EREMA®
HEATING ELEMENTS

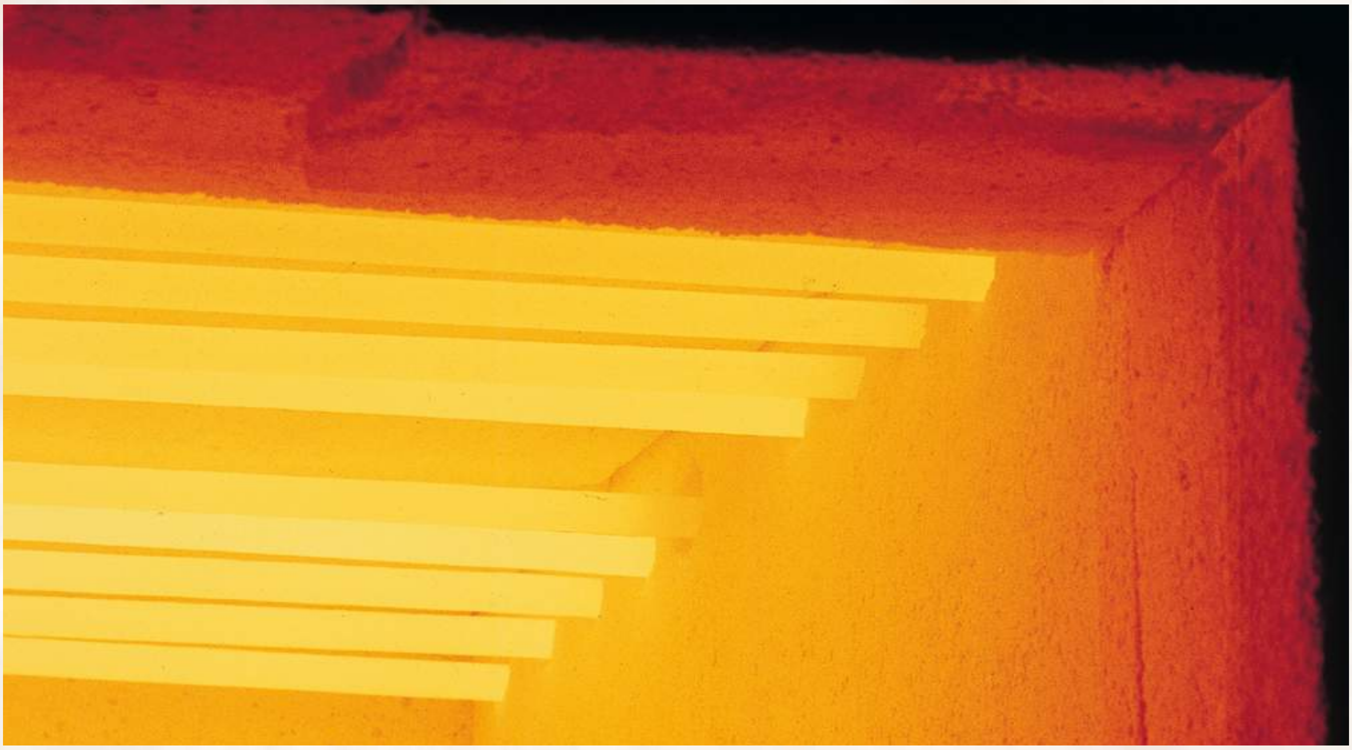
ELECTRIC RESISTANCE MATERIAL

TOKAI KONETSU KOGYO CO.,LTD

EREMA®

Heating Elements Fine Ceramics Pioneer

We have been actively developing fine ceramics and products since our company was established in 1936. Among our products, our silicon carbide heating elements are dominant.
Produced using the finest raw materials, advanced technology and superior quality; **EREMA®** heating elements have achieved high acclaim. **EREMA®** heating elements products have pioneered many advanced applications in high temperature and heating technology. Our continuous improvements are focused on "Energy Savings", "Environment Friendly", "High Temperature" and "High Quality" results.
EREMA® heating elements are produced in organized, cutting-edge facilities which are environmentally friendly and so support technological progress.





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About EREMA® Heating Elements

EREMA® heating elements, composed of re-crystallized, high-purity silicon carbide, were the first of their kind to be introduced into the market in Japan. EREMA® heating elements have earned a reputation as being high quality products, as well as the world's largest production scale, as the culmination of many years of research activities combining technologies from Japan and abroad, and making every effort to enhance and upgrade quality since they were introduced to the market in 1927.

Application Fields and Categories

Metallic industry	Powder metallurgy sintering
	Melting, molten metal holding and aging treatment of aluminum alloy
	Gas carburizing hardening of components for automotives, aircrafts, and machinery
	Carburizing, nitriding, and bright annealing for steel parts
	Hardening and tempering of various dies
	Brightness processing of die steel
	Tempering and soldering of machine components
	Carbon and sulfur analysis, tempering process for band steel
	Patenting processing for steel wire
Electronics industry	Firing of ceramic capacitors
	Sintering of alumina and steatite porcelain
	Firing of piezoelectric elements
	Firing of I.C. substrate
	Firing of ceramic resisters, varistor and thermistors
	Temporary sintering and calcinations of soft and hard ferrite
	Bright annealing of silicon steel plate, heat treatment of copper soldering and optical fiber
Porcelain industry	Fusion, retention, and gradual cooling of glass
	Surface treatment of glass
	Heat treatment of liquid crystal
	Lens heat treatment
	Manufacturing and machining of safety glass
	Manufacturing of ceramics and glass fiber
	Manufacturing of various fine ceramics
	Firing of quartz raw materials
	Firing of porcelain enamel
	Firing of ceramic ware
	Firing of grind stone
	Test for various refractory products
Chemical industry	Firing of Cathode and Anode materials for lithium ion battery
	Firing of fluorescent paint
	Firing of various pigments
	Firing of carriers and catalyst
	Heating of reactive gas
	Coal carbonization
	Firing of activated carbon
	Cleaning furnace and deodorizing furnace
Others	Various high temperature test furnaces
	Ignition of gas and kerosene appliances
	Ignition of various types of industrial equipment
	Various high temperature tests
	Local heating

EREMA®
Heating Elemets

Types and Features of EREMA® Heating Elements

It is possible for EREMA® heating elements to heat up to 1600°C. The heat value per unit area is very large, 5 to 10 times that of nichrome wire. It is a chemically stable and an environmentally friendly heating source free of air pollution and noise compared with air and liquid fuel. Various types of EREMA® heating elements are available and selectable for appropriate materials and shapes according to their application.
EREMA® heating elements were certified for ISO 9001 in 1997.

CERTIFIED JQA MANAGEMENT SYSTEM QUALITY SYSTEM
JQA-2026
Sendai Factory

Type E2, E2-DV & F2

These type is manufactured by exploiting our excellent manufacturing technologies and the fruits of years of research; consisting of dense and hard crystal.
These were designed to improve corrosion resistance so that it can be used in special environments where SiC deterioration is quicker. It can be used in extraordinarily toxic atmospheres with existence of nitrogen, hydrogen, alkali, lead, halogen and others.
Various coatings can be applied to improve resistance to oxidation or corrosion depending on the use. To select the coatings, please refer to page 14.
(Type E2-DV is an old type D.)
Manufactured dimensions are φ16 to φ30 for type E2, ø16 to ø30 for type E2-DV, and ø35 to ø50 for type F2. Type E2-DV has the same resistance as products of the same diameter from other companies, so it is easily replaceable.

Type SG

This type has a spiral groove engraved on the heating zone, withstands higher temperatures than type E2 and F2, and has high corrosion resistance, thus shows excellent performance in severe service conditions.

Type SGR

This type also has a spiral groove engraved on the heating zones similar to type SG. This has the cold end only at one end, which is its distinguishing feature. As the connecting terminals are at the one side, it is very convenient to use and moreover an energy saving furnace can be built by using this. Use of the types SG and SGR is recommended for the applications where service conditions are severer or where the temperature in the furnace chamber exceeds 1400°C.

Type U2

This type is "U"-shaped, consisting of a combination of one each of the EREMA® heating elements types E2 and F2 respectively. It is a single-phase heating element with both cold ends in one direction, facilitating increased furnace design flexibility, because connection terminals can be centered on one side. In addition, a furnace with an energy saving structure can be built because the number of heating element holes on the furnace can be reduced compared with the E2 or F2 types.

Type W

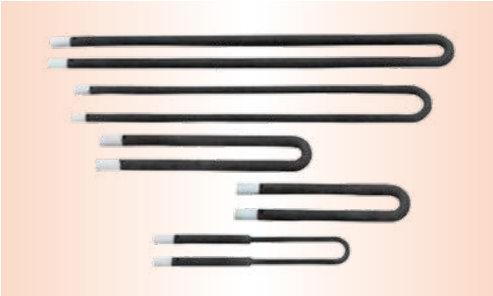
This is the heating element to be used with a three phase power supply combining 3 units of the heating elements to make a "W" shape. The principal application is in manufacturing furnaces for float glass.

Type W-D6

This is the heating element to be used with a three-phase power supply. Thanks to its larger surface area than the type W cited, it can handle a higher power capacity. Like type W, it is adopted into float bath furnaces.

Type U3

This was designed by modifying and integrating the tip of the type U heating element to generate the heat uniformly and enable the input of greater electric power, resolving the temperature decrease at the tip area by doing so. While there is a limit in dimension for manufacturing reasons, the electric specifications are the same as type U. You are recommended to use it in a vertical position, as the tip portion is heated.

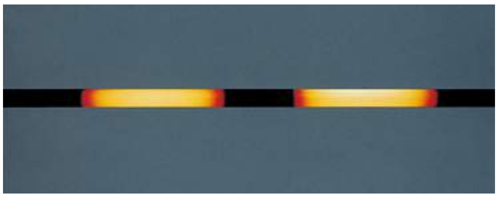


Type M2

The cold end of a bar shape heating element is normally located on the extension of the heating element, but the cold end of type M2 is designed to be vertical in order to support uses such as the installation of electric equipment and the requests to change the cold end structure. The distance between the heating element and the heating object can be adjusted easily. The same materials as in types E2 and F2 are used.

Type SDL2

This type has a non-heating element at the center of the hot zone to improve the temperature distribution in the furnace chamber by suppressing the temperature around the central part of the furnace. The same materials as in type E2 and F2 are used.



Type SA

The type SA is a dense and long life heating element manufactured with our unique technology, unlike those products on the extension of the conventional SiC heating elements. Please feel free to contact us for the specifications.

Type E7, F7 & U7

These heating element are SDGs model, are an improved and densified conventional recrystallized silicon carbide heating element with improved oxidation resistance and corrosion resistance, while all the electrical specifications and shapes are the same as types E2, F2, and U2. Various coatings can be applied to improve oxidation resistance and corrosion resistance depending on applications.

