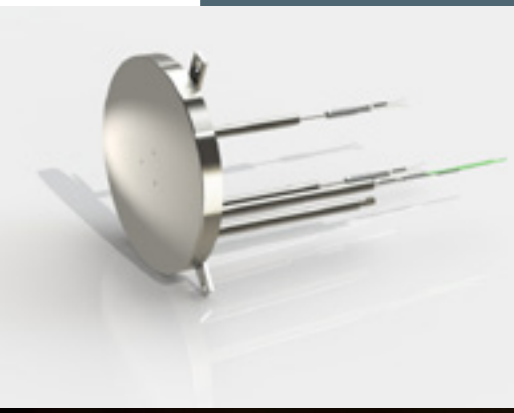
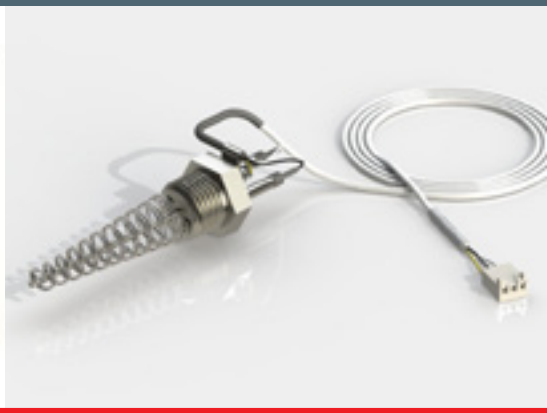
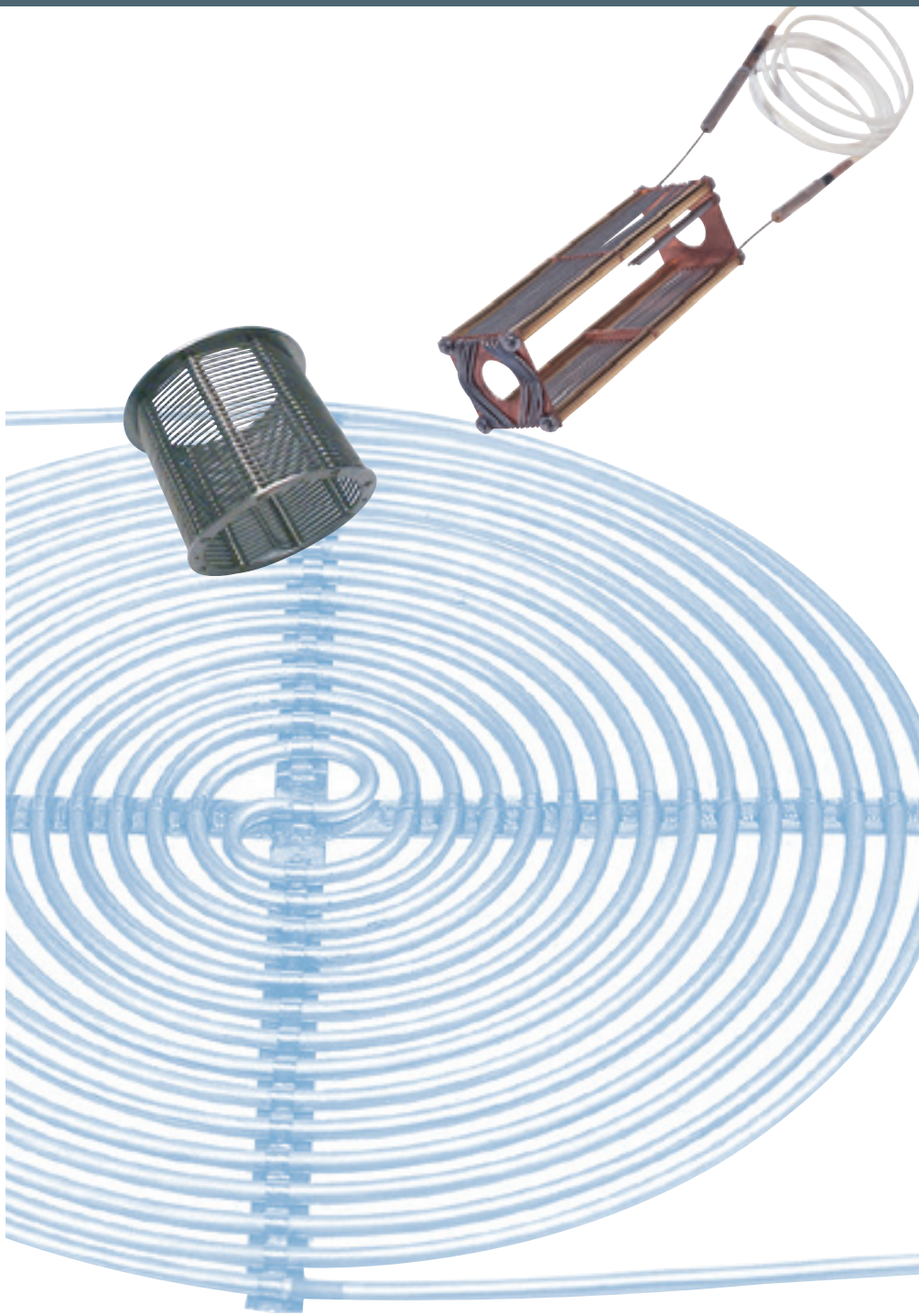
TEMPERATURE MEASUREMENT SOLUTIONS

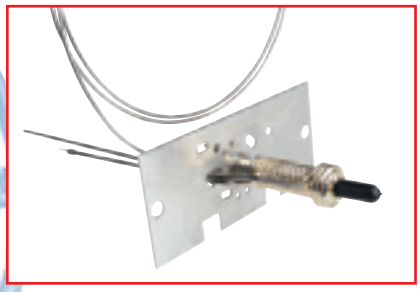


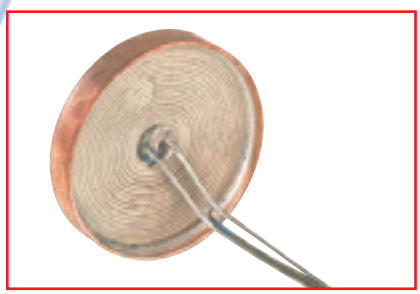


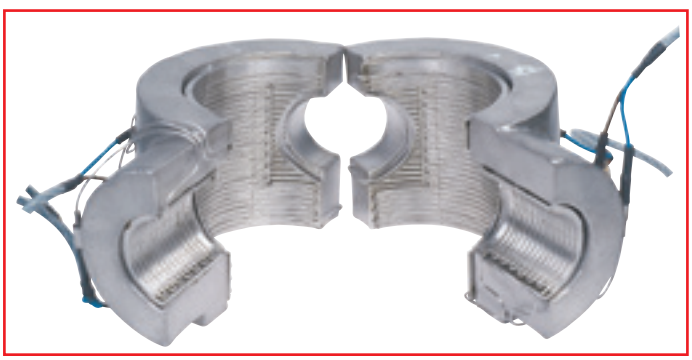
How to choose your THERMOCOAX heating element ?

THERMOCOAX





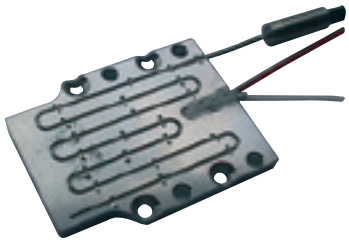




Summary

HEATING

Introduction to heating



Resistance heating

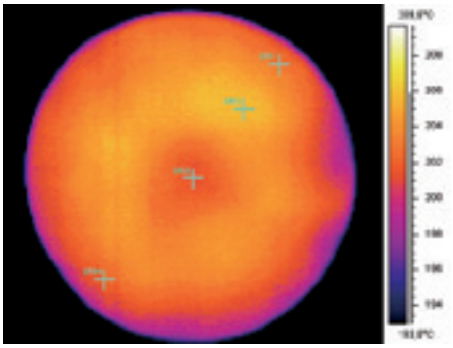
Resistance heating is one of the first applications of electricity. In the course of a century, thousands of heating problems have been solved ranging from megawatts down to a few watts, or less.

