70					
Duplex	12.70	≥ 1.27	≥ 1.91	≥ 0.89	≥ 1000 MΩ	SS316L SS321 SS310 SS446 SS304 Inconel 600 Inconel 601 and others	K Type J Type E Type N Type R Type S Type	MgO (Standard Purity ≥ 97%)  MgO (High Purity ≥ 99.4%)	Class 1 / Class 2 Accuracy as per IEC 584-2 / ANSI MC 96.1 / ASTM E 230
	1.50	≥ 0.15	≥ 0.18	≥ 0.08					
	2.00	≥ 0.20	≥ 0.24	≥ 0.11					
	2.50	≥ 0.25	≥ 0.30	≥ 0.14					
	3.00	≥ 0.30	≥ 0.36	≥ 0.17					
	4.50	≥ 0.45	≥ 0.54	≥ 0.25					
	6.00	≥ 0.60	≥ 0.72	≥ 0.33					
	6.40	≥ 0.64	≥ 0.77	≥ 0.35					
	8.00	≥ 0.80	≥ 0.96	≥ 0.44					
	9.50	≥ 0.95	≥ 1.14	≥ 0.52					
Triplex	10.00	≥ 1.00	≥ 1.20	≥ 0.55	≥ 1000 MΩ	SS316L SS321 SS310 SS446 SS304 Inconel 600 Inconel 601 and others	K Type J Type E Type N Type R Type S Type	MgO (Standard Purity ≥ 97%)  MgO (High Purity ≥ 99.4%)	Class 1 / Class 2 Accuracy as per IEC 584-2 / ANSI MC 96.1 / ASTM E 230
	12.70	≥ 1.27	≥ 1.52	≥ 0.70					
	3.00	≥ 0.30	≥ 0.27	≥ 0.12					
	4.50	≥ 0.45	≥ 0.41	≥ 0.18					
	6.00	≥ 0.60	≥ 0.54	≥ 0.24					
	6.40	≥ 0.64	≥ 0.58	≥ 0.26					
	8.00	≥ 0.80	≥ 0.72	≥ 0.32					
	9.50	≥ 0.95	≥ 0.86	≥ 0.38	≥ 1000 MΩ	SS316L SS321 SS310 SS446 SS304 Inconel 600 Inconel 601 and others	K Type J Type E Type N Type R Type S Type	MgO (Standard Purity ≥ 97%)  MgO (High Purity ≥ 99.4%)	Class 1 / Class 2 Accuracy as per IEC 584-2 / ANSI MC 96.1 / ASTM E 230
	10.00	≥ 1.00	≥ 0.90	≥ 0.40					
	12.70	≥ 1.27	≥ 1.14	≥ 0.51					

## Ordering Example

**60K600** : 6.0 mm OD, K Type, Simplex, Inconel 600 Sheath with high purity of MgO Insulation and accuracy class 1 as per specification IEC 584

**64NN316** : 6.4 mm OD, N Type, Duplex, SS316L Sheath with high purity of MgO Insulation and accuracy class 1 as per specification IEC 584

# MINERAL INSULATED THERMOCOUPLE CABLE

## Standard Deviation of Mineral Insulated Thermocouple Cable as per IEC 584-2

Type	Temperature Range	Tolerance for Class 1 Accuracy	Tolerance for Class 2 Accuracy
K/N	-40°C to +1100°C	+/- 1.5°C or +/-0.004(t)	+/- 2.5°C or +/-0.0075(t)
J	-40°C to +750°C	+/- 1.5°C or +/-0.004(t)	+/- 2.5°C or +/-0.0075(t)
T	-40°C to +350°C	+/- 0.5°C or +/-0.004(t)	+/- 1.0°C or +/-0.0075(t)
E	-40°C to +800°C	+/- 1.5°C or +/-0.004(t)	+/- 2.5°C or +/-0.0075(t)
R/S	0°C to +1600°C	+/-1°C or +/-[1+0.003(t-1100)]	+/- 1.5°C or +/-0.0025(t)