EREMA® Heating Elemets

Characteristics of EREMA® Heating Elements

Physical Characteristics

Characteristics Items	Unit	Type					
		E2	E2-DV	F2	SDL2	SG/SGR	SA
Apparent Density		3.2	3.2	3.2	3.2	3.1	3.2
Bulk Density		2.58	2.58	2.58	2.58	2.8	2.9
Apparent Porosity	%	20	20	20	20	5	10
Bending Strength	MPa at 25°C	60	60	60	50	98	100
Specific Heat	kJ/kg·K at 25°C to 1300°C	1.0	1.0	1.0	1.0	1.0	1.0
Specific Resistance	Ω cm at 1000°C	0.08	0.10	0.10	0.08/0.10	0.016	0.045
Coefficient of Thermal Expansion	1000°C ($x10^{-6}$/°C)	4.5	4.5	4.5	4.5	4.5	4.5
Surface Temperature of Heating Element	°C	1400	1400	1400	1400	1600	1600
EREMA® Heating Elements Dia.	mm	16 to 30	16 to 30	35 to 50	14 to 50	16 to 55	16 to 35

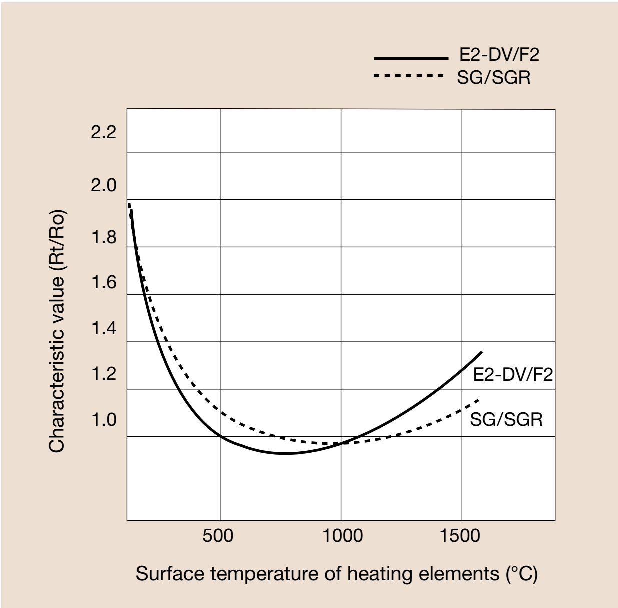
Characteristics Items	Unit	Type					
		U2		U3	M2	E7/F7/U7	
Apparent Density		3.2		3.2	3.2	3.2	
Bulk Density		2.58		2.50	2.58	2.65	
Apparent Porosity	%	20		22	20	17	
Bending Strength	MPa at 25°C	60		70	60	60	
Specific Heat	kJ/kg·K at 25°C to 1300°C	1.0		1.0	1.0	1.0	
Specific Resistance	Ω cm at 1000°C	0.08	0.10	0.10	0.08	0.08	0.10
Coefficient of Thermal Expansion	1000°C ($x10^{-6}$/°C)	4.5		4.5	4.5	4.5	
Surface Temperature of Heating Element	°C	1400		1400	1400	1400	
EREMA® Heating Elements Dia.	mm	16 to 30	35 to 40	16 to 30	12 to 30	20 to 30	35 to 40

* For detailed EREMA® heating elements diameters, please contact us.

Resistance and Temperature Characteristics

As shown in Fig.1, the temperature coefficient of EREMA® heating elements resistance-temperature characteristics are negative up to 650°C to 700°C (When the temperature goes up, the resistance value goes down). Then, when it exceeds that temperature, it becomes positive (When the temperature goes up, the resistance value goes up.)

Note. The EREMA® heating elements resistance are usually measured at 1000°C in open air and the nominal resistance differs extremely from that measured at room temperature. (Refer to Fig. 1)



■ Fig. 1 Characteristics of resistance and temperature
Characteristic value (Rt/Ro):

Ro ...... Resistance value at 1000°C
Rt .... Resistance value at each temperature

Chemical Characteristics

The EREMA® heating elements are made of chemically stable silicon carbide with high purity and are superior to metal heating elements in terms of high temperature stability, oxidation resistance and corrosion resistance. When the heating elements are operated at high temperatures, they come into contact and react with a gas atmosphere such as vapor, hydrogen, nitrogen, sulfur, halogen, etc., molten alkali, alkaline salts (K_2CO_3, KCl. KOH. NaF. etc.), molten metals (Fe. Ni. Co. etc.), and some metal oxides (CuO. Pb_3O_4, FeO. etc.), and will be affected by erosion or oxidation when the above reactions occur.
When EREMA® heating elements are handled in a gas atmosphere, refer to " Influence of Atmosphere on EREMA® Heating Elements " on P14.
In designing a furnace, when the above corrosive substances by which EREMA® heating elements are affected are involved, caution must be exercised to avoid any direct contact by EREMA® heating elements.

EREMA® Heating Elements SDGs Model

Features of SDGs Model

EREMA® SiC heating elements are generally made of recrystallized silicon carbide and are widely used. However, due to the recent diversification of processing materials, the sintering temperature and furnace atmosphere have changed significantly, so care must be taken when using EREMA® heating elements.

In order to respond to such an environment, EREMA® heating elements SDGs model is an improved and densified conventional recrystallized silicon carbide heating element with improved oxidation resistance and corrosion resistance.

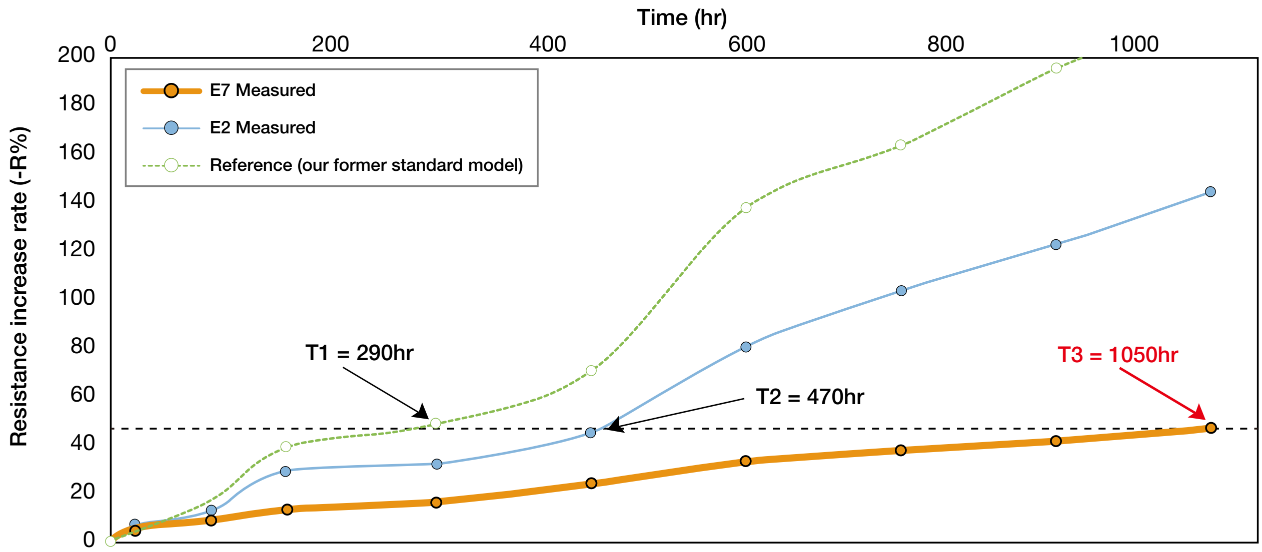
By using EREMA® heating elements SDGs model, which was developed for the purpose of reducing the environmental load and contributing to the development of society, you can expect a reduction in waste due to its long life, to improve productivity by reducing maintenance frequency and to save energy when restarting the furnace.

Representative Physical Characteristics

Model	SDGs model		Conventional		Features of SDGs model	
	E7	F7	E2	F2		
Composition	SiC > 98%		SiC > 98%			
Bulk density	2.65		2.58		High density	High corrosion resistance
Apparent porosity (%)	17		20		Low porosity	
Flexural strength (MPa)	60		60			
Specific resistance (Ω cm)	0.08	0.1	0.08	0.1	Same electrical conditions	
Max operating temp (°C)	1400		1400			

Dimensions and electrical conditions are the same as conventional EREMA® SiC heating elements, and various coatings can be applied.

Life Test (Alkaline Atmosphere Resistance Increase)



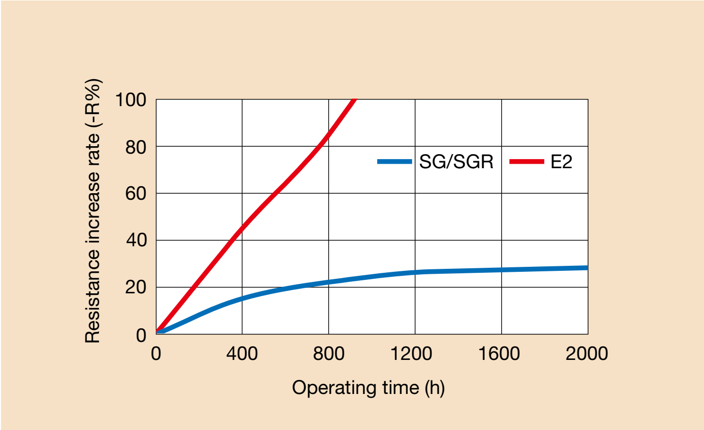
Life time comparison at T3 resistance increase (T3 = 1050hr)

T3/T2 = 2.23　　T3/T1 = 3.62　　T2/T1 = 1.62

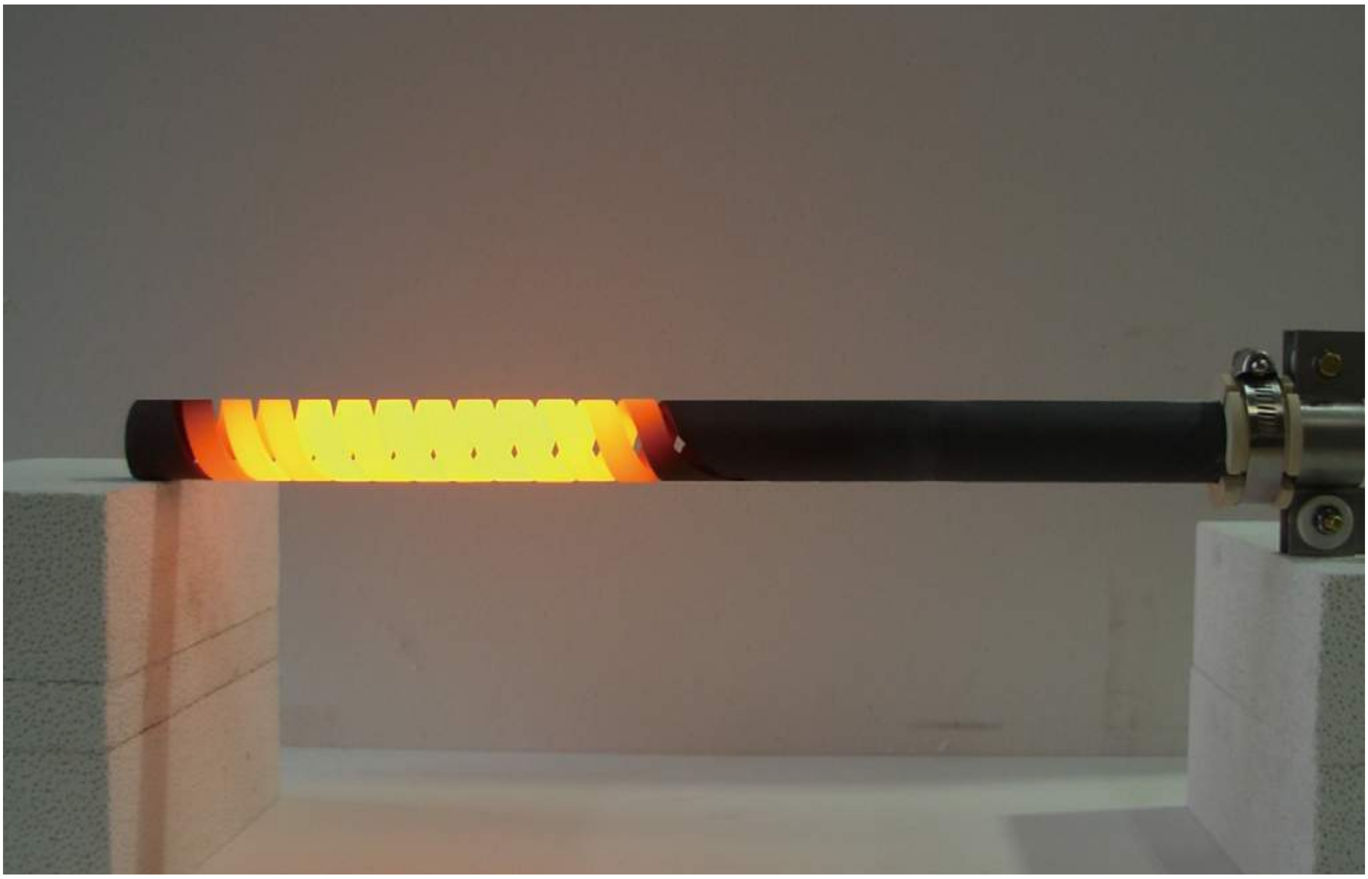
EREMA® High Temperature and Oxidation-resistant Heating Elements