The fundamentals are always the same, the requirements and solutions widely different.

Between a large furnace constructed as an individual unit and a domestic heater produced in large quantities, there exist a number of cases where no «ready-made» solution is available.

For such cases, THERMOCOAX often presents a suitable answer to:

- Heating from the cryogenic temperatures up to 1000°C.
- Heat dissipation either very low or very high power (from few watts to several tens of kilowatts).
- For use in air, under vaccum or high pressure and in any corrosive enviroment compatible with the sheath material.
- In applications requiring high reliability components.



Suitable THERMOCOAX solution for each case

Heat transfer

Heat tranfer only takes place when there is a difference of temperature between two bodies.

In electrical heating this difference always occurs at the point where energy is dissipated and its surroundings.

The heat transfer mechanism is always a combinaison of:

- conduction
- convection
- radiation

When heating solids, conduction plays a major role ; in a liquid, conduction is always the start but convection will take over its importance.

In a gaseous medium, one can hardly speak of conduction, and heat transfer is mainly a question of convection. Radiation, though always present is strongly dependant on its temperature level and, often, the only way of heat transfer in vacuum.

In heat transfer these three phenomena play a role, only local circumstances will define the share played by each.

THERMOCOAX will provide a suitable solution to each heating application. The following pages describe the various heating cables which will meet any requirements.

About THERMOCOAX heating elements

Construction of THERMOCOAX heating elements

The THERMOCOAX heating elements are screened electrical resistances of small diameter designed to be shaped and incorporated into heating systems from the simplest to the most sophisticated.

They consist of one or two straight current-carrying cores in a flexible metal sheath, electrically insulated from one another and from the sheath by means of a highly compacted refractory powder.

To cope with the problems of high heat density dissipation, the special THERMOCOAX cold-end construction has been developed. Here the resistive core is extended at both ends by a different material of significantly lower resistance.

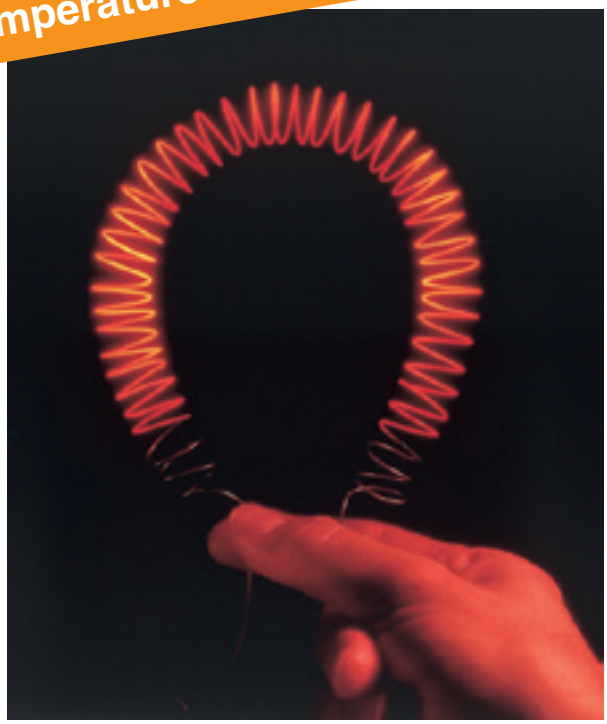
The outer sheath is continuous only the inner-core construction changes. These ends can be fitted with connectors.

By combining small diameter and hardpacked insulation, a heater made of such a cable can be given virtually any shape without deterioration of either its insulation or its sheath.

To improve the heat contact, and thus heat transfer, the cable can be deformed, brazed or welded into its optimum position.

Minimum bending radius: 3 x OD

From cryogenic temperatures up to 1000°C



Easy fitting

Shielding

THERMOCOAX heaters can be attached directly to metal parts

Tight bending radius

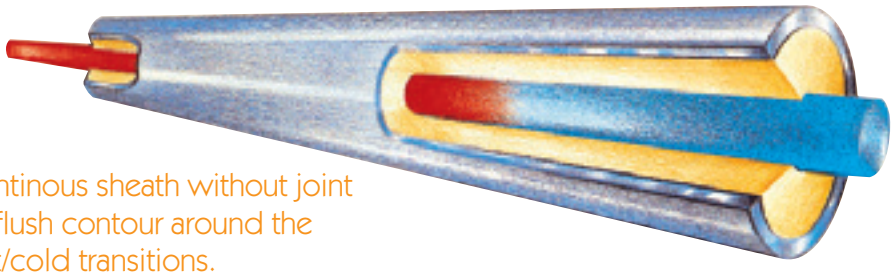
Only 3 times the outer diameter

Small dimensions

The heat can be generated exactly where it is required thus power losses are reduced as well as power consumption

Excellent heat exchange

The heater can be brazed onto any metal piece



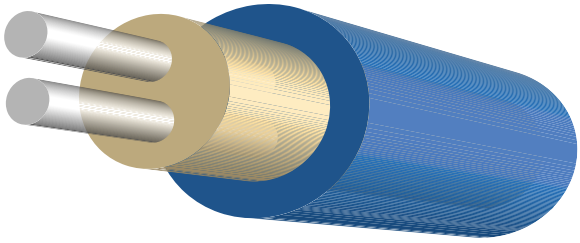
Continous sheath without joint or flush contour around the hot/cold transitions.

Heating elements materials

Core

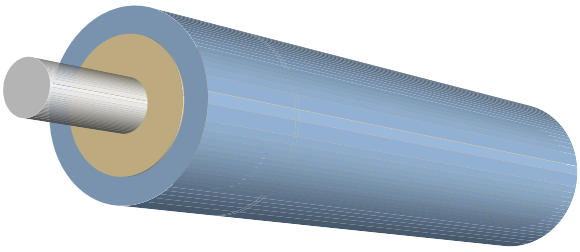
For the heating part:

Generally nickel-chromium 80/20, for applications which require relatively low and self-limited powers, Balco® or pure nickel and coiled core for relatively low power with standard voltage (i.e. 110V - 220 V).



For the cold parts:

Copper (in some special cases, pure nickel).



Insulant

Highly compacted mineral powder, generally magnesium oxide.

Sheath

For temperatures not exceeding 600°C:
Austenitic stainless steel, AISI 304L,

For temperatures up to 1000°C:
Inconel® alloy 600.

The materials listed here are standard. Others are available on request.

Type	Standards	Use
Ac Austenitic stainless steel, Low carbon content	NF Z2CN18-10 DIN X2Cr - NI 18.9 1.4306 BS 304 S12 AISI 304L	■ Easy to weld, ■ Corrosion and heat resistant steel ■ Good resistance against a variety of aggressive media, such as steam, gases etc… ■ Small sensitivity against intra-crystalline corrosion because of the small carbon content, ■ Maximum temperature for continuous utilisation: 800°C **Use:** Nuclear energy, Chemical, Food and Car industry, Research and Development
I Inconel® alloy 600	NF NC15Fe DIN 17742 ; 2-4816 AISI B168, 163, 167	■ Resistant against corrosion and low electrochemical corrosion, ■ In oxidizing atmosphere usable up to 1150°C, ■ In carbon dioxide usable up to 500°C, ■ In sulphurous atmosphere not recommended over 500°C, ■ Inconel® is permeable to hydrogen at high temperatures, ■ In chloride-free water, it can be used up to 500°C. **Use**: in high temperature and corrosive atmosphere

Heating elements materials

Physical properties of the sheath and cores materials

	Sheath		Conductors			
	Ac	I	Cu	Ni	Ba	Nc
Materials	Stainless steel 304L	Inconel® alloy 600	Cuc2	Ni 270	Balco®	Nickel-chromium 80/20
Melting temperature (°C)	1 425	1 400	1 080	1 440	1 425	1 380
Maximum working temperature (°C)	800	1 050	300	800	700	1 050
Thermal expansion coefficient (10^{-6}/mK)	17.3	13.3	18	13.3	13	15
Specific heat (J/kg K)	500	444	385	444	460	440
Thermal conductivity (W/mK)	14.7	14.8	394	85.7	14	15
Resistivity per centimetre (μΩ.cm)	72	103	1.8	7.5	118	112
Temperature coefficient of resistivity between 0 and 100°C^{-1}	0.0125	0.0001	0.0037	0.0076	0.0045	0.0001

High dissipated power

Increase the dissipated power.