## Mineral Insulated Thermocouple Cables with Precious Thermocouple:

Precious metal thermocouples are exceptionally suitable 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 Atmosphere								
Sheath Material	Thermocouple	Max. Operating Temperature	Oxygen	Nitrogen	Hydrogen	Carbon	Chlorine	Sulphur
Inconel 600 2.4816	S Type	1100°C	Good	Good	Good	Good	Good	Conditional
	R Type	1100°C	Good	Good	Good	Good	Good	Conditional
	B Type	1100°C	Good	Good	Good	Good	Good	Conditional
pt10%Rh	S Type	1300°C	Good	Good	Conditional	Conditional	Conditional	Conditional
	R Type	1300°C	Good	Good	Conditional	Conditional	Conditional	Conditional
	B Type	1300°C	Good	Good	Conditional	Conditional	Conditional	Conditional

# MINERAL INSULATED COMPENSATING CABLE

Mineral Insulated Compensating Cables have inner conductors of R/S Type (Cu- CuNi) and B Type (Cu-Cu), Compensating conductor with copper sheath.

Conductor	No. of Pair	Sheath Material	Operating Temperature	Testing
R/S Type Compensating Wire (Cu-CuNi)	1	Copper Sheath	200°C	(0.645 +/- 0.057) mV as per ANSI MC 96.1
R/S Type Compensating Wire (Cu-CuNi)	2		200°C	(0.645 +/- 0.057) mV as per ANSI MC 96.1

## Ordering Example

**60 R SC** : 6.0 mm OD, R Type compensating Conductor, Simplex, and Copper Sheath

**60 SS SC** : 6.0 mm OD, S Type compensating Conductor, Duplex, and Copper Sheath

# MINERAL INSULATED RTD CABLE

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

Sheath Diameter (mm)	Number of Core	Nominal Wall Thickness (mm)	Element Diameter (mm)	Insulation Resistance (MΩ)	Sheath Material	Conductor Type	Insulation
2.00	2 Core & 3 Core	≥ 0.20	≥ 0.30	≥ 100 MΩ	SS316L SS321 SS304 Inconel 600 and others	Copper Nickel Nickel-Copper Alloy and others	MgO (Standard Purity ≥ 97%)  MgO (High Purity ≥ 99.4%)
2.50		≥ 0.25	≥ 0.38				
3.00		≥ 0.30	≥ 0.45				
4.50		≥ 0.45	≥ 0.68				
6.00		≥ 0.60	≥ 0.90				
6.40		≥ 0.64	≥ 0.96				
8.00		≥ 0.80	≥ 1.20				
9.50		≥ 0.95	≥ 1.43				
10.00		≥ 1.00	≥ 1.50				
2.00	4 Core	≥ 0.20	≥ 0.24	≥ 100 MΩ	SS316L SS321 SS304 Inconel 600 and others	Copper Nickel Nickel-Copper Alloy and others	MgO (Standard Purity ≥ 97%)  MgO (High Purity ≥ 99.4%)
2.50		≥ 0.25	≥ 0.30				
3.00		≥ 0.30	≥ 0.36				
4.50		≥ 0.45	≥ 0.54				
6.00		≥ 0.60	≥ 0.72				
6.40		≥ 0.64	≥ 0.77				
8.00		≥ 0.80	≥ 0.96				
9.50		≥ 0.95	≥ 1.14				
10.00		≥ 1.00	≥ 1.20				
3.00	6 Core	≥ 0.30	≥ 0.30	≥ 100 MΩ	SS316L SS321 SS304 Inconel 600 and others	Copper Nickel Nickel-Copper Alloy and others	MgO (Standard Purity ≥ 97%)  MgO (High Purity ≥ 99.4%)
4.50		≥ 0.45	≥ 0.45				
6.00		≥ 0.60	≥ 0.60				
6.40		≥ 0.64	≥ 0.64				
8.00		≥ 0.80	≥ 0.80				
9.50		≥ 0.95	≥ 0.95				
10.00		≥ 1.00	≥ 1.00				
6.00	8 Core	≥ 0.60	≥ 0.60	≥ 100 MΩ	SS316L SS321 SS304 Inconel 600 and others	Copper Nickel Nickel-Copper Alloy and others	MgO (Standard Purity ≥ 97%)  MgO (High Purity ≥ 99.4%)
6.40		≥ 0.64	≥ 0.64				
8.00		≥ 0.80	≥ 0.80				
9.50		≥ 0.95	≥ 0.95				
10.00		≥ 1.00	≥ 1.00				

## Ordering Example

**80-4Cu316 RTD MI Cable** : 8.0 mm OD, 4 Cores, Copper Conductor, SS316L Sheath

**60-6NiCu600 RTD MI Cable** : 8.0 mm OD, 4 Cores, Nickel-Copper Alloy Conductor (Constantan), Inconel 600 Sheath



# MINERAL INSULATED HEATER CABLE

Tempsens 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 used in the Machinery, Power Generating Industry, Chemical and Petrochemical Industry as well as Research and Development.