Type SG and SGR

The service life of EREMA® heating elements are affected by the increase in electrical resistance caused by the formation of Silica (SiO_2) due to oxidation of silicon carbide. Types SG and SGR were designed to enhance oxidation resistance by reducing apparent porosity and oxidation surface area, increasing sintering strength, and improving density. Since this heating element is denser compared with other general heating elements and has higher corrosion resistance, it is appropriate to use it in higher temperature atmospheres and in severer service conditions. The SGR type has a connecting terminal on one side and can be used in combination with a protection tube. When used as an immersion heater, it can be used with a higher surface load density than other types.



■ Fig. 2 Comparison of types SG and SGR with type E2 (Test conditions 1600°C in open air)



EREMA® High Temperature, Long Service life Heating Elements

Type SA

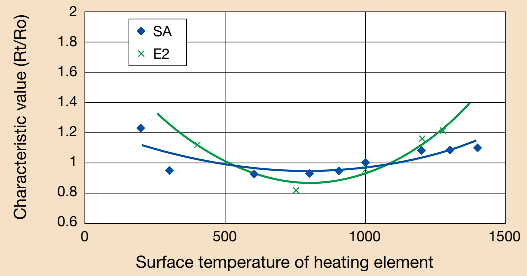
EREMA® heating elements, composed of re-crystallized silicon carbide, are being widely used. The service life may be shortened by the temperature exceeding 1300 (°C) because its reaction with an atmosphere of nitrogen etc., becomes extremely active, especially with a low dew point. Type SA is the product of a dense structure and long service life manufactured with our unique technology, unlike those products on the extension of the conventional SiC heating elements. Due to these features, by using this heating element it is possible to achieve (1) maintenance cost reduction such as for replacement, (2) measures to save natural resources and reduce industrial waste.

Major applications

- Heaters for special atmospheres:
  Alkali, N_2, H_2, H_2O, Halogen atmosphere in which SiC reacts
- Heaters for high temperatures
  * Example of applications -> fluorescent paint, BME furnace, etc.

R-T characteristics

Fig.6 shows its R-T characteristics indicates it has more flat positive characteristics than those of type E2.



■ Fig. 3 Resistance-temperature characteristics of the SA type

Note: Rt = Resistance value at each temperature, Ro=Resistance value at 1000°C

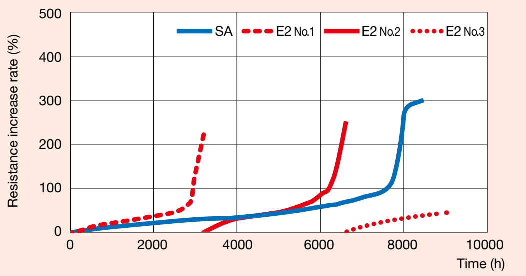
Life Test

(1) Atmosphere

(Nitrogen 93% + Hydrogen 7%)

(Temperature in the furnace chamber: 1400°C, DP: + 30 to + 40°C)

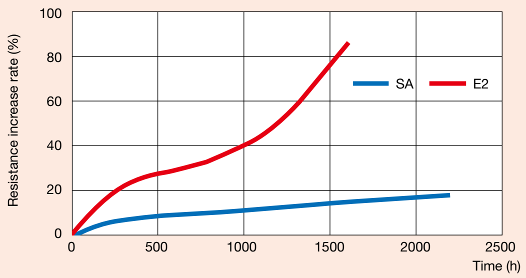
Note: The test was continued in order to ascertain the deterioration status of EREMA® heating elements type SA. (Completed after 8444 hours including 7 shut downs)



■ Fig. Service life comparison between the SA and E types

(2) Water-vapor atmosphere

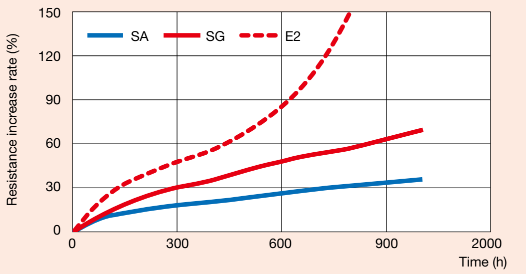
(Temperature in the furnace chamber: 1400°C, DP: more than +80°C)



■ Fig. 5 Service life comparison between the SA and E types

(3) Open air atmosphere

(Temperature in the furnace chamber: 1600°C)



■ Fig. 6 Service life comparison between the SA, SG and E2 types

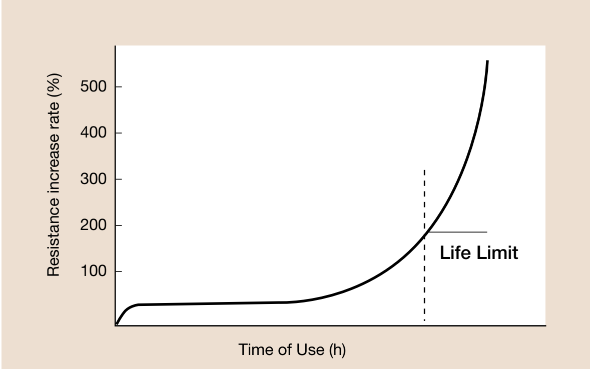
EREMA® Heating Elements Lifetime

Silicon carbide heating elements are generally subject to gradual oxidation, the formation of Silica and an increase in electric resistance, so called deterioration while in use.
This oxidation reaction is shown in the following formula.

$$SiC + 2O_2 \longrightarrow SiO_2 + CO_2$$

Silicon carbide (SiC) reacts with oxygen (O_2) in the atmosphere and the surface of the heating elements gradually oxides, forming Silica (SiO_2), which is an insulator, while its amount increases. This raises electrical resistance. Oxidation occurs when the temperature reaches 800°C and is accelerated as the temperature increases. Rapid oxidation will occur in the early stage of use, but the rate of oxidation will gradually diminish.

General variation in electrical resistance is shown in Fig. 7. For Types E2, E2-DV, F2, U2 and M2, the service life limit is suggested to be when its resistance increases to about 3 times the initial resistance. The life of SG, SGR and SA lasts until resistance reaches 1.7 times the original value. The reason is that, reaching an approximate threefold increase, the variation in each element's resistance becomes greater and heat distribution per one element worsens, causing inefficient temperature distribution in the furnace chamber.
Also, silicon carbide heating elements, when coming to the end of their life, cause not only resistance increase but changes in apparent porosity and fracture damage by deterioration in strength, so caution must be exercised. Especially Types SG and SGR have a tendency to cause meltdown when approaching the end of their lives. Caution must be exercised, as the time required for electric resistance to increase three times the initial value i.e. the life of heating elements, varies greatly according to the following application conditions.
It varies depending on (1) Operation Temperature (2) Surface Loading (3) Atmospheres and Materials to be Processed (4) Energizing Method (5) Electrical Connection (6) Installation Method of Heating Elements.
Detailed explanations are given as follows.



■ Fig. 7 Increase in Resistance (Types E2, E2-DV and F2)

Operating Temperature

The higher the temperature of EREMA® heating elements, the shorter the life. Oxidation accelerates and the life shortens especially when the surface temperature of heating elements exceeds 1400°C (for Types E2, E2-DV, F2, U2 and M2) or 1600°C (for Types SG and SGR). Therefore, it is recommended the surface temperature of EREMA® heating elements shall be kept as low as possible when in use. Namely, it is necessary to minimize the difference in temperature between inside the furnace chamber and the EREMA® heating elements. This point will be discussed in the next section on surface loading (W/cm²).

Surface Loading (Watts Density)

When a level of electric power applied to EREMA® heating elements are expressed, it is expressed in terms of the electric power applied per square centimeter of the heating surface. This is called a surface loading density or a surface loading (W/cm²). The larger the surface loading density (electric power) of EREMA® heating elements, the higher the surface temperature, but the higher the temperature, the shorter the life of EREMA® heating elements. As shown in Fig. 8 under the same furnace chamber temperature, the surface temperature of heating elements rises in relation to the increase in the surface loading density.

Surface Load (Watts Density) Limit

The line of the operation range indicated in Fig. 8 shows the limit of surface load. But practical operation is made with one second to one third of the max. surface load of the limited line.