To increase the dissipated power without excessively heating up the connectors, a solution with swaging could be the answer:

Median swaging

Allows the power to be doubled.
Several combinations of diameters are possible such as:

6 - 4 - 6 mm
4 - 3 - 4 mm
3 - 2 - 3 mm
2 - 1.5 - 2 mm

Tip swaging

Allows multiplication of the power by a factor of 4.

In this case, the end of the cable is normally grounded. The ratio between the diameters is 1 to 2.

This solution can be used when the power supply does not exceed 48 VDC or 24 VAC.

The swaging can be used on heating elements without cold ends as well with cold ends.

The purpose is to double or quadruple the power of the element.

Mounting methods

Thanks to the metallic sheath and the electrically insulated conductor, the THERMOCOAX heating elements can be fitted onto any kind of material, either insulants or metal, in an infinite number of ways. Effectively, they can be bent, wrapped around a part, grooved or even brazed.

The heat transfer between core and sheath of THERMOCOAX heating cable is basically ideal on relatively high power levels. When mounting the heater to an object care should be taken that the heat transfer capabilities remain in balance with the required power or temperature distribution.

This means, in practice, that any region of lower heat conduction, and thus chance of overheating, should be prevented.

The choice of mounting is not only dependant upon heat flux requirements but other parameters such as temperature level, available space, response (heating up, cooling down) and supply voltage form a set of primary conditions.

In the sequence of increasing heat flux density a number of mounting methods are discussed.

As a result of the flexibility of the cable's construction, THERMOCOAX heaters may be sharply bent with a minimum radius equal to the overall diameter.

Their minimum bending radius equals only:
- twice the outer diameter of the cable with stainless steel sheath
- 3 times the outer diameter of the cable with Inconel sheath.

Repeated bending of THERMOCOAX cables does not result in damage to the sheathing or the wires nor does it unfavourably affect the insulation properties.

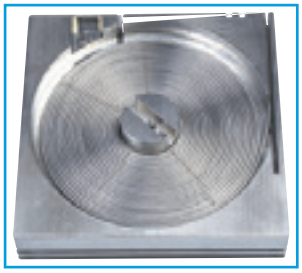
Low thermal flux <3 W/cm^2, i.e. < 100 W/m for a cable OD 2 mm

The power density is low. Therefore, regardless of the temperature, it is not important to obtain a perfect thermal contact between the element and the part to be heated.

Consequently, all fixing methods are suitable, even the simplest (figures 1 to 4).

Mean thermal flux 3 to 6 W/cm^2, i.e. < 300 W/m for a cable OD 2 mm

- Should the temperature be lower than 300°C, the thermal flux can be considered low and all fixing methods are suitable.
- Should the temperature be between 300 and 600°C, the power density is high and the fixing methods considered must ensure good thermal contact between the heating element and the piece. Therefore, the fixing methods best suited are those shown by figures 5 to 9.
- Over 600°C, a very good thermal contact is required. See fig. 6 to 9.



High thermal flux > 6 W/cm^2, i.e. 300 to 1000 W/m for a cable OD 2 mm

For this range of high flux, it is necessary to obtain very good thermal contact all along the heating length or even better, on its whole circumference. Only fixing methods shown by figures 7, 8 and 9 are suitable.

Mounting methods

Special bending properties !

The higher the temperature and the power density, the better the heat exchange has to be. There are several suitable methods of fitting to facilitate the heat exchange. The following are given in increasing order of efficiency: inserted into grooves, metal sprayed, cast into metal i.e. zinc alloy, aluminium, etc.

1
The heating element is wrapped around the part.

2
The heating element is put into the tube by its own spring effect.

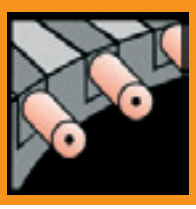
3
The heating element is maintained by a screwed clamp.

4
The heating element is fixed by spot welded brackets.

5
The heating element is sandwiched between 2 plates.

6
The heating element is brazed or fixed by metal-spraying on a tube.

7
The heating element is inserted into grooves and soft metal covered.



8
The heating element is brazed into grooves.

9
The heating element is cast in metal.

Choice of the most suitable heater

A comprehensive range

Whatever the requested power, temperature or media, there is always a THERMOCOAX choice. The chart shows the diversity of possible solutions.

Types	Ends	Code	Diameters in mm*						
			0.5	1	1.5	2	2.5	3	4
Single core	With cold ends	Standard SEI		●	●	●		●	
		Standard SEA		●	●	●			
		On request ZEZ		●	●	●	●	●	●
		On request ZUZ			●	●	●	●	●
	Without cold end	1 Nc	●	●	●	●	●	●	●
		1 Hc		●	●	●	●	●	●
	With true cold ends	TET or TUT			●	●	●	●	
	With median swaging				●	●		●	●
	Self-regulated	1 N (nickel)	●	●	●	●			
		1 Ba (Balco)			●	●			
	With coiled core	NWN, NWNN, NWBaN			●				
Twin core	Without cold end	2 NcNc	●	●	●	●	●	●	●
		2 NN		●	●	●	●	●	
		2 BaBa		●	●	●			
	With cold ends	2 ZE		●	●	●	●	●	●

* other diameters on request

How to choose your THERMOCOAX heating element

In any application somewhat well defined requirements usually exist. Such requirements may be the power, final temperature, rate of temperature rise, often combined with available space limitations or supply-voltage restrictions.

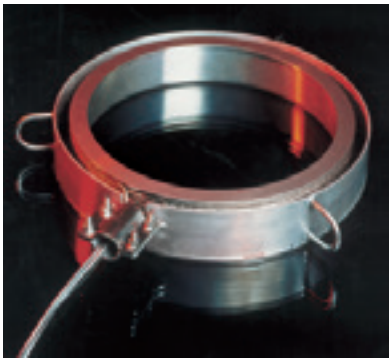
As the application field of THERMOCOAX Heaters is enormously diversified, a complete description of all possibilities would become impractical; a few simple rules have been established for selecting a good heater.

However, in the majority of applications, the solution can be found with the THERMOCOAX standard heating elements, i.e. single core with cold ends.

To provide the largest choice in terms of heated length, the 2 mm outer diameter SEI range should be adopted if possible.
When specific lengths or resistances are required, then type ZEZ or ZUZ should be used.

Once the temperature is defined and the power **P** estimated, the heating element will be determined. When the voltage **U** is imposed, the line resistance **R** has to be calculated: $R=U^2/P$, then the hot part will be deduced: $L=R/r$, r being the line resistance per metre of the chosen element.
The heating element can be stabilized at equilibrium temperature by means of a controller or within a laboratory by means of a voltage set-point adjuster.

More diameters: Please ask.



Your THERMOCOAX heating solution

Unique solution

THERMOCOAX has developed an extensive range of heaters and heating assemblies as standard components of custom assemblies.

To help us to define your heater or your heating solution, some basic information are needed.

What	Properties
Working temperature	Starting at °C - Working up to °C
Environment	Air ❑ Under vacuum ❑ Liquid ❑ Pressure ❑ Gas ❑ Please specify Please specify Others: please specify
The piece to heat up	Materials: steel, liquid, gas, plastic, oil…
	Weight kg
	Dimensions
	Hot / cold transition
	Support piece provided: YES NO
Electrical properties	Power W Intensity A Resistance Ω Voltage V
Other information	
Tests	
Qualification / Certification	QA Control, Certification: ML, ANSI, ISO, ATEX…
Your need	Prototypes: ❑ Series production: pieces
Assembly drawing	Provided ❑ Realised by THERMOCOAX ❑

Company .....
Address .....
.....
.....
Your name.....
Your Dpt .....
e-mail .....
Phone .....
Fax .....