Heating Element	Sheath Material	Operating Temperature up to
NiCr Alloy	Inconel 600 (2.4816) and SS316L (1.4404)	800°C
CuNi Alloy	SS321/AISI 321 (1.4541)	500°C

## Technical Data

Conductors NiCr Alloy, applicable for temperature up to 800°C				
Outer Diameter (mm)	Resistance at 20°C (Ω/m)	Conductor Diameter (mm)	Wall Thickness(mm)	Maximum Voltage Rating
3.2	10	0.38	≥ 0.32	800 V
3.2	6.3	0.48	≥0.32	
3.2	4	0.61	≥0.32	
3.6	2.5	0.77	≥ 0.36	
3.8	1.6	0.96	≥ 0.38	
4.1	1	1.21	≥ 0.41	
4.5	0.63	1.52	≥ 0.45	
5	0.4	1.91	≥ 0.50	
5.6	0.25	2.42	≥ 0.56	
6.5	0.16	3.03	≥ 0.65	
Conductors CuNi, applicable for temperature up to 500°C				
6.5	0.16	3.03	≥ 0.65	up to 300V /500V
6.5	0.16	3.03	≥ 0.65	
6.5	0.16	3.03	≥ 0.65	
6.5	0.16	3.03	≥ 0.65	
6.5	0.16	3.03	≥ 0.65	
6.5	0.16	3.03	≥ 0.65	

Tolerance for the resistance per mtr: ± 10%

Tolerance for the outer diameter: according to DIN EN 61515

**Example :** 45-NiCr316 Heater MI Cable : 4.5 mm OD, 1 Core, NiCr Alloy Conductor, SS316L Sheath

# MINERAL INSULATED POWER CABLE

Mineral Insulated Copper cable belongs to electric cable class.

**Outer Sheath** : Copper Sheath with melting point of 1083°C

**Insulation** : Magnesium oxide insulator, hardly compressed, with melting point of 2400°C.

**Conductor** : Annealed conductor of 99.9% of purity electrolytic copper wire, with melting point of 1083°C

**Covering** : Addition LSF (Low Smoke Fumes) outer covering.

**Applicable Standard** : IEC/EN 60702 Part 1, BS6387, IEC60331, Categories C, W & Z

- **Operating Temperature** : Maximum 250°C (But will operate up to a temperature of 1083°C but this will reduce the life of the cable)
- **Voltage** : 450/750 V (Heavy Duty Grade Cable )  
300/500 V (Light Duty Grade Cable)

Details	Standard Follow	Description
MI Power Cable	IEC/EN 60702 Part 1	Mineral Insulated Copper sheathed Cable with Copper Conductor
Copper Conductor	IEC 60228 for Class 1	Copper (>99.9 %)
Insulation	IEC/EN 60702 Part 1	MgO (>99.4 % Pure)
Metallic Sheath	ASTM B75 Specification	Seamless Copper Tube (99.9%)
Insulation Resistance	IEC/EN 60702 Part 1	>1000 MΩ for above 100 Mtr coil
<b>TESTING</b>		
A) Routine Test	IEC/EN 60702 Part 1	Conductor Resistance, Insulation Resistance, Sheath And Insulation Integrity, Diameter & ovality
B) Type Test	IEC/EN 60702 Part 1	Voltage Test , Resistance of Copper Sheath, Insulation Thickness, Sheath Thickness, Bending test, Flattening test, Fire Resistance,