EREMA® Heating Elements Rating

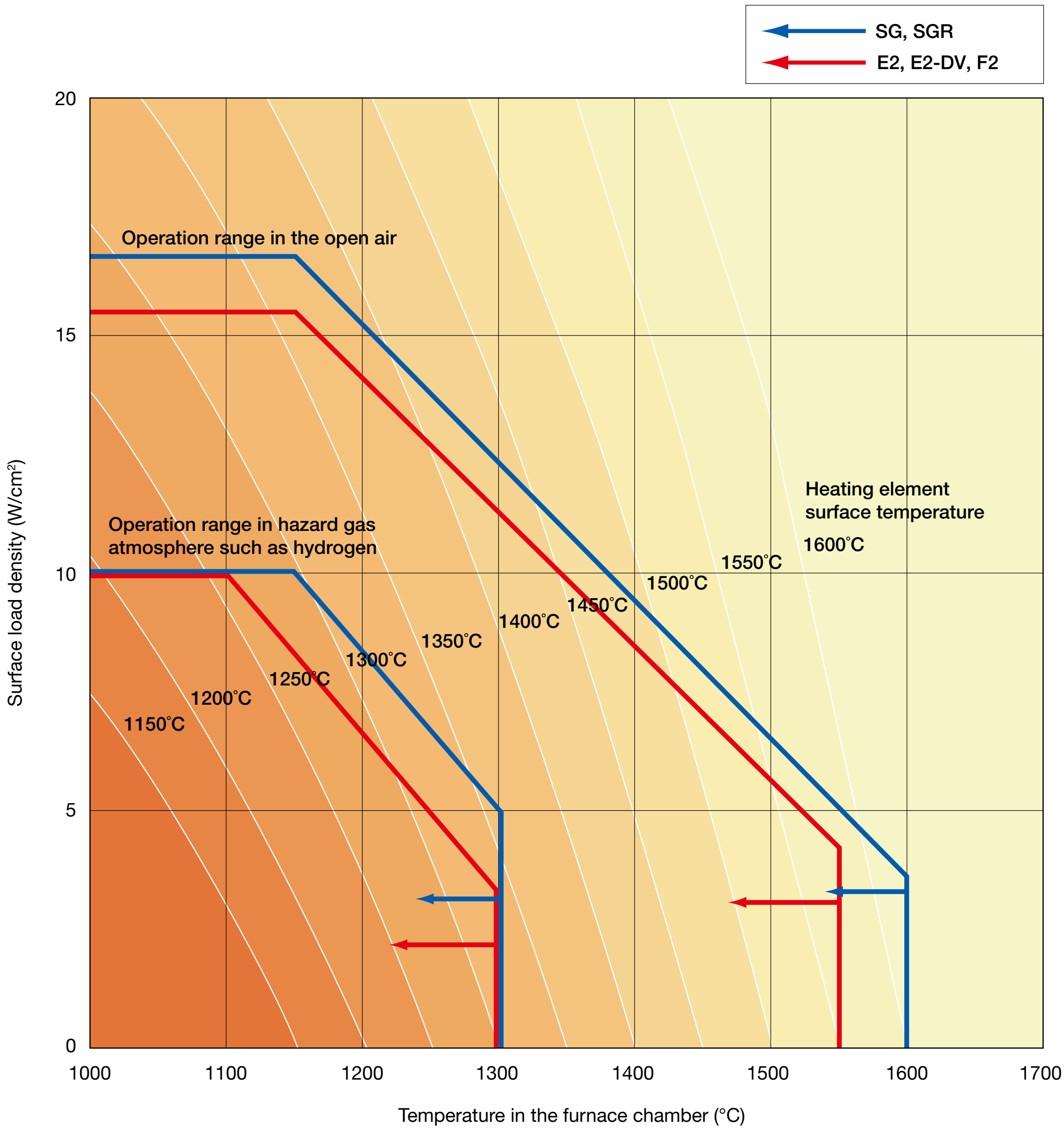
EREMA® heating elements rating is indicated at the EREMA® heating elements cold ends. This rated current is the value to keep the temperature of the heating element surface at 1000°C in open air, and in this case the surface load density will be around15W/cm². Caution must be exercised because if this voltage and current is applied to the EREMA® heating elements on operation, overloading occurs.

Caution

Thick EREMA® heating elements with a diameter of more than ø30mm may get thermal shock by the rapid increase in the element temperature, and may fracture and become damaged. When the temperature of the elements starts to increase, it is recommended that the voltage shall be applied from one third the rated voltage and be increased gradually.

Energizing Method (Intermittent and Continuous Operation)

Comparing EREMA® heating elements life between the case where it is continuously operated and in the case where it is intermittently operated, it is maximized in the former case. During operation, silicon carbide heating elements oxidize at the surface, where a silica film is formed. With long, continued use this film gradually thickens, resulting in an increase in the resistance of the heating element. The silica film behaves abnormally by expanding or contracting at around the crystal transformation temperature (270°C). If heating elements temperature goes up and down repeatedly around this temperature by intermittent use, the accumulated film will be destroyed repeatedly and oxidation will be promoted. Therefore, when the temperature of the furnace chamber goes down to room temperature due to a power failure etc., the resistance may increase rapidly.



■ Fig. 8 Temperature in the furnace chamber and the surface load density, and heating element surface temperature

Influence of Atmosphere on EREMA® Heating Elements

In recent years, cases requiring furnace atmosphere control have been increasing and caution must be exercised for EREMA® heating elements use in various atmospheres. Similarly, caution is necessary to prevent the reaction of EREMA® heating elements with various chemical substances emitted from processed materials during heating operation.
Takai Konetsu Kogyo has therefore developed special protective coatings (protective films) for special atmosphere or corrosive substances in order to prevent EREMA® heating elements aging.
The correct application of coating increases EREMA® heating elements's service life.
In any atmosphere, it is recommended to decrease the surface load as much as possible.

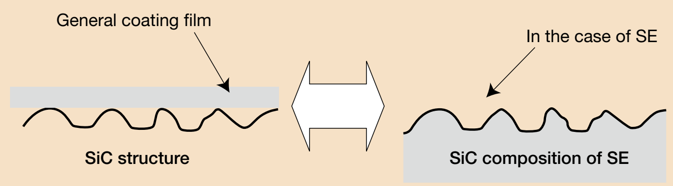
Atmosphere	Effect	Countermeasure	Recommended coat
Vapor	Heater's lifespan is sometimes cut to less than one fifth of the expected lifespan under dry open-air conditions.	It is important to raise the temperature after purging moisture sufficiently at a low temperature when initiating a new furnace or starting to use one after a long suspension.	U Coat Type SE
Hydrogen gas	EREMA® heating elements's resistance increases rapidly and its mechanical strength deteriorates quickly if the surface temperature of heating element exceeds 1350°C in a hydrogen gas atmosphere. The service life, however, depends very much on the intensity of moisture of the gas.	It is recommended that it shall be used at a surface temperature of EREMA® heating elements of less than 1300°C. It is recommended that the surface load shall be decreased as much as possible. (Refer to Fig. 8)	
Nitrogen gas	Nitrogen gas reacts with silicon carbide, forming silicon nitride when the surface temperature of heating element exceeds 1400°C, and this shortens the service life. With regard to moisture, it is the same as in the case of hydrogen.	It is recommended that it shall be used at a surface temperature of EREMA® heating elements of less than 1300°C . It is recommended that the surface load shall be decreased as much as possible. (Refer to Fig. 8)	N Coat
Ammonia converted gas	This is the same as in the cases of hydrogen gas and nitrogen gas.	It is recommended that it shall be used at a surface temperature of EREMA® heating elements of less than 1300°C. It is recommended that the surface load shall be decreased as much as possible. (Refer to Fig. 8)	N Coat P Coat Type SE
Decomposition reaction gas	Decomposed hydrocarbon attaches on the surface of EREMA® heating elements and may cause short-circuiting in an atmosphere including hydrocarbon.	It is necessary to burn off carbon by occasionally introducing air into the furnace. The electric furnace should be designed with wide spacing between EREMA® heating elements to prevent short-circuiting.	
Sulfur gas	The surface of heating elements will be damaged and resistance rapidly increases if the surface temperature of EREMA® heating elements exceed 1300°C.	It is recommended that it shall be used at a surface temperature of EREMA® heating elements of less than 1200°C. (Refer to Fig. 8)	
Vacuum	In the high vacuum, SiO_2 protective film is not formed and silicon carbide dissolves itself. As a result, the service life will be shortened.	Avoid operation pressure from getting over 0.13Pa and use it at temperatures below 1100°C.	P Coat
Others	Various substances, for example, chemical compounds emitted from processed materials including lead, antimony, and alkaline earth may react with EREMA® heating elements and may shorten its service life.	It is important to remove these beforehand from processed materials or exhaust them by installing an exhaust port.	H Coat P Coat, etc.

* Incorrect coating selection may adversely affect element life. Special coatings are available upon request. Please feel free to contact us.

EREMA® High Durability Heating Elements

Type SE

EREMA® heating elements, composed of re-crystallized silicon carbide, are being widely used. Caution is required in using EREMA® heating elements depending on the atmosphere in a furnace chamber. Also, care should be taken with regard to reaction with various chemical substances which are vaporized from the processing substances during heating. Thus, various coatings (protective films) have been developed for use in special atmospheres and with corrosive substances in order to prevent EREMA® heating elements from aging. It is possible to extend the life of EREMA® heating elements by applying the appropriate coating.
Type SE is a high durability SiC heater developed with our unique technology, and it is completely different from those products on the extension of the coating for the conventional EREMA® heating elements.
While with general coating, the coating film is observed on the surface of the EREMA® heating element, type SE is manufactured so that the protective film is formed on the whole SiC structure of EREMA® heating elements. (Image drawing) Because of that. it has higher durability against special atmospheres and corrosive gases.



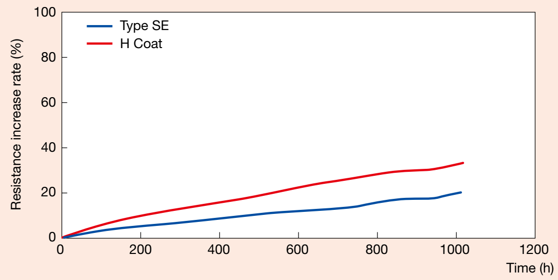
[Image drawing]

Major applications
- Heating process of molten glass
- Atmosphere of heating process including vapor

Feasible dimension for manufacturing
Up to 2000mm. Please feel free to contact us for dimensions over 2000mm.

Comparative Life Test

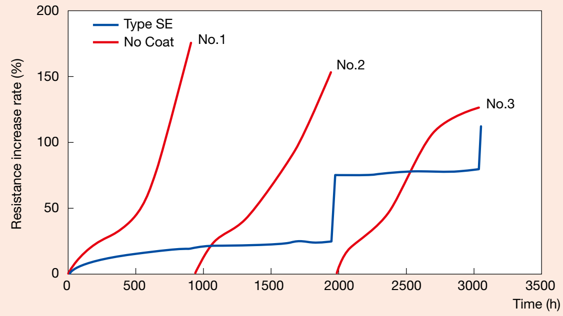
(1) Alkaline atmosphere
(Temperature in the furnace chamber: 1100°C)



■ Fig. 9 Service life comparison between the SE type and the H-coating

(2) Water-vapor atmosphere
(Temperature in the furnace chamber: 1400°C, DP: + 15 to +30°C)

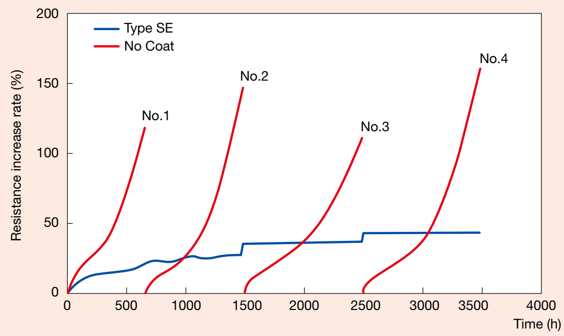
* The test was continued in order to ascertain the deterioration status of SE.
(Completed after 3048 hours including 3 shut downs)



■ Fig. 10 Service life comparison between the SE type and the non-coating

(3) Atmosphere
(Nitrogen 90% + Hydrogen 10% + Water vapor atmosphere)
(Temperature in the furnace chamber: 1350°C, DP: more than +20°C)

* The test was continued in order to ascertain the deterioration status of SE.
(Completed after 3467 hours including 4 shut downs)



■ Fig. 11 Service life comparison between the SE type and non-coating

Installation Method of EREMA® Heating Elements

1. Handle with care to avoid damage from mechanical shock when installing EREMA® heating elements.

2. The standard diameter of a through-hole for an EREMA® heating elements drilled through the brick layers should be about 1.5 times the diameter of EREMA® heating elements for the following ranges.
   Sizes under ø20mm are suitable for brick layers up to 150mm in thickness.
   Sizes over ø25mm are suitable for brick layers up to 250mm in thickness.