The best explanation is the sketch. Do not hesitate to send it with your request. Please fax this form to your contact

The THERMOCOAX standard range

- SEA types with stainless steel sheath well-suited from the cryogenic temperatures up to +600°C
- SEI types with Inconel ® alloy sheath well-suited from the cryogenic temperatures up to +1000°C

Outer diameter: 2 and 3 mm

SHEATH			Hot part in	at 20°C	POWER in WATTS										
Stainless Steel 600°C code	Inconel® alloy 1000°C code	O.D. mm	m	Ω	100	200	350	500	750	1000	1250	1500	1750	2000	3500
					Supply voltage (the indicated voltage produces the power mentioned above)										
	SEI 20/50	2	0.5	1.6	12	18	24								
	SEI 20/100	2	1	3.1	18	24	33	40							
SEA 20/150		2	1.5	4.7	22	30	40	48	60	70					
	SEI 20/200	2	2	6.2	24	36	48	56	70	80	90				
SEA 20/300		2	3	9.3		45	60	70	80	100	110	120			
	SEI 20/400	2	4	12.5			70	80	100	110	125	140	150		
SEA 20/500		2	5	15.6				90	110	125	140	150	165	175	
	SEI 20/600	2	6	18.6				95	120	140	150	165	180	190	
SEA 20/800		2	8	25					140	160	180	195	210	220	
	SEI 20/800	2	8	25					140	160	180	195	210	220	
	SEI 30/500	3	5	7				60	70	85	95	100	110	120	
	SEI 30/800	3	8	11.2					90	105	120	130	140	150	
	SEI 30/1000	3	10	14						120	130	145	155	165	220

Outer diameter: 1 and 1.5 mm

SHEATH			Hot part in	at 20°C	POWER in WATTS										
Stainless Steel 600°C code	Inconel® alloy 1000°C code	O.D. mm	m	Ω	25	50	75	100	150	200	350	500	750	1000	1500
					Supply voltage (the indicated voltage produces the power mentioned above)										
	SEI 10/25	1	0.25	3.1	9	12	15	18							
	SEI 10/50	1	0.50	6.2		18	22	25	30	35					
SEA 10/75		1	0.75	9.4			28	30	38	45					
	SEI 10/100	1	1	12.5			30	35	45	50	65				
SEA 10/150		1	1.5	18.8				45	55	60	80	95			
	SEI 10/200	1	2	25				50	60	70	95	110	135		
	SEI 15/50	1.5	0.5	2.8		12	15	18	20	24					
	SEI 15/100	1.5	1	5.5			20	24	28	33	45	50			
SEA 15/150		1.5	1.5	8.2				28	35	40	55	65	80		
	SEI 15/200	1.5	2	11					40	48	60	75	90		
SEA 15/300		1.5	3	16.5						60	75	90	110	130	
	SEI 15/400	1.5	4	22							90	105	130	150	
	SEI 15/600	1.5	6	33								130	16	18	220

Mounting:

It is necessary to take into consideration the indicated voltage values (see also pages 8 & 9):

- **Blue:** low voltage: every mounting method is suitable, even simple wrapping.
- **Yellow:** high voltage: the fixing method must ensure a good thermal contact.

Tolerances:

Diameter: ±0.05 mm.

Hot part length:

Cable ≤ 1 m: ±10% - mini: ±50 mm

Cable >1 m: ±5% - mini: ±100 mm

Cold part minimum length guaranteed:

Hot part < 2 m → cold part = 0.50 m

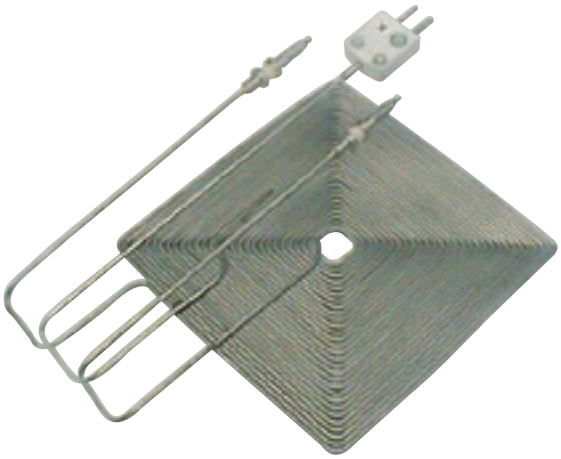
Hot part ≥ 2 m → cold part = 1 m

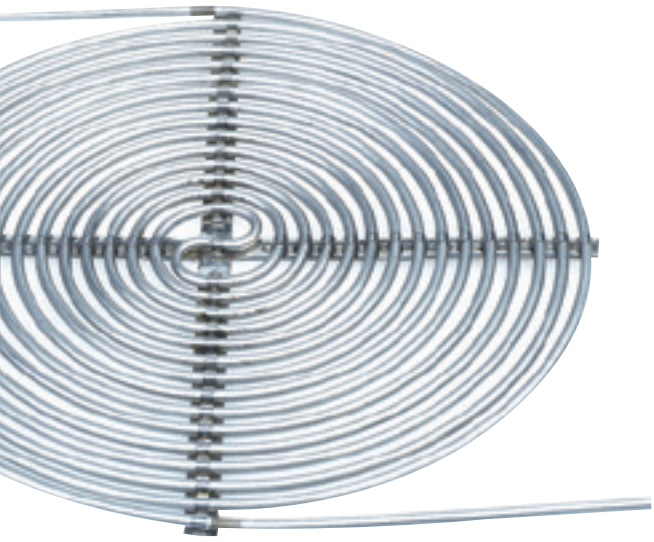
Single core without cold ends: 1 Nc and 1 Hc types

Heaters insulated from the sheath by highly compacted mineral powder.

Suitable for all kind of applications when the power density is low (<100 W/m) and the ends do not go through an insulated wall.

- Working temperature: from cryogenic temperatures up to 1000°C with Inconel® alloy sheath.
- Outer diameter range available from 0.5 up to 6 mm and length up to 150 m
- Compatible UHV, O_2, pressure up to 2000 bars
- Minimum bending radius:
  Stainless steel sheath: twice the outer diameter,
  Inconel® sheath: 3 times the outer diameter





Materials

- **Core:** nickel-chromium 80/20 over the whole length.
- **Insulant:** highly compacted mineral powder.
- **Standard sheath:** stainless steel 304L - DIN 1.4306 (Code Ac) or Inconel® alloy 600 (Code I) according to the working temperature.
  Sheath materials for special applications:
  austenitic stainless steels:
  - titanium stabilized (AISI 321, DIN 1.4541)
  - niobium stabilized (AISI 347, DIN 1.4550)
  - Molybdenum stabilized, low carbon content (AISI 316L, DIN 1.4404)
  - refractory stainless steel (AISI 310, DIN 1.4841)
    Please consult us

Standard types

Sheath / O.D. in mm	Stainless steel 304L	Inconel® alloy 600	Stainless steel 304L	Inconel® alloy 600
	1 Nc Ac	1 Nc I	1 Hc Ac	1 Hc I
	Line resistance in ohms / m at 20°C			
0.5	50		-	
1.0	12.5		28	
1.5	5.5		12.4	
2.0	3.1		7	
2.5	1.98		4.5	
3.0	1.38		3.1	
4.0	0.77		1.75	

Tolerances:

Line resistance: ±8% - variation from 0 up to 1000°C: ~5%
Diameter: ±0.05 mm.
Lengths:

- in several coils with a tolerance of -0%, +10% on the total length,
- on request only and depending on availability:
  in one length with a tolerance of -0%, +10%,
  cut to length and equipped with connectors: -0%, +2%

Maximum voltage

The voltage is determined by calculation. However, it must be limited at 110V for diameters 1 and 1.5 mm and to 220/380V for larger diameters.