## How to Order - MI Power Cable

Type of Cable	No. of Core X Core Size(mm2)	Nominal Outer Copper Sheath Diameter (mm)	LSF Cable Diameter (mm)	Nominal Core Diameter (mm)	Maximum Core resistance (Ω/Km)	Copper Sheath Cross Section (mm2)	Maximum Resistance of Copper Sheath (Ω/Km)
<b>Suitable For (300/500 V) Light Duty Grade Cable</b>							
2 L 1.5	2 X 1.5	5.70	7.00	1.38	11.49	7.12	2.42
2 L 2.5	2 X 2.5	6.60	7.90	1.78	6.90	9.41	1.83
2 L 4	2 X 4	7.70	9.20	2.26	4.31	12.15	1.42
3 L 1.5	3 X 1.5	6.40	7.70	1.38	11.49	8.93	1.93
3 L 2.5	3 X 2.5	7.30	8.80	1.78	6.90	10.68	1.61
4 L 1.5	4 X 1.5	7.00	8.30	1.38	11.49	10.21	1.69
4 L 2.5	4 X 2.5	8.10	9.60	1.78	6.90	12.83	1.34
2 T 1.5	2 X 1.5	5.70	7.00	1.38	11.49	7.12	2.42
2 T 2.5	2 X 2.5	6.60	7.90	1.78	6.90	9.41	1.83
<b>Suitable For (450/750 V) Heavy Duty Grade Cable</b>							
1 H 1.5	1 X 1.5	4.9	6.20	1.38	12.1	5.78	4.13
1 H 2.5	1 X 2.5	5.3	6.60	1.78	7.41	6.44	3.71
1 H 4	1 X 4	5.9	7.20	2.26	4.61	7.70	3.09
1 H 6	1 X 6	6.4	7.70	2.76	3.08	8.93	2.67
2 H 1.5	2 X 1.5	7.9	9.40	1.38	12.1	12.49	1.9
2 H 2.5	2 X 2.5	8.7	10.20	1.78	7.41	14.56	1.63
2 H 4	2 X 4	9.8	11.30	2.26	4.61	17.61	1.35
2 H 6	2 X 6	10.9	12.40	2.76	3.08	20.93	1.13
3 H 1.5	3 X 1.5	8.3	9.80	1.38	12.1	13.62	1.75
3 H 2.5	3 X 2.5	9.3	10.80	1.78	7.41	16.14	1.47
3 H 4	3 X 4	10.4	11.90	2.26	4.61	19.34	1.23

## Mineral Insulated Copper Cables are useful:

- Doesn't deteriorate with age.
- High current carrying capacity.
- Over come the overload and short circuit.
- Resist to flame.
- Works under fire condition.
- Ideal solution for places where it is not allowed to break the walls to embed the conduit.

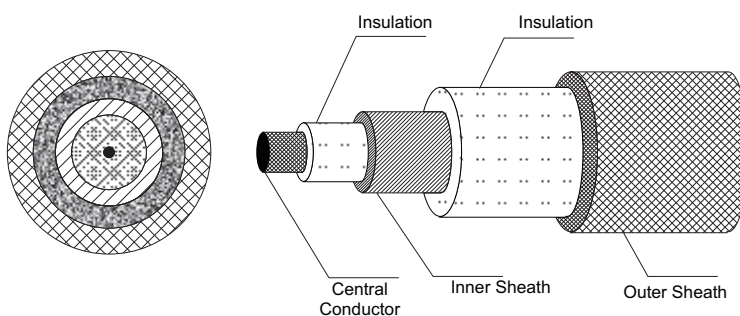
# OTHER SPECIAL TYPE OF MINERAL INSULATED CABLE

## Coaxial Cables

Coaxial cable is a type of cable that has an inner conductor surrounded by a tubular insulating layer, surrounded by a tubular conducting shield.