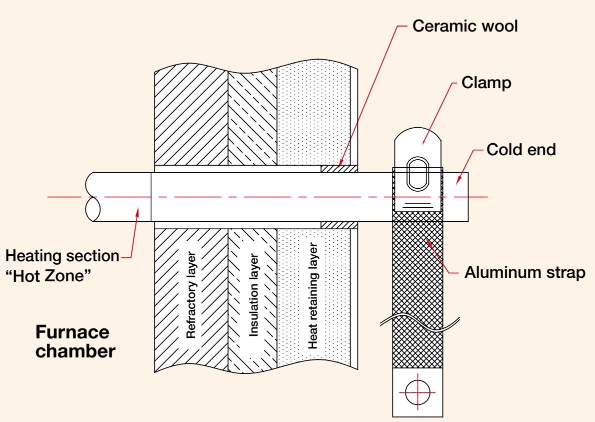
   (1) When brick layers are thicker than the above thickness widen the piercing hole diameter 5mm more.
   (2) When SG-type heating element is used, take a 5mm greater margin than the above standard value.

3. EREMA® heating elements are electrically conductive. Care should be taken to avoid electric leakage due to direct contact with a conductive material or electric shock to a human body.

4. It is recommended to use similar electric current ratings in order to equalize EREMA® heating elements load on the same circuit. Refer to the initial current rating value marked on the EREMA® heating elements' s cold end and apply those with close current values on the same circuit.

5. Arrange so that an equal length of both EREMA® heating elements's cold ends protrude out of the furnace wall and the heating zone is positioned at the center of the furnace chamber.

6. Install so that EREMA® heating elements are positioned at the center of the through-hole of the furnace wall and the surrounding area is filled lightly with ceramic wool as shown in Fig. 12.



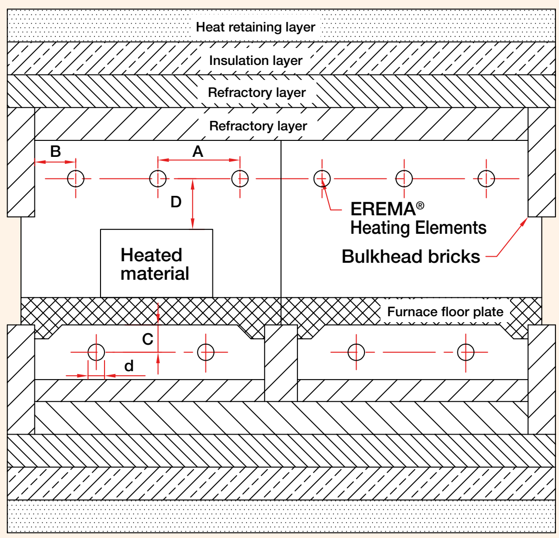
■ Fig. 12 Installation with a terminal clamp

7. Make sure that neither the terminal clamp nor the terminal strap will come into contact with the furnace wall directly. Also, the terminal strap must have enough slack to insert a finger.

8. After completing EREMA® heating elements connections, turn on electricity after lightly pressing the heating element with a finger tip and making sure that it will move easily.

9. When replacing EREMA® heating elements, it is recommended that all heating elements on the same circuit shall be replaced, otherwise the resistance difference between the new and old elements can cause a load difference and could shorten its service life. It is recommended that older or aged EREMA® heating elements shall be used on the same circuit.

10. For safety, it is recommended that installing space shall be given some clearance over the value shown in Fig. 13



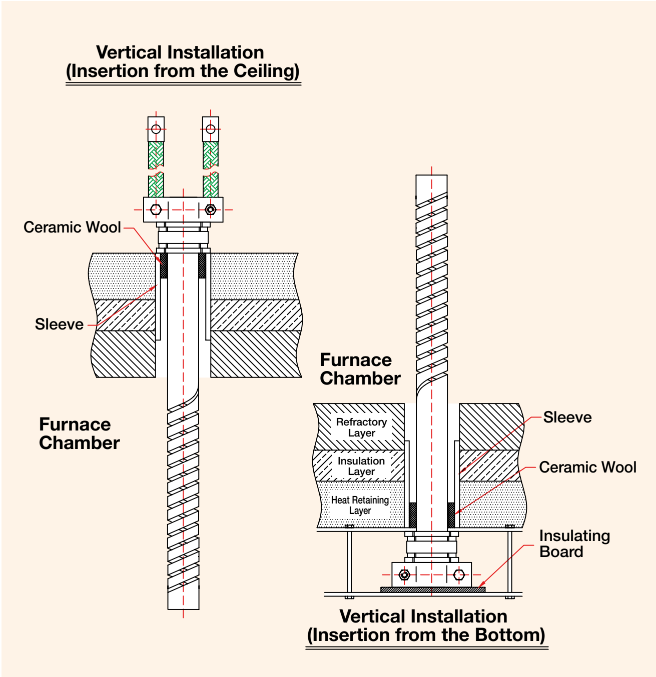
■ Fig. 13 Installing space of heating elements

[Recommended space for heating elements]
d: Diameter of heating elements
A: Space of heating element 2d or more
B: Distance from heating element to bulkhead bricks 2d or more (min. 30mm)
C: Distance from heating element to furnace floor plate 2d or more
D: Space from heating element to heated material √2A or more

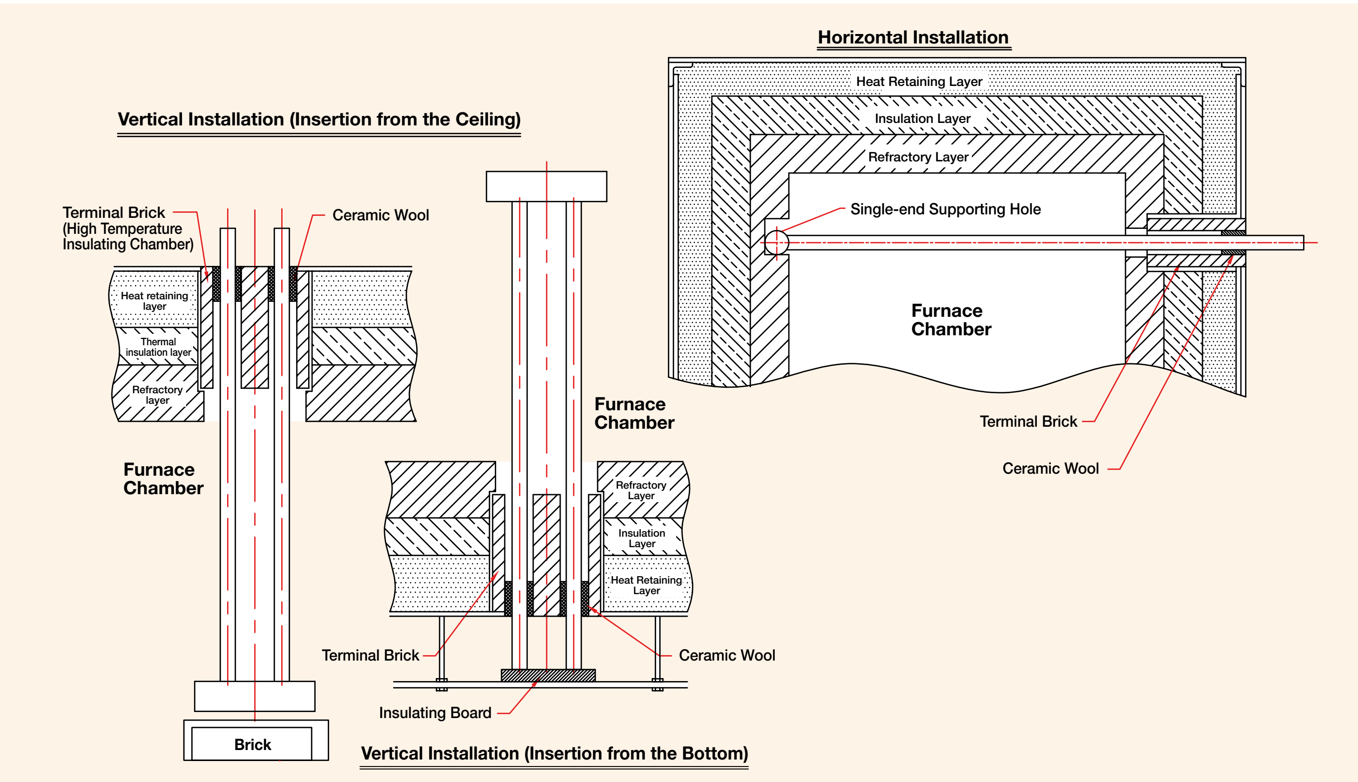
Precautions to Take When Installing EREMA® Heating Elements Type SG & SGR

Types SG and SGR have a spirally cut groove, and are consequently vulnerable to mechanical shock. The utmost care must be exercised when handling these types.

1. Unlike other heating elements, Types SG and SGR rotate slightly by expansion or contraction. It is important piercing hole and strap length shall be given some clearance.
2. Furnaces operated at high temperatures should adopt a parallel connection.
3. When installing SGR, fitting a highly pure alumina tube into the through-hole is recommended. (This prevents electrical short-circuiting which may be caused by slipping bricks and the sticking of refractory fragments and help EREMA® heating elements hold at the center of the through-hole when it is hung from the ceiling.) When filling up the ceramic wool, wind ceramic wool around the cold end of EREMA® heating elements before inserting it into the through-hole and then insert the EREMA® heating elements into the holes.
4. If SGR is to be installed horizontally, adequate support must be provided by not only holding it at the single-end but by drilling a hole through the inner wall of the furnace chamber.



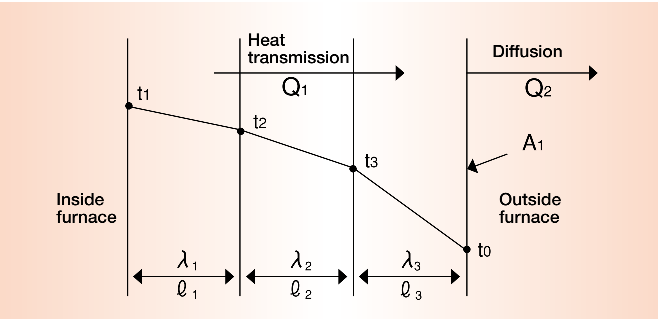
■ Fig. 14 Installation of Type SGR



■ Fig. 15 Installation of Type U2
[Note] A set pin can be used for the U2-type vertical installation (ceiling insertion). (Selection of pin hole size is optional.)

Determination of Electric Capacity for Box Type Furnace

From heat loss through furnace walls, the electric capacity can be approximated from the following formula and figures.