When temperature exceeds 600°C, it is advisable to use an isolating transformer.

Single core with cold ends: ZEZ and ZUZ types

These types are the most commonly used. With the Inconel® alloy sheath and with fixed lengths, they are available standard under the names SEI and SEA.

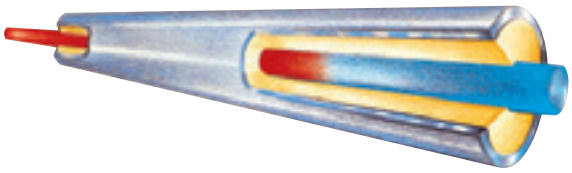
They are suitable for all types of applications with either low or high power and they are chosen according to the line resistance.

Maximum working temperature:
- Hot part: 1000°C
- Cold parts: 600°C

Materials

- **Core:** nickel-chromium 80/20 elongated at each end by a conducting wire made of copper plated in stainless steel.
- **Insulant:** highly compacted mineral powder.
- **Standard sheath:** continuous over the complete length, stainless steel (Ac) or Inconel® 600 alloy (I), without any joints, flush contour around the hot/cold transitions.

Continuous sheath without joint or flush contour around the hot/cold transitions.



Standard types

Sheath material	O.D.* in mm	Minimum heating length in cm	ZEZ		ZUZ	
			Line resistance in ohms / m at 20°C			
			Hot part	Cold part	Hot part	Cold part
Stainless steel (Ac) or Inconel® (I)	1.0	100	12.5	0.6	-	-
	1.5	50	5.5	0.3	12.4	0.3
	2.0	25	3.1	0.15	7.0	0.15
	2.5	25	2.0	0.1	4.5	0.1
	3.0	25	1.4	0.07	3.1	0.07
	4.0	25	0.78	0.04	1.8	0.04

(*) Other diameters on request

Tolerances:

Line resistance: ±8% - on the hot part

Hot part length:
- Cable ≤ 1 m: ±10% - mini: ±50 mm
- Cable >1 m: ±5% - mini: ±100 mm

Cold part minimum length guaranteed:
- Hot part < 2 m → cold part = 0.50 m
- Hot part ≥ 2 m → cold part = 1 m

Diameter: ±0.05 mm.

Maximum voltage

The voltage is determined by calculation. However, it must be limited at 110V for diameters 1 and 1.5 mm and to 220/380V for larger diameters.

When temperature exceeds 600°C, it is advisable to use an isolating transformer.

Single core with true cold ends: TET and TUT types

These types are recommended when the specific power (W/m) is very high and the cold ends have to be long.

The materials and characteristics are identical to those of the ZEZ or ZUZ types except for the electrical resistance of the core at the cold ends: the rate of the resistances per metre between hot part and cold ends are:

- about 80 for TET types,
- about 160 for TUT types.

This ratio diminishes when the cold ends are driven to a temperature of 300°C.

- Maximum temperature:
  - hot part: 1000°C
  - cold part: 300°C
- Outer diameter range available from 0.5 up to 6 mm and length up to 150 m
- Compatible UHV, O_2, pressure up to 2000 bars
- Minimum bending radius:
  - Stainless steel sheath: twice the outer diameter,
  - Inconel® sheath: 3 times the outer diameter

Materials

- **Core:** nickel-chromium 80/20 elongated at each end by a conducting wire made of zirconium copper plated in stainless steel.
- **Insulant:** highly compacted mineral powder.
- **Sheath:** continuous over the complete length, stainless steel (Ac) or Inconel® 600 alloy (I), without any joints, flush contour around the hot/cold transitions.

Standard types

Sheath material	O.D. in mm	Minimum heating length in cm	TET		TUT	
			Line resistance in ohms / m at 20°C			
			Hot part	Cold part	Hot part	Cold part
Stainless steel (Ac) or Inconel® (I)	1.5	100	5.5	0.07	12.4	0.07
	2.0	100	3.1	0.04	7.0	0.04
	2.5	100	2.0	0.03	4.5	0.03
	3.0	100	1.4	0.02	3.1	0.02

Tolerances:

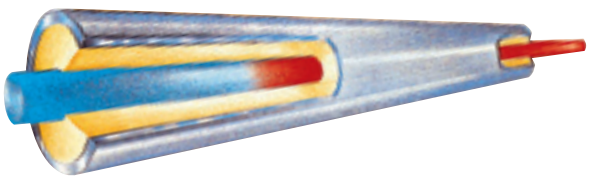
Line resistance: ±8% on the hot part
Hot part length: ±5% with ±100 mm minimum
Diameter: ±0.05 mm.

Maximum voltage

The voltage is determined by calculation. However, it must be limited at 110V for diameters 1 and 1.5 mm and to 220/380V for larger diameters.

When temperature exceeds 600°C, it is advisable to use an isolating transformer.

Continuous sheath without joint or flush contour around the hot/cold transitions.



Single core self-regulated: 1 N and 1 Ba types

- Nickel core: 1 N type
- Balco® core: 1 Ba type

The THERMOCOAX heating elements are used for applications which require relatively low powers (from tens to hundreds of watts) and particularly for de-icing components on aircraft.

The increase in resistance of nickel or Balco with the temperature allows limitation of temperature without a thermostat or regulator.

The sheath and the insulant are identical to the 1 NC type heating element (page 13). Only the nature of the core is different: nickel or Balco (nickel alloy).

Materials

- **Core:** nickel or Balco
- **Insulant:** highly compacted mineral powder.
- **Sheath:** stainless steel (Ac) or Inconel® 600 alloy (I) according to the temperature.

Standard types

Sheath material	O.D. in mm	1N		1Ba	
		Line resistance in ohms / m at 20°C			
		at 20°C	at 600°C	at 20°C	at 600°C
Stainless steel (Ac) or Inconel® (I)	0.5	5	24	-	-
	1.0	1.2	6	4	19
	1.5	0.53	2.5	1.8	8
	2.0	0.3	1.5	1	5

Tolerances:

Line resistance: ±10%
Diameter: ±0.05 mm.

The characteristics are also identical to the 1 NC type except for the line resistance which varies with temperature.

As for the nickel-chromium heating elements, the thermal dissipation can be diminished at the ends and particularly at the connectors by means of a median swaging or on the tip with earth return.

These elements can be manufactured on request subject to minimum economic batch quantities.

Single core with coiled core: NW types

- Nickel-chromium core: NWN type
- Nickel core: NWNN type
- Balco® wire: NWBaN type

These heating elements are intended for applications requiring low power within a small space.
As an example, these THERMOCOAX elements are used in the manufacture of miniature heating collars intended for injection moulding nozzles.

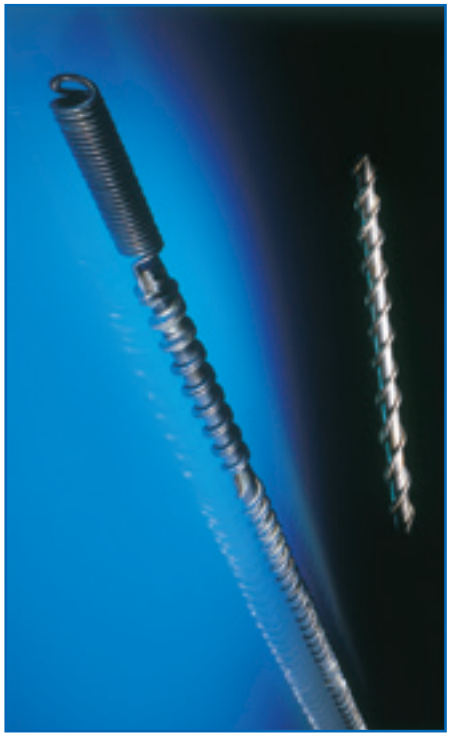
Materials

- **Core:**
  Hot part: nickel-chromium or when the power has to be self-limited, nickel or Balco®
  Cold part: nickel
- **Insulant:** highly compacted mineral powder.
- **Sheath:** stainless steel (Ac)

Characteristics

- **Power:** in hundreds of watts
- **Voltage:** 110/220 V
- **Hot part:** maximum 1 m (length)
- **Temperature:** 500°C maximum

For any information concerning these products, please consult us. They can be supplied subject to availability or within economic batch quantities.