## Triaxial Cable

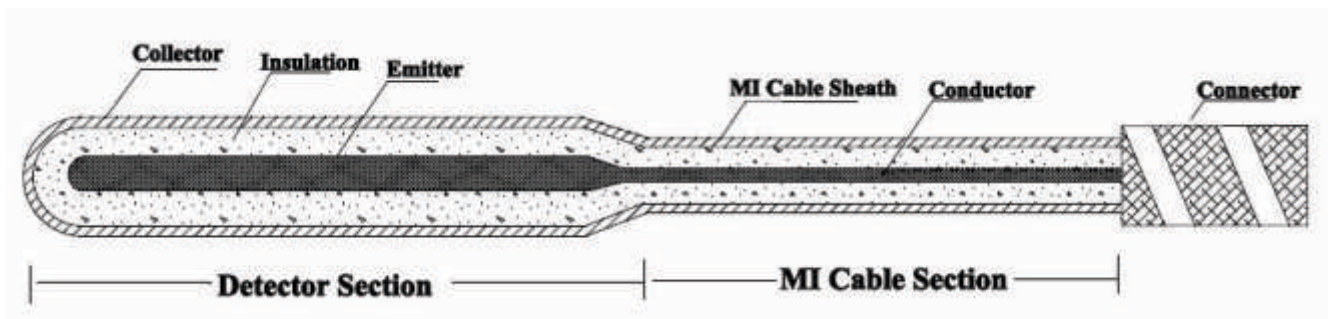
Triaxial cable is a type of electrical cable similar to coaxial cable, but with the addition of an extra layer of insulation and a second conducting sheath. It provides greater bandwidth and rejection of interference than coax, but is more expensive.



Triaxial Mineral Insulated Cables

## SPND

Self-Powered Neutron Detectors have been used effectively as in-core flux monitors for over twenty-five years in nuclear power reactors world-wide. The typical SPND is a coaxial cable consisting of an inner electrode (the emitter), surrounded by insulation and an outer electrode (the collector).



Self Powered Neutron detector (SPND)

Various type of SPND emitters are used in power reactor application.

1. Inconel 600
2. Rhodium ( $\text{Rh}^{103}$ )
3. Vanadium ( $\text{V}^{51}$ )
4. Platinum ( $\text{Pt}^{195}$ )



## Cadmium (Cd)

- Need no power supply.
- Simple and robust structure.
- Relatively small mechanical size desired for in-core installation.
- Good stability under temperature & pressure conditions.



# RAW MATERIAL FOR MINERAL INSULATED CABLE

## (I) Sheath Material

Sheath Material	Maximum Operating temperature	Specification	Material Properties	Applications
SS304 AISI 304 1.4301	800°C	ASTM A 269 or ASTM A 213	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.	Used in chemical, petrochemical and fertilizer industries, and as equipment in dairy, food processing, pharmaceutical industries, in hospitals, households as kitchenware, cryogenic vessels and as heat exchanger in air conditioning refrigeration, for machinery in paper, pulp and textile beverage sectors.
SS316 AISI 316 1.4401	800°C	ASTM A 269 or ASTM A 213	An austenitic stainless steel with 2.0 to 3% Mo. which improves corrosion resistance and imparts hot strength characteristics. Used for applications requiring resistance to pitting corrosion. and in halogen atmospheres. Good welding properties	Architectural trims, marine exteriors, chemical processing equipment, food processing equipment, petroleum refining equipment, pharmaceutical equipment, photographic equipment, pulp and paper processing equipment, textile finishing equipment, etc.
SS321 AISI 321 1.4541	800 °C	ASTM A 269 or ASTM A 213	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. used for aircraft exhaust stacks and manifolds, pressure vessels, large mufflers for diesel engines, carburetors, expansions belows, stack liners, fire walls etc.
SS446 AISI 446 1.4749	1150 °C	ASTM A 268	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.
Ss310 / 310S AISI 310 / 310S 1.4845	1100 °C	ASTM A 213	Grade 310S is a low carbon version of grade 310. 310S is less prone to embrittlement and sensitization in service. 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.	Boilers and blast furnaces, cement and brick kilns, glass production, crude oil and petrochemical industries, furnace construction and power stations. Kilns, Heat Exchangers, Radiant Tubes, Muffles, retorts, annealing covers, Tube hangers for petroleum refining and steam boilers, Coal gasifier internal components, Saggars, Furnace parts, conveyor belts, rollers, oven linings, fans, Food processing equipment, Cryogenic structures.
Inconel 600 2.4816	1100 °C	ASTM B 167	Good general resistance to corrosion, resistant to tension crack corrosion. Excellent resistance to oxidation. Not recommended with gases containing CO <sub>2</sub> 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.