■ Fig. 16

Pm: Equipment Electric Power [kW]

A_1: Outside surface area of furnace wall [m²]

Ps': Theoretical rated power [kW]

Ps: Steady-State Electric Power [kW] (The electric power required for maintaining the prescribed temperature in an empty furnace)

$Ps' = \Sigma Q_1 A_1/860$ [kW]

$Ps = \alpha Ps'$[kW] (α=2 to 3)

$Pm = \beta Ps$[kW] (β=1.3 to 2, depending on the temperature raising time)

$Q_1 = \frac{\lambda_1}{\ell_1}(t_1 - t_2) = \frac{\lambda_2}{\ell_2}(t_2 - t_3) = \frac{\lambda_3}{\ell_3}(t_3 - t_0)$

$= (t_1 - t_0) / (\ell_1/\lambda_1 + \ell_2/\lambda_2 + \ell_3/\lambda_3)$ .... (1)

Relation between t_0 and Q_2 (Fig. 17) .... (2)

$Q_1 = Q_2$ .... (3)

Here

Q_1: Heat transfer amount of each furnace wall per unit time and unit area [kcal/m²h]

Q_2: Heat diffusion amount from outer wall surface to still air per unit time and unit area [kcal/m2h]............................ *

t_1: Inner wall temperature [°C]

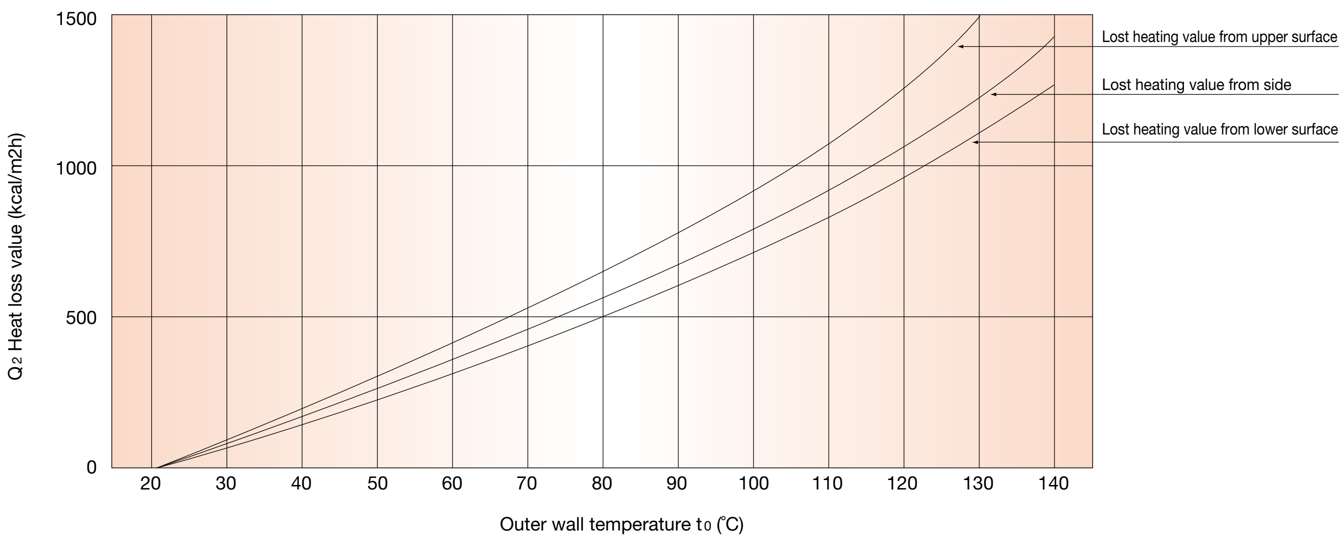
t_2, t_3: Temperature at each boundary [°C]

t_0: Outer wall temperature [°C]

λ_1, λ_2, λ_3: Heat conductivity of each furnace material at average temperature [kcal/mh°C] (Refer to manufacturer's catalog value)

ℓ_1, ℓ_2, ℓ_3: Thickness of each furnace material [m]

The temperature raising time and thermal capacity of processed material are not included in this formula.



■ Fig. 17 Relation between outer wall temperature and heat diffusion amount

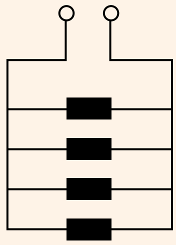
* $Q_2 = h\,(t_0 - t_a)^{1.25} + 4.88 \times \varepsilon \left[\left(\frac{273+t_0}{100}\right)^4 - \left(\frac{273+t_a}{100}\right)^4 \right]$ .... (2)

Here h:2.1 (in the case of upper surface)
1.5 (in the case of side)
1.1 (in the case of lower surface)
ε: Blackness (in the case of steel plate $\varepsilon \approx 0.8$)
t_a: Ambient temperature (average 20 [°C])

Connection

Combination of series and parallel connections are generally used with EREMA® heating elements. The maximum number of EREMA® heating elements in series must be limited to 2 units, or a two-step series connection must be used. If the furnace chamber temperature exceeds 1350°C a parallel connection must be used. Open delta connection (single-phase 3 circuits) is recommended for a three-phase connection.

1. Single-phase parallel connection (Fig. 18)
2. Single-phase 2 units series and parallel connections (Fig. 19)
3. Open delta connection (Fig. 20)



■ Fig. 18 Single-phase parallel connection

Calculation of Rated Voltage

The rated voltage can be obtained by the following formula.

$V = \sqrt{Pm \times r \times S/P}$

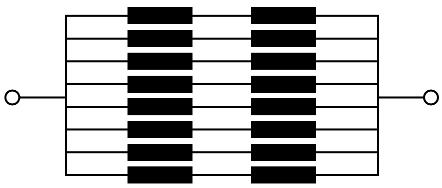
Here

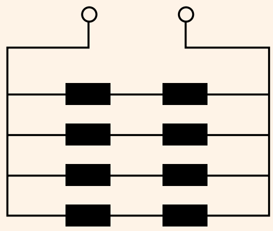
V: Circuit rated voltage [V]
Pm: Equipment power [W]
r: Resistance [Ω] of EREMA® heating elements at 1000 [°C] (Refer to Specification Table)
S: Number of series connections [units]
P: Number of parallel connections [units]

(Calculation example) The following conditions are used:

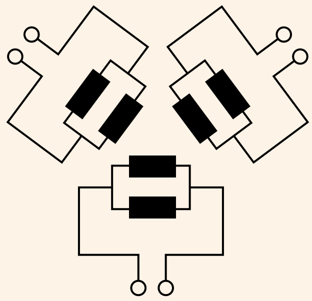
Equipment power Pm = 16 [kw]
2S-8P (2 units series connection. 8 units parallel connections)
If ER EMA El 6 × 400 × 300 (2.21Ω) is used:
$V = \sqrt{16000 \times 2.21 \times 2/8}$
$= 94.0 \rightarrow 90$ [V]

Round down the obtained voltage (94.0V) to (90V) based on 5V as a unit.





■ Fig. 19 Single-phase 2 units, series connection and parallel connection



■ Fig. 20 Open delta connection (single phase 3 circuits)

Electric Power Control Devices

As described earlier, the resistance of EREMA® heating elements increases during operation requiring a voltage control device against resistance change. A thyristor control device or multi-tapped transformer will be used for this purpose.
In general, a matching transformer (with 3 to 4 taps) is most commonly used in combination with a thyristor. For SG or SGR, which has a limited voltage fluctuation range, only a thyristor is used. Thyristors have the following advantages:
(1) Long service life because of no moving parts and contact-less control are used.
(2) Accurate temperature control is possible because of its rapid response.
(3) Temperature control is fully automated with easy control of PID (proportion, integration and differentiation) and program control being readily available.
(4) Handling is easy, high reliability in operation, and easy to maintain.
(5) Can reduce equipment power consumption by using in combination with a matching transformer.
A thyristor with a soft start function is recommended.

Capacity of Power Control Device

The capacity of an EREMA® heating elements electric furnace is generally indicated by equipment power in kW and the capacity of the transformer and thyristor is indicated by the apparent power of kVA. The capacity of a transformer has a 10% margin.
kVA=1.1 × Pm
For example, the capacity of a transformer is 33kVA if the equipment capacity of an electric furnace is 30kW. The capacity of a thyristor matching transformer is determined in the following way.
kVA=(1.15 to 1.20) × Pm

Extent of Secondary Voltage Compensation

As outlined in the section "EREMA® Heating Elements Lifetime" (page 12). heating elements should be replaced when the resistance increases to 3 times the initial resistance for Types E2, E2-DV, F2, U2 and M2, and increases by about 1.7 times for Types SG and SGR. Consequently, the extent of compensation is as follows.
Types E2, E2-DV, F2, U2 and M2 1.73 × rated voltage
Types SG and SGR 1.3 × rated voltage
The secondary voltage range for the thyristor matching transformer is voltage compensated with a three to four-step tap.

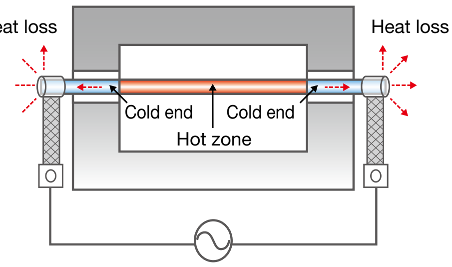
EREMA® Heating Elemets

To Save Energy EREMA® Heating Elements "CLEAN EH"

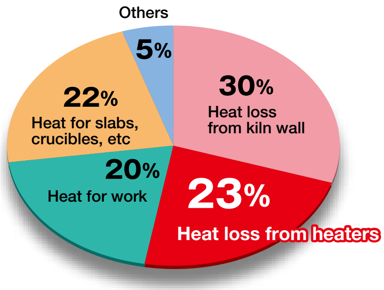
New SiC heaters, CLEAN EH, has been developed by Tokai Konetsu Kogyo Co., Ltd.
Considering environment friendly and reduce Carbon emissions.

Features of New SiC heater "Clean EH"

Generally, electric kilns have heat loss such as heat radiation from kiln wall, heaters*[1] and so on, in which cold ends account for approx. 23%*[2]. "Clean EH" was developed as a heater, keeping the same high quality of standard heaters, with new cold ends with resistance of 1/3 times lower than that of standard heaters to fulfill energy saving.
As a result, "Clean EH" can facilitate replacement to standard heaters reducing heat loss at cold ends dramatically.



*1 Name of heaters and heat flow



*2 Studied by TKK

Reference

Ref. 1 Heat Comparison of cold ends

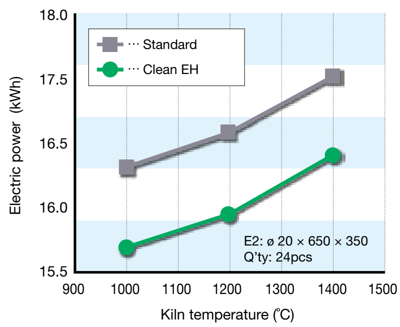
Condition: E type ø20 × 300 × 300 (nominal loading value: 59V/53. 5A)

	Total Heat	Heat Cold ends	Energy Saving
Standard	3,157W	255W	–
Clean EH	**2,974W**	**73W**	**-5.8%**

Note: Actual value depends on condition of a kiln operation

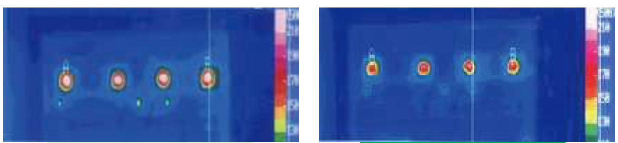
Ref. 2 Comparison of power consumption

"Clean EH" achieved a power reduction of 5% in case of a lab kiln at 1000°C to 1400°C.



Ref. 3 Comparison of temperature of cold ends

The following photos show temperature of cold ends in case of a lab kiln at 1200°C.