Standard types

O.D. in mm	NWN		NWBaN		NWNN	
	Line resistance in ohms / m at 20°C					
	mini	maxi	mini	maxi	mini	maxi
1.5	70	700	20	160	6	50
2.2	30	1 000	5	180	2	65
3.2	30	1 250	5	230	2	80

Tolerances:

Line resistance: ±10% - please consult us for maximum resistance.
Diameter: ±0.05 mm.

Twin core with and without cold ends, with tip swaging

The twin core heating elements are usually recommended for:

- Low wattage applications (generally lower than 200 W),
- Low power supply.

It is advised not to have a heating length longer than 2 m. Please consult us.

The main advantage of the twin core heating element is that:

- The conductors come off the sheath at only one end, this makes it easier to install in systems requiring compactibility or gas tightness.

Similar to the single core, they can be producted in 3 versions:

Without cold ends

- 2 NcNc type: Constant power
- 2 BaBa type: Self-regulated

With cold end

- 2 ZE type
  This type should be used when the linear power is higher than 100 W/m or the end has to pass through an insulated wall.

With tip swaging

- 2 NcNc, 2 BaBa, 2 ZE types
  The larger diameter is considered to be the cold part and therefore the power in the heated length can be increased.

Materials

- **Core:**
  Nickel-chromium (2NcNc type) or Balco (2BaBa type), for the 2ZE type, the nickel-chromium cores are extended by copper cores.
- **Insulant:** highly compacted mineral powder.
- **Sheath:** stainless steel (Ac) or Inconel® 600 alloy

Standard types

Sheath material	O.D. in mm	2 NcNc	2 BaBa	2 ZE	
				Hot part	Cold part
		loop resistance in ohms / m at 20° C			
Stainless steel (Ac) or Inconel® (I)	0.5	328	-	-	-
	1.0	82	16	62.5	< 5.80
	1.5	36.4	7.1	27.8	< 2.50
	2.0	20.5	4	15.6	< 1.40
	2.5	13.1	-	10	< 0.75
	3.0	9.1	-	6.9	< 0.37
	4.0	5.1	-	3.9	< 0.22

Tolerances:

Loop resistance of the hot part: ±10%. Diameter: ±0.05 mm.

Maximum voltage

The voltage is determined by calculation. However, it must be limited at 110V for diameters 1 and 1.5 mm and to 220/380V for larger diameters.

When temperature exceeds 600°C, it is advisable to use an isolating transformer.

Connection

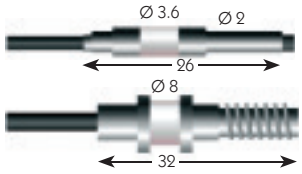
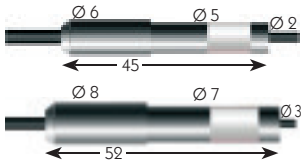
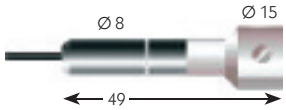
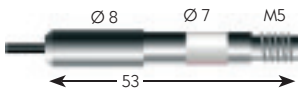
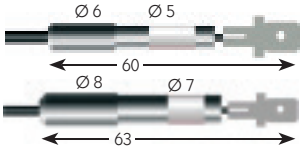
THERMOCOAX heating elements are designed to work in very diverse and severe conditions.

Our connectors range covers this diversity and the specific requirements of any application.

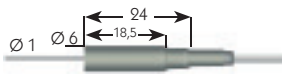
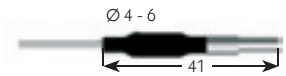
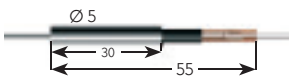
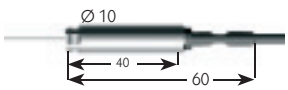
Generally, the connections are mounted in our workshops.

In this case, the cold ends are cut to the required length.

Metal / ceramic connection

		Type Code	For heating element Ø (mm)	Max. working tempera-ture	Max. current (A)*	Power supply
CP 10 **CP** 15-45		CP 10 CP 15 CP 20 CP 30 CP 35 CP 40 CP 45	1 1.5 2 3 3.5 4 4.5	600°C short periods 500°C conti-nuous	10 15 20 30 32 35 38	Socket (for CP10) + Adapter (from CP10 to 30 - other Ø: please consult us).
CV 10 to 20 **CV** 25 to 30		CV 10 CV 15 CV 20 CV 25 CV 30	1 1.5 2 2.5 3	500°C short periods 400°C conti-nuous	9 13 18 25 30	-
CFG 10 to 30		CFG 10 CFG 15 CFG 20 CFG 25 CFG 30	1 1.5 2 2.5 3	400°C	10 15 20 25 30	Cable: Length: 22 cm Section: 2.5 mm² for Ø 1 to 2 mm Section 4 mm² for Ø 2.5 and 3 mm
CFP 10-30		CFP 10 CFP 15 CFP 20 CFP 25 CFP 30	1 1.5 2 2.5 3	400°C	10 15 20 25 30	-
CW1 10 to 20 **CW1** 25-30		CW1 10 CW1 15 CW1 20 CW1 25 CW1 30	1 1.5 2 2.5 3	400°C	9 13 18 25 30	Cable: Length: 22 cm Section: 4 mm² + faston

Resin connection

		Type Code	For heating element Ø (mm)	Max. working tempera-ture	Max. current (A)*	Power supply
MCM 10 to 20		MCM 10 MCM 15 MCM 20	1 1.5 2	150°C	8 12 16	Cable: Length: 20 cm Section: 1 mm²
CT 10 to 20		CT 10 CT 15 CT 20	1 1.5 2	100°C	4 7 10	Socket
CM 10 to 20		CM 10 CM 15 CM 20	1 1.5 2	200°C	8 12 16	Cable: Length: 20 cm Section: 2 mm²
CM20G **CM** 25 to 40		CM 20G CM 25 CM 30 CM 40	2 2.5 3 4	200°C	20 25 30 40	Cable: Length: 20 cm Section: 4 mm²

*) These values are given for a mounting on a ZEZ type heating element. For the types 1Nc and 1Hc, divide the values respectively by 4 and 6.

Environment: the ceramic / metal connections can be used in vacuum (10^{-9} bars).

Maximum supply: the indicated values are given for ambient atmosphere. Higher values are possible when the connectors are cooled.

Maximum temperature: it is necessary to take into account the possible temperature rise of the connections when the heating element is operating.

Accessories

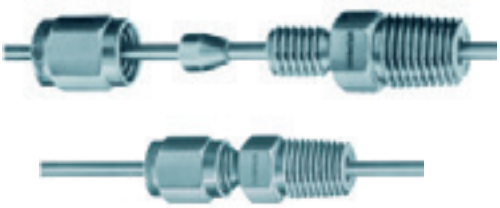
Any form of brazing or welding of a heating element through a wall requires some skill, and to facilitate its mounting, a range of small seal-glands has been developed and adapted to the standard THERMOCOAX dimensions.
The seal glands can easily be mounted and dismounted and only require the threading of a suitable hole of at least 5 mm in a wall.

THERMOLOK seal glands

Such a seal-gland consists of three stainless parts (AISI 316L):

- a body either with a cone-shaped NPT thread or with a metric thread, a ferrule and a gland nut.

The body is screwed into the wall. The ferrule is slipped over the heating element into its chosen position and, with the gland nut, it is secured into position. Both ferrule and cable sheath are slightly but uniformly deformed and thus form a perfect seal.