# RAW MATERIAL FOR MINERAL INSULATED CABLE

Sheath Material	Maximum Operating temperature	Specification	Material Properties	Applications
Inconel 800 1.4876	1100 °C in air	ASTM B 163	This material provides superior thermal stability due to the addition of titanium and aluminum. Suitable for applications requiring maximum stability under load in addition to scaling resistance. Excellent resistance to carburization 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.
Nimonic 75 2.4951	1100 °C	-	Excellent high-temperature stability and resistance to oxidation and carburization. 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.
Pt 10 % Rh	1300 °C		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 armoring 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.
Copper Tube	250°C	ASTM B 75	Good Corrosion resistance, Antibacterial, Non Magnetic, Good Mechanical Strength	Air Conditioning & Refrigeration, Medical Gas and Vacuum, Fire Sprinklers, Fuel Gas (Natural Gas L.P. Gas) Distribution, Direct Exchange Geothermal Heating/Cooling,

Other sheathed material are available on request

## (ii) Insulation (Magnesium Oxide)

Tempsens supplies MgO as the standard insulator with standard purity of  $\geq 97\%$  as well as MgO with a high purity of  $\geq 99.4\%$  as per specification ASTM E 1652

PURITY	HIGH PURITY ( $\geq 99.4\%$ PURE)	STANDARD PURITY ( $\geq 97\%$ PURE)
COMPOSITION	CONCENTRATION (MASS) %	CONCENTRATION (MASS) %
MgO	99.4 % (min)	97 % (min)
CaO	0.35 % (max)	0.80 % (max)
Al <sub>2</sub> O <sub>3</sub>	0.15 % (max)	1.00 % (max)
Fe <sub>2</sub> O <sub>3</sub>	0.04 % (max)	0.08 % (max)
SiO <sub>2</sub>	0.13 % (max)	1.20 % (max)
C	0.02 % (max)	0.02 % (max)
S	0.005 % (max)	0.005 % (max)
B	0.0035 % (max)	0.0025 % (max)
Cd	0.001 % (max)	0.001 % (max)
B+Cd	0.004 % (max)	0.003 % (max)
Fe	-	0.02 % (max)

Values obtained from specification ASTM E 1652

## (iii) Conductors

1. Thermocouple Conductors (K, J, E, N, R, S, B, T Type)
2. Pure Nickel wire, Pure Copper Wire, Copper Nickel Alloy wire for RTD Extension Cable
3. Nichrome 80-20 wire, Nichrome 60-40 wire etc. for Heater MI cable
4. Pure Copper Wire for MI Copper Cable
5. Inconel 600, SS316L etc. for Coaxial and other special cables

# PROCESSING OF MINERAL INSULATED CABLES

## Sintering Of MgO



Raw MgO is hygroscopic, so it has to be sintered in order to remove the moisture contents. MgO is put inside the furnace at a temperature of  $1280^{\circ}\text{C}$  for around 5 hours.

## Annealing Of Cable



Annealing of MI cable is done in a furnace having five zones at different temperatures depending on material types & properties.

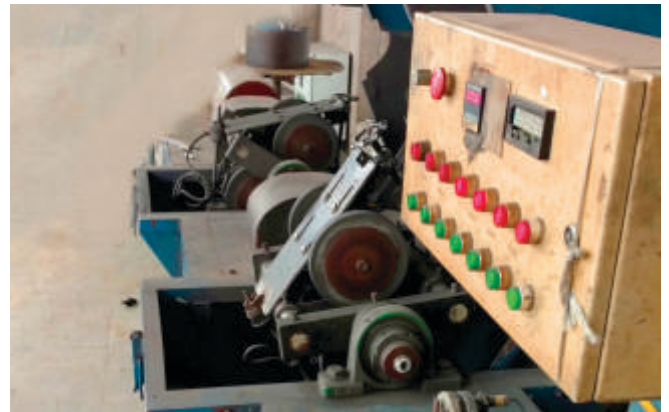
## Drawing Of Sheath with Raw Materials

### Bar Drawing Machine



Employing special equipments step by step reduce the diameter of MI cable.

## Polishing of MI Cable



Polishing has to be performed for better finishing of surface and free from any foreign material.

### Horizontal Drawing Machine (Below 8m)





# TESTING OF MINERAL INSULATED CABLE

## Auto Calibration

Tempsens has facility of auto calibration at three temperature points which is performed on 100 percent Thermocouple MI Cable.