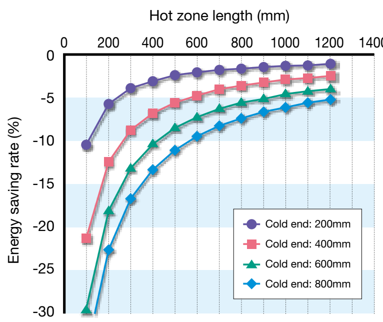
Standard:
276°C

Clean EH:
208°C

Note: Temperature of cold ends depend on kiln temp., brick structure, surrounding temp.

Ref. 4 Energy Saving Effect

It depends on ratio between length of Hot zone and Cold ends. Fig. shows a simulation between hot zone and cold end.



Simulation of energy saving rate

Note: Actual value depends on condition of a kiln operation

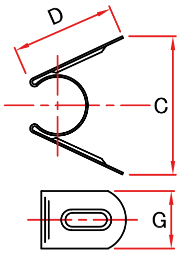
EREMA®
Heating Elemets

Connecting Terminals of EREMA® Heating Elements

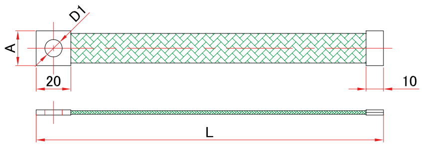
Terminal clamps and terminal straps are supplied with EREMA® heating elements. Loop the strap uniformly around the EREMA® heating elements terminal in the circumferential direction, and fasten it evenly using the clamp. For higher temperatures or atmosphere furnaces, heat-proof terminal clamps and straps should be applied because those terminals are exposed to high heat due to the structure of the furnaces.

Type HV Terminal Clamps / Type SL, SH Terminal Straps

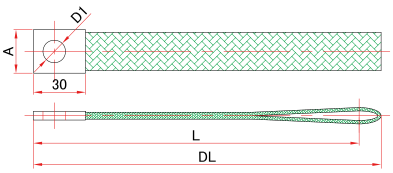
Type HV

Type SL

Type SH

■ Standards for Terminal Strap

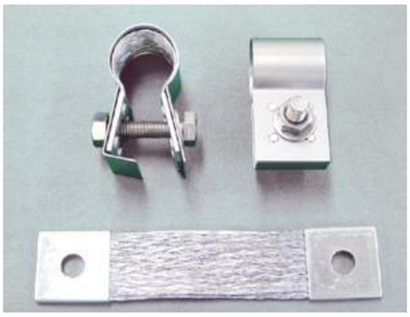
(Unit: mm) (Unit: A)

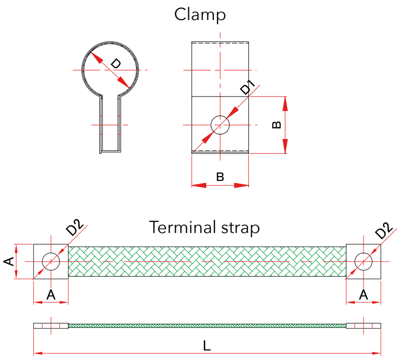
Clamp					Strap						
No.	EREMA® Heating Elements Dia. (ø)	D	G	C	No.	EREMA® Heating Elements Dia. (ø)	L	DL	A	D1	Rated current value
HV-12	12	30	12	30	SL-12	12	150		12	7	30
HV-14	14	35	14	40	SL-14	14			20	10	75
HV-16	16		16		SL-16	16					
HV-20	20	40	20	55	SL-20	20	180				
HV-25	25	45	25	60	SL-25	25	200		23		100
HV-30	30	55	30	75	SH-30	30		250	25	13	300
HV-35	35	65	35	85	SH-35	35	300	350			
HV-40	40	70	40		SH-40	40					
HV-45	45	80		95	SH-45	45					
HV-50	50				SH-50	50					

Material: SUS304

Material: Aluminum


Furnaces Heat-proof Terminals (Clamps and Straps)





■ Standards for Furnaces Heat-proof Terminals

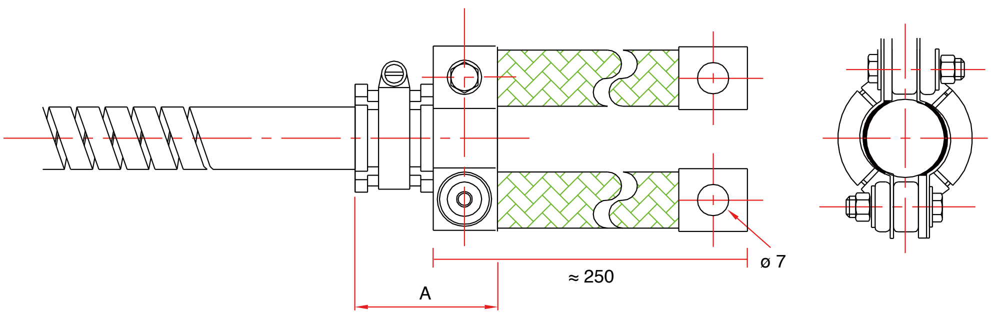
(Unit: mm) (Unit: A)

EREMA® Heating Elements Dia. (ø)	Clamp No.	Clamp D	Clamp B	Clamp D1	Terminal strap No.	Terminal strap L	Terminal strap A	Terminal strap D2	Clamping Bolt Screw Dia. (ø)	Clamping Bolt Length	Strap rated current value
12	G-12	13	17	7	GH-12	90	17	7	5	20	150
14	G-14	15	20	10	GH-14		20	10	8	30	
16	G-16	17	22		GH-16	100	22				
20	G-20	21	25		GH-20	120	25				200
25	G-25	27	30		GH-25	140	30			35	225
30	G-30	32	35	13	GH-30	300	35	13	10	40	300
35	G-35	37	40		GH-35		40			45	
40	G-40	42	45		GH-40					50	
45	G-45	47	50		GH-45						
50	G-50	52			GH-50						

Materials: Clamp...... Aluminum, SUS304
Strap........ Aluminum

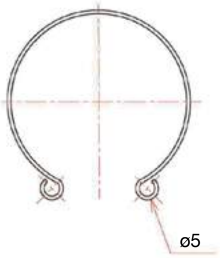
Connecting Terminal for EREMA® Heating Elements SGR Type

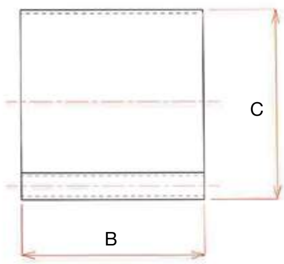
■ Drawing of a Type SGR assembly example



EREMA® Heating Elements Dia. (ø)	A
16	45
20	
25	
30	55
35	
40	
45	
50	70
55	

Clamp for Type HC

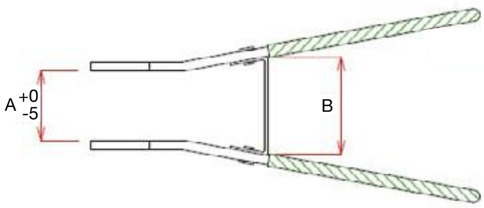


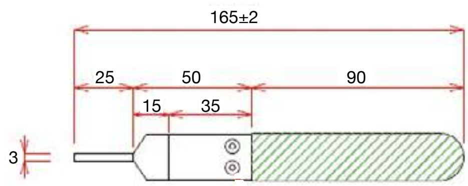


No.	EREMA® Heating Elements Dia. (ø)	B	C
HC-16	16	16	21
HC-20	20	20	25
HC-25	25	25	30
HC-30	30	30	35
HC-35	35	35	40
HC-40	40		45
HC-45	45	40	50
HC-50	50		54

Material: SUS304

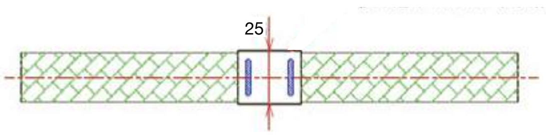
HC plier

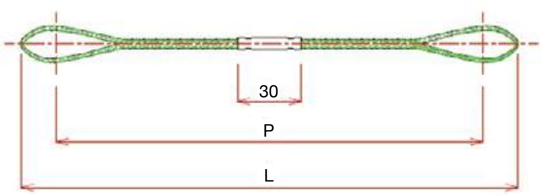




	A	B
Small	30	40
Large	40	50

Special Straps (Both Rings)



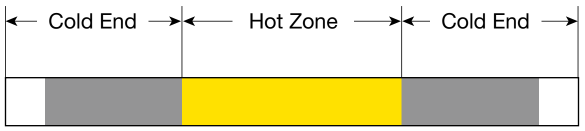


■ Special Straps (Both Rings) (Unit: A)

	P	L	Rated current value
(1)	100	200	
(2)	150	250	
(3)	200	300	
(4)	250	350	300
(5)	300	400	
(6)	350	450	
(7)	400	500	

L=D × π + P - D + 35
L is rounded up to the nearest multiple of 5 mm.

Type E2



Metallized Width

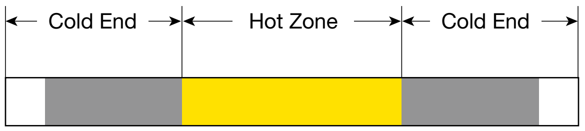
Outside diameter (mm)	Metallized Length (mm)
ø16	(30)
ø20 to 30	(50)

Number	Size				Hot Zone surface area	Nominal loading values*		
	External diameter	Hot Zone Length	Cold End Length	Overall Length				
	mm	mm	mm	mm	cm²	Volts	Watts	Ohms
E2-163025	16	300	250	800	150	64	2430	1.69
E2-163035		300	350	1000	150	66	2510	1.74
E2-164025		400	250	900	201	83	3150	2.19
E2-164030		400	300	1000	201	84	3190	2.21
E2-164035		400	350	1100	201	86	3270	2.26
E2-164530		450	300	1050	226	94	3570	2.48
E2-165025		500	250	1000	251	103	3910	2.71
E2-166025		600	250	1100	301	122	4640	3.21
E2-203030	20	300	300	900	188	59	3160	1.10
E2-204030		400	300	1000	251	77	4120	1.44
E2-204035		400	350	1100	251	78	4170	1.46
E2-204040		400	400	1200	251	79	4230	1.48
E2-204535		450	350	1150	282	87	4650	1.63
E2-204540		450	400	1250	282	88	4710	1.64
E2-205030		500	300	1100	314	94	5030	1.76
E2-205040		500	400	1300	314	97	5190	1.81
E2-207030		700	300	1300	439	130	6960	2.43
E2-208045		800	450	1700	502	151	8080	2.82
E2-254030	25	400	300	1000	314	68	4860	0.95
E2-254040		400	400	1200	314	70	5010	0.98
E2-254540		450	400	1250	353	78	5580	1.09
E2-255030		500	300	1100	392	84	6010	1.17
E2-255040		500	400	1300	392	86	6150	1.20
E2-256030		600	300	1200	471	100	7150	1.40
E2-257040		700	400	1500	549	118	8440	1.65
E2-257045		700	450	1600	549	119	8510	1.66
E2-258030		800	300	1400	628	132	9440	1.85
E2-258035		800	350	1500	628	133	9510	1.86
E2-258040		800	400	1600	628	134	9580	1.87
E2-258050		800	500	1800	628	136	9720	1.90
E2-306035	30	600	350	1300	565	92	8600	0.98
E2-306040		600	400	1400	565	93	8700	0.99
E2-307030		700	300	1300	659	106	9910	1.13
E2-307045		700	450	1600	659	108	10100	1.15
E2-308030		800	300	1400	753	120	11200	1.29
E2-308040		800	400	1600	753	122	11400	1.31
E2-309030		900	300	1500	848	135	12600	1.45
E2-309040		900	400	1700	848	136	12700	1.46
E2-301030		1000	300	1600	942	149	13900	1.60

* Nominal loading values are measured at 1000°C in open air. The tolerance range is ±15% of center current value by converting into current value.