Tightness:

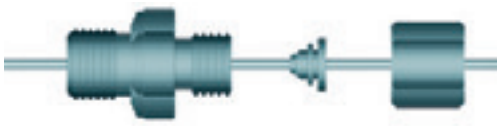
- up to 700°C, under atmosphere pressure
- up to 500 bars is possible

Cable diameter	NPT thread			With metric thread (thin thread)*			Ferrule	
	Code	ø	Ø hole (mm)	Code	Thread	Ø hole (mm)	Al SI 316 L	PTFE
1 mm	MG 10	1/16	6.25	**MGM 10**	M8 x 1	7.00	**FE 10**	**FE 10T**
1.5 mm	MG 15	1/16	6.25	**MGM 15**	M8 x 1	7.00	**FE 15**	**FE 15T**
2 mm	MG 20	1/16	6.25	**MGM 20**	M8 x 1	7.00	**FE 20**	**FE 20T**
3 mm	MG 30	1/14	11.10	**MGM 30**	M12 x 1.5	10.50	**FE 30**	**FE 30T**

SGS Seal glands

The tightness is ensured at 300°C maximum pressure 25 bars when using a metallic ferrule and 200°C at maximum 2 bars when using a PTFE ferrule.

Cable diameter	With ferrule				Ferrule	
	Metallic	PTFE	Thread	Length	Metallic	PTFE
1 mm	**SGS-M 10**	**SGS-T 10**	M8x 1	23 .5	**SES 10**	**SET 10**
1.5 mm	**SGS-M 15**	**SGS-T 15**	M8x 1	23 .5	**SES 15**	**SET 15**
2 mm	**SGS-M 20**	**SGS-T 20**	M8x 1	23 .5	**SES 20**	**SET 20**
3 mm	**SGS-M 30**	**SGS-T 30**	M8x 1	25	**SES 30**	**SET 30**



Bushings SB

Made of stainless steel AISI 304L or INCONEL® 600 alloy, they can be brazed or welded onto the heating element sheath.

Cable diameter	Stainless steel			INCONEL® alloy		
	Code	Length	ø	Code	Length	ø
1 mm	**SB 10**	45 mm	5 mm	**SBI 10**	35 mm	5 mm
1.5 mm	**SB 15**	45 mm	5 mm	**SBI 15**	35 mm	5 mm
2 mm	**SB 20**	45 mm	5 mm	**SBI 20**	35 mm	5 mm
2.5 mm	**SB 25**	45 mm	6 mm	**SBI 25**	35 mm	6 mm
3 mm	**SB 30**	45 mm	6 mm	**SBI 30**	35 mm	6 mm

Expertise

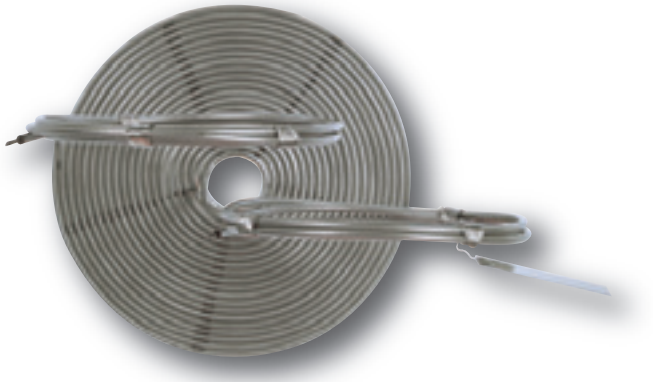
With almost 55 years of experience, **THERMOCOAX** provides high-quality heating elements and devices.

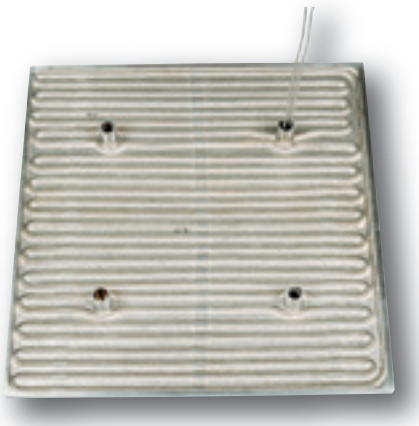
We design, develop and manufacture both standard and custom designed thermal systems, comprised of industrial heaters and temperature sensors.

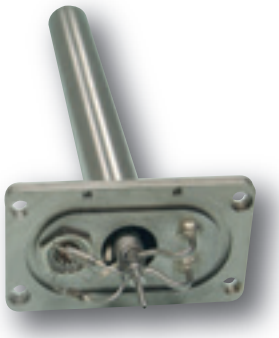
A powerful potential

Full Engineering capabilities

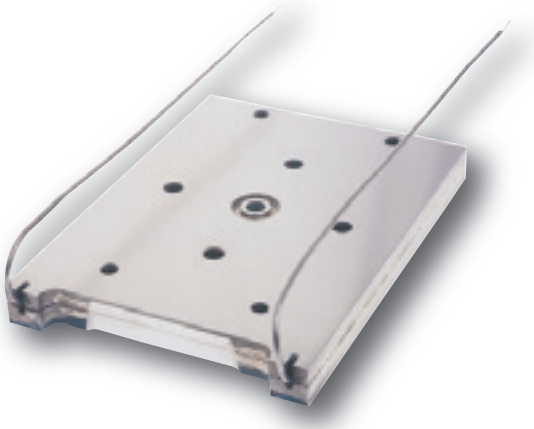
- Engineering and full technical assistance at every stage of your project,
- Assembly workshops offering semi-fi nished products as well as full assemblies,
- Welding (Laser, Plasma, TIG),
- Brazing (torch and vacuum brazing),
- Calibration Services
- 3D design development
- Computer Aided Thermal and Mechanical Modeling (CosmosWorks)
- THERMOCOAX Development Laboratory has a number of equipment to perform all kind of experiments, aging, qualifications according to customers requirements and official standards.