S. No.	Name Of Test	Descriptions	Standard	Test
1	Dimensions test	a) Sheath Outer Diameter	ASTM E585/E585M-09	Routine Test
		b) Sheath Wall Thickness	ASTM E585/E585M-09	Routine Test
		c) Insulation thickness	ASTM E585/E585M-09	Type Test
		d) Conductor Diameter	ASTM E585/E585M-09	Routine Test
2	Insulation Resistance Test	a) At ambient Temperature	ASTM E 839-03	Routine Test
		b) At elevated Temperature	ASTM E 839-03	Type Test
3	Insulation Compaction Density	a) By Tension test	ASTM E 839-03	Type Test
		b) By Calculation	ASTM E 839-03	Type Test
4	Continuity Test	By Measuring	ASTM E 839-03	Routine Test
5	Loop Resistance Test	By Measuring	ASTM E 839-03	Routine Test
6	Sheath Integrity Test	a) Water test	ASTM E 839-03	Routine Test
		b) Helium leak test	ASTM E 839-03	Routine Test
		c) Dye Penetrate Test	ASTM E 839-03	Type Test
		d) Bend Test	ASTM E 839-03 / IEC 60702-1/IEEE 515	Type Test
		e) Tension Test	ASTM E 839-03	Type Test
7	Calibration Test	As per standard Temperature	ANSI MC 96.1 IEC 584-2	Routine Test for MI Thermocouple cable
8	Thermal Cycle Test	At 325°C for 5 Cycle minimum	ASTM E 839-03	Type Test
9	Fire Resistance Test	At 750°C	IEC 60702 Part 1	Type Test for MI Power Cable
10	Flattening Test	At 750°C	According to Cable OD	Type Test for MI Power Cable

All tests are performed in house and as per standard.

# TESTING OF MINERAL INSULATED CABLE

## Packaging and Storage


Stored in dry & dust free atmosphere with proper tag. The magnesium oxide insulation is hygroscopic. To prevent moisture penetration, both ends are sealed. Under extreme conditions some moisture absorption could take place in spite of the sealing, so a dry place is desirable for storage.

When pieces are cut from stock lengths, the exposed ends to be sealed at once. If moisture enters, this will lower the insulation resistance and may prove troublesome in welding. Moisture Penetration can be corrected by heating the sheath.





## Tagging

Each coil is fitted with a temporary seal to prevent moisture ingress during storage and shipping. Each coil is tagged with a unique identification number for traceability purposes.

A-190, Road No.5, M.I.A., Udaipur-313003 (Rajasthan) INDIA info@tempens.com								
Type :	Length :							
Serial No. :	Core :							
Sheath :	OD :							
Deviation								
<table border="1"><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>								
Date :	Final Inspection :							

## Dispatch and Test Certificate

		TEMPSENS INSTRUMENTS (PVT.) LTD. (ENTIRE) A-190, ROAD NO. 5, M.I.A., UDAIPUR-313003, RAJASTHAN, INDIA PHONE : +91 294 240250 FAX : +91 294 240250 200770 E-MAIL : info@tempens.com	
TEST CERTIFICATE			
Certificate No : 1847/13/TC-063		Date : 06/05/2018	
Customer Name :			
P.O. Name : AS PER MAIL	P.O. Date : 2018-02-01	Lot No : 30	
P.O. Name : T-102130/3118		P.O. Date : 2018-02-01	
Type : 800C18		Description : 8.0 mm GILK Type - DUPLEX - 55118 Sheath	
MATERIAL CERTIFICATE			
Type Test Report		Conductor Chemical Analysis	
Sheath : 90119		T.C. No : 1000000000	
T.C. No : 90119		T.C. No : 1000000000	
F.R. No : 90119		F.R. No : 1000000000	
Chemical Analysis		Chemical Analysis	
C : 0.002 %		C : 0.002 %	
Si : 0.002 %		Si : 0.002 %	
Mn : 0.002 %		Mn : 0.002 %	
P : 0.002 %		P : 0.002 %	
S : 0.002 %		S : 0.002 %	
Fe : 0.002 %		Fe : 0.002 %	

		TEMPSENS INSTRUMENTS (PVT.) LTD. (ENTIRE) A-190, ROAD NO. 5, M.I.A., UDAIPUR-313003, RAJASTHAN, INDIA PHONE : +91 294 240250 FAX : +91 294 240250 200770 E-MAIL : info@tempens.com	
BMF CHARACTERISTICS AND ADDITIONAL MEASUREMENT			
Serial No.	400 °C	500 °C	600 °C
1000	0.002 %	0.002 %	0.002 %
2000	0.002 %	0.002 %	0.002 %
3000	0.002 %	0.002 %	0.002 %
4000	0.002 %	0.002 %	0.002 %
5000	0.002 %	0.002 %	0.002 %
6000	0.002 %	0.002 %	0.002 %
7000	0.002 %	0.002 %	0.002 %
8000	0.002 %	0.002 %	0.002 %
9000	0.002 %	0.002 %	0.002 %
10000	0.002 %	0.002 %	0.002 %
Through Our Inspection, Certification of MI Cables comply with Standard : IEC 60480-2 Class 1			
INSPECTED BY		APPROVED BY	
DESIGNER Q.C.		MANAGER Q.C.	

Test Certificate

# ENDURES MINERAL INSULATED CABLES

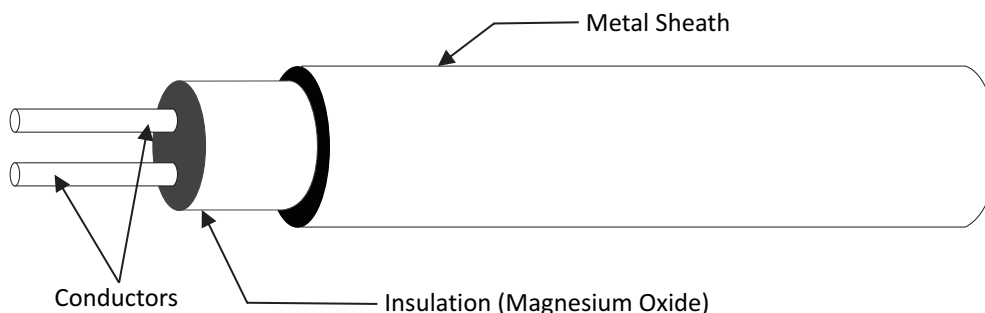
## Low Drift Mineral Insulated Cables for Use up to 1200°C

Tempsens is pleased to offer **EnduRes** sheath material of MI cables.

### The chemical composition wt % of EnduRes :

Chromium	:	22
Nickel	:	Balance
Molybdenum	:	3
Silicon	:	1.4
Carbon	:	0.01 max.

Rare Earth Elements



The Special sheathing offer high-temperature corrosion resistance and strength; with very low long term drift.

EnduRes is a Ni-22% Cr alloy with the addition of 1.4% Si, 3.0% Mo and rare earth elements. Elements such as manganese and aluminum, which can diffuse through the thermocouple insulator and contaminate the thermo-element wires leading to emf drift over time, are controlled at very low levels thus giving excellent long term performance. In addition, the composition is similar to the thermo-element wires, which further reduces the potential for the diffusion of elements between the alloys. The sheath has outstanding static and cyclic oxidation resistance at temperatures up to 1200°C.

MI cables are available in K/N type, simplex and duplex in various diameters.

OD (MM)	TYPE	SHEATH	MGO GRADE	ACCURACY
0.5	K - Simplex	316 En	STANDARD (≥ 96% PURE)	CLASS 1
1.0	KK - Duplex			CLASS 2
1.5	N - Simplex	<b>Note:-</b> Diagonal Element Supplied Unless Specified	HIGH PURITY (≥ 99.4% PURE)	As per
2.0				IEC 584-2
2.2	or			
3.0	ANSI MC 96.1			
4.5				
5.0				
6.0				
8.0				
9.5				
10.0				



## CERTIFICATES



## THERMAL ENGINEERING SOLUTIONS



[www.tempsens.com](http://www.tempsens.com)

[www.thermowellworld.com](http://www.thermowellworld.com) | [www.temperaturecalibration.in](http://www.temperaturecalibration.in) | [www.glassthermocouples.com](http://www.glassthermocouples.com) | [www.compensatingcables.net](http://www.compensatingcables.net) | [www.marathonheater.in](http://www.marathonheater.in)

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