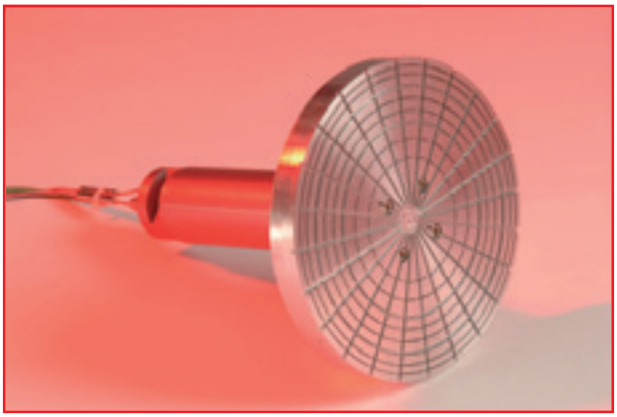




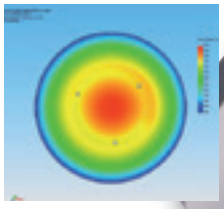


Custom made heating plates





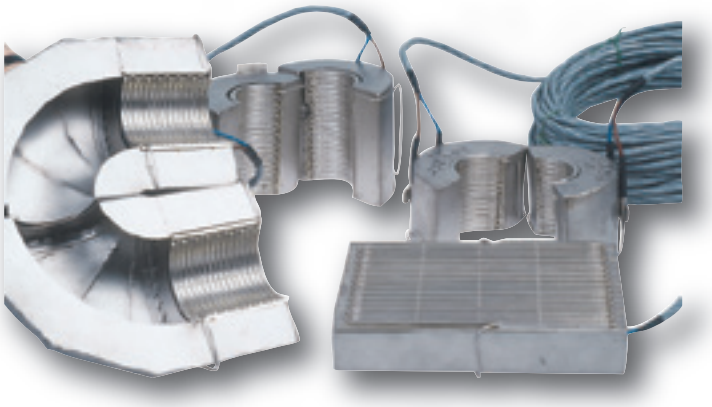
Temperature uniformity



A powerful potential

Custom made furnaces

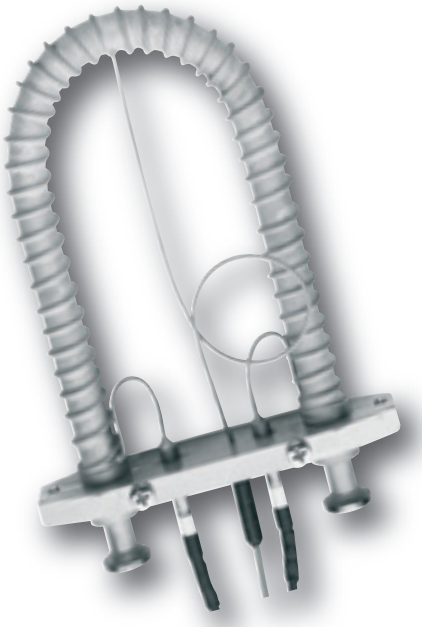
Moisture tight



Mechanical parts provided by the customer or supplied by THERMOCOAX

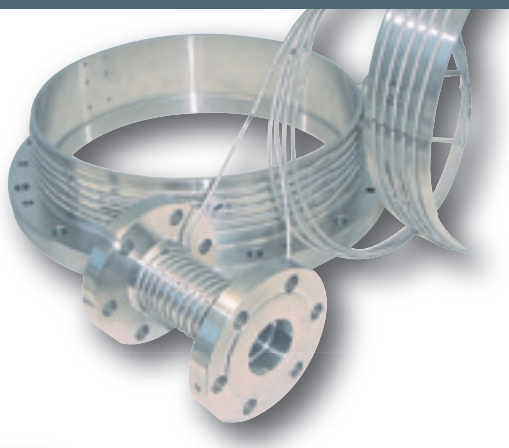
Corrosive media

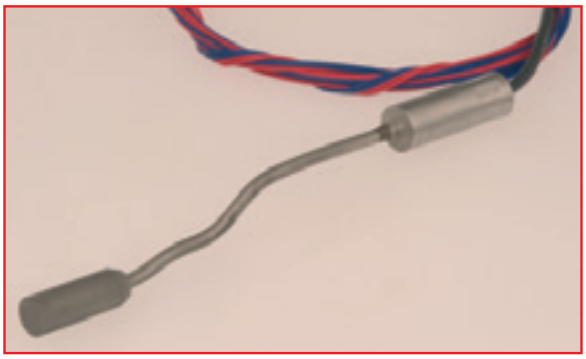
Minimum bending radius: 3 x OD



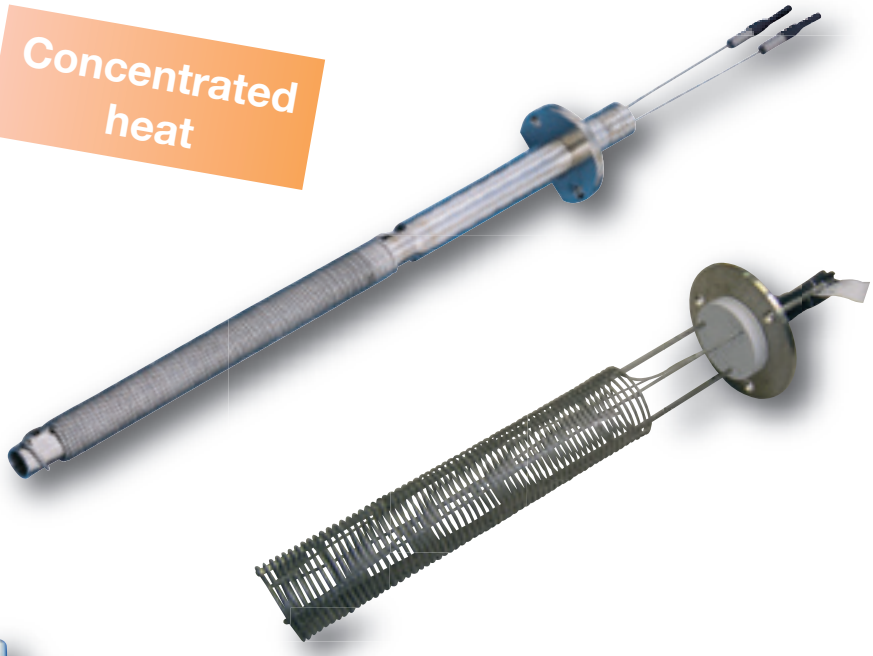
A powerful potential

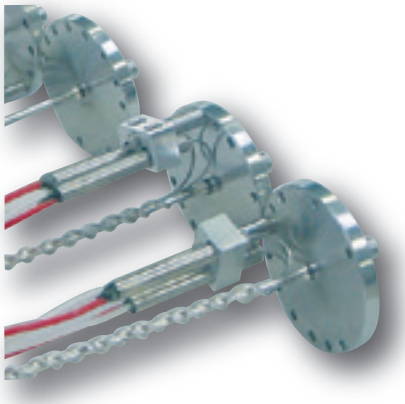
Fits any shape and any size

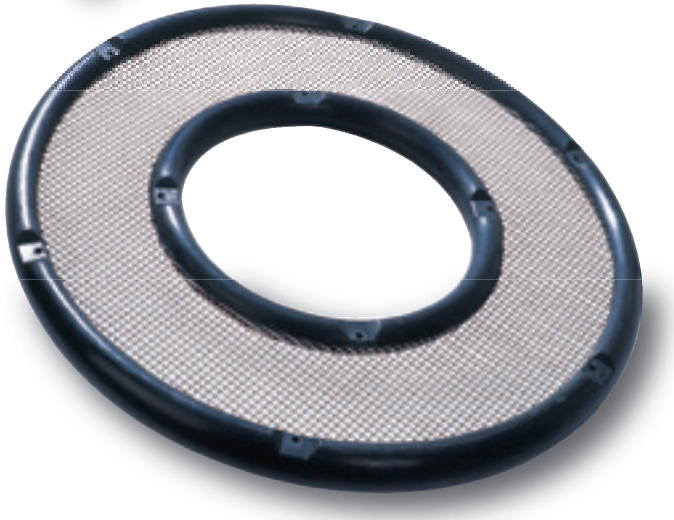




Concentrated heat







Control and Quality

All THERMOCOAX thermocouples are subject to dimensional and electrical controls (line resistance and insulation resistance).

Mechanical, electrical, dimensional controls are often required for devices working in severe media conditions and for which a perfect reproducibility and/or accuracy is needed. These controls can be defined with the customer and our techical services within precise specifications.

In order to fulfil the particular demands of the nuclear, aeronautical and space industries, THERMOCOAX can on request set up a Quality Assurance Program focused on the whole development cycle of the products.

Whether they are standard or manufactured to customers specifications, all THERMOCOAX products are developed with the same procedures, the same control principes, the same feed back and the same qualified personnel.

Temperature measurement

- Temperature sensors (thermocouples, and also specialised sheath materials, high temperature, platinum resistance thermometers)
- Temperature harnesses
- Specific sensors (fluxmeters…)

Heating solutions

- Heating cables and elements (cold ends, or with a coiled core)
- Rod heaters
- Heating devices according to customer specifications : heating platens, ovens

Other measurements and Detection

- Mineral Insulated Signal Transmission cables
- Silica insulated cables
- High temperature capacitive sensors TURBOCOAX®
- Neutron Detectors NEUTROCOAX®
- Overheating and fire detectors NEGACOAX®
- Traffic sensors VIBRACOAX®

THERMOCOAX

OUR COMPANY

With nearly 60 years of experience in heating solutions and temperature measurement, THERMOCOAX has acquired a great deal of skill and expertise.
THERMOCOAX products are widely used and endorsed in many industries where the highest quality and utmost reliability are essential. All our mineral insulated cables are manufactured in-house with our proprietary and unique procedures.

www.thermocoax.com

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Thermocouples & Heating Elements ATEX certified and notified

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