* Pre-shipment heat generation tests are conducted in open air with the heating element surface temperature at 850°C.

Type E2-DV



Metallized Width

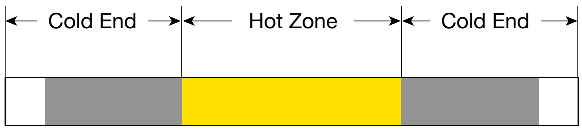
Outside diameter (mm)	Metallized Length (mm)
ø16	(30)
ø20 or more	(50)

Number	Size				Hot Zone surface area	Nominal loading values*		
	External diameter	Hot Zone Length	Cold End Length	Overall Length				
	mm	mm	mm	mm	cm^2	Volts	Watts	Ohms
E2-DV-161520	16	150	200	550	75	39	1330	1.14
E2-DV-162020		200	200	600	101	50	1700	1.47
E2-DV-162520		250	200	650	126	61	2070	1.80
E2-DV-163020		300	200	700	150	72	2450	2.12
E2-DV-163025		300	250	800	150	74	2520	2.17
E2-DV-163030		300	300	900	150	76	2580	2.24
E2-DV-164025		400	250	900	200	96	3260	2.83
E2-DV-164030		400	300	1000	200	98	3330	2.88
E2-DV-164525		450	250	950	225	107	3640	3.15
E2-DV-165025		500	250	1000	250	118	4010	3.47
E2-DV-165030		500	300	1100	250	120	4080	3.53
E2-DV-166025		600	250	1100	300	140	4760	4.12
E2-DV-203020	20	300	200	700	188	65	3120	1.35
E2-DV-203025		300	250	800	188	66	3170	1.37
E2-DV-203030		300	300	900	188	68	3260	1.42
E2-DV-203040		300	400	1100	188	71	3410	1.48
E2-DV-204025		400	250	900	251	86	4130	1.79
E2-DV-204030		400	300	1000	251	88	4220	1.84
E2-DV-204035		400	350	1100	251	90	4320	1.88
E2-DV-204040		400	400	1200	251	91	4370	1.89
E2-DV-204535		450	350	1150	283	100	4800	2.08
E2-DV-205030		500	300	1100	314	108	5180	2.25
E2-DV-205040		500	400	1300	314	111	5330	2.31
E2-DV-206030		600	300	1200	376	128	6140	2.67
E2-DV-207030		700	300	1300	439	148	7100	3.09
E2-DV-208030		800	300	1400	502	168	8060	3.50
E2-DV-254030	25	400	300	1000	314	76	4940	1.17
E2-DV-254040		400	400	1200	314	79	5140	1.21
E2-DV-255030		500	300	1100	392	94	6110	1.45
E2-DV-255040		500	400	1300	392	97	6310	1.49
E2-DV-256025		600	250	1100	470	110	7150	1.69
E2-DV-256030		600	300	1200	470	111	7220	1.71
E2-DV-257030		700	300	1300	550	129	8390	1.98
E2-DV-257035		700	350	1400	550	130	8450	2.00
E2-DV-257040		700	400	1500	550	131	8520	2.01
E2-DV-307030	30	700	300	1300	660	117	10100	1.36
E2-DV-307040		700	400	1500	660	119	10200	1.39
E2-DV-308030		800	300	1400	750	133	11400	1.55

* Nominal loading values are measured at 1000°C in open air. The tolerance range is ±15% of center current value by converting into current value.

* Pre-shipment heat generation tests are conducted in open air with the heating element surface temperature at 1000°C.

Type F2



Number	Size				Hot Zone surface area	Nominal loading values*		
	External diameter	Hot Zone Length	Cold End Length	Overall Length				
	mm	mm	mm	mm	cm²	Volts	Watts	Ohms
F2-354040	35	400	400	1200	439	64	6850	0.60
F2-355030		500	300	1100	549	78	8350	0.73
F2-355035		500	350	1200	549	79	8450	0.74
F2-355040		500	400	1300	549	79	8450	0.74
F2-356035		600	350	1300	659	94	10100	0.87
F2-356040		600	400	1400	659	94	10100	0.87
F2-356050		600	500	1600	659	96	10300	0.89
F2-357040		700	400	1500	769	109	11700	1.02
F2-358035		800	350	1500	879	124	13300	1.16
F2-351040		1000	400	1800	1099	154	16500	1.44
F2-351430		1400	300	2000	1539	213	22800	1.99
F2-406045	40	600	450	1500	753	88	11500	0.67
F2-407050		700	500	1700	879	103	13500	0.79
F2-408040		800	400	1600	1005	115	15100	0.88
F2-401035		1000	350	1700	1256	143	18700	1.09
F2-451035	45	1000	350	1700	1413	117	19700	0.69
F2-501540	50	1500	400	2300	2356	182	33900	0.98

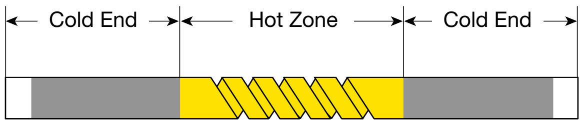
* Nominal loading values are measured at 1000°C in open air. The tolerance range is ±15% of center current value by converting into current value.

* Pre-shipment heat generation tests are conducted in open air with the heating element surface temperature at 850°C

Metallized Width

Outside diameter (mm)	Metallized Length (mm)
ø35 or more	(50)

Type SG



Number	Size				Hot Zone surface area	Nominal loading values*		
	External diameter	Hot Zone Length	Cold End Length	Overall Length				
	mm	mm	mm	mm	cm²	Volts	Watts	Ohms
G-142020	14	200	200	600	87	59	1650	2.11
G-142025		200	250	700	87	60	1680	2.14
G-142520		250	200	650	109	71	1990	2 53
G-142525		250	250	750	109	73	2040	2.61
G-143025		300	250	800	131	85	2380	3.04
G-162025	16	200	250	700	100	58	1970	1.71
G-162520		250	200	650	125	69	2350	2 03
G-162525		250	250	750	125	70	2380	2.06
G-162530		250	300	850	125	71	2410	2.09
G-163020		300	200	700	150	81	2750	2.39
G-163025		300	250	800	150	82	2790	2.41
G-163030		300	300	900	150	83	2820	2.44
G-163525		350	250	850	175	94	3200	2.76
G-163530		350	300	950	175	95	3230	2.79
G-203040	20	300	400	1100	188	84	3440	2.05
G-203540		350	400	1150	219	97	3980	2 36
G-204040		400	400	1200	251	109	4470	2.66
G-204540		450	400	1250	282	121	4960	2.95
G-253040	25	300	400	1100	235	84	4120	1.71
G-253050		300	500	1300	235	86	4210	1.76
G-254040		400	400	1200	314	110	5390	2.24
G-255040		500	400	1300	392	135	6620	2.75
G-303040	30	300	400	1100	282	79	4980	1.25
G-303050		300	500	1300	282	80	5040	1.27
G-304040		400	400	1200	376	103	6490	1.63
G-304050		400	500	1400	376	104	6550	1.65
G-305040		500	400	1300	471	127	8000	2.02
G-306040		600	400	1400	565	151	9510	2.40
G-354040	35	400	400	1200	439	101	7680	1.33
G-354050		400	500	1400	439	102	7750	1.34
G-355040		500	400	1300	549	124	9420	1.63
G-355050		500	500	1500	549	125	9500	1.64
G-356040		600	400	1400	659	148	11200	1.96
G-357040		700	400	1500	769	171	13000	2.25
G-405040	40	500	400	1300	628	116	10700	1.26
G-405050		500	500	1500	628	117	10800	1.27
G-406040		600	400	1400	753	138	12700	1.50
G-406045		600	450	1500	753	139	12800	1.51
G-407040		700	400	1500	879	161	14800	1.75
G-457045	45	700	450	1600	989	149	16800	1.32
G-458040		800	400	1600	1130	168	19000	1.49

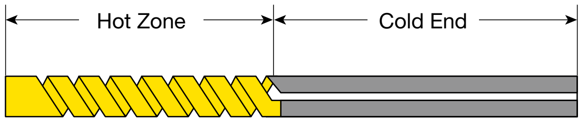
* Nominal loading values are measured at 1000°C in open air. The tolerance range is ±15% of center current value by converting into current value.

* Pre-shipment heat generation tests are conducted in open air with the heating element surface temperature at 1000°C.

Metallized Width

Outside diameter (mm)	Metallized Length (mm)
ø14 to 16	(30)
ø20 or more	(50)

Type SGR



Metallized Width

Outside diameter (mm)	Metallized Length (mm)
ø16	(30)
ø20 or more	(50)

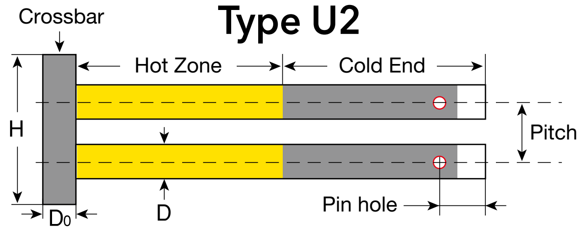
Number	Size				Hot Zone surface area	Nominal loading values*		
	External diameter	Hot Zone Length	Cold End Length	Overall Length				
	mm	mm	mm	mm	cm²	Volts	Watts	Ohms
GR-161015	16	100	150	250	50	61	940	3.96
GR-161020		100	200	300	50	69	1060	4.49
GR-161025		100	250	350	50	77	1190	4.98
GR-161515		150	150	300	75	84	1290	5.47
GR-161520		150	200	350	75	91	1400	5.92
GR-161525		150	250	400	75	99	1520	6.45
GR-162015		200	150	350	100	106	1630	6.89
GR-162020		200	200	400	100	113	1740	7.34
GR-162025		200	250	450	100	121	1860	7.87
GR-162515		250	150	400	125	128	1970	8.32
GR-162520		250	200	450	125	135	2080	8.76
GR-162525		250	250	500	125	143	2200	9.30
GR-162530		250	300	550	125	151	2330	9.79
GR-201015	20	100	150	250	62	58	1110	3.03
GR-201020		100	200	300	62	65	1250	3.38
GR-201025		100	250	350	62	72	1380	3.76
GR-201515		150	150	300	94	80	1540	4.16
GR-201520		150	200	350	94	87	1670	4.53
GR-201525		150	250	400	94	94	1800	4.91
GR-202015		200	150	350	125	102	1960	5.31
GR-202020		200	200	400	125	109	2090	5.68
GR-202025		200	250	450	125	116	2230	6.03
GR-202515		250	150	400	157	124	2380	6.46
GR-202520		250	200	450	157	131	2520	6.81
GR-202525		250	250	500	157	138	2650	7.19
GR-203020		300	200	500	188	153	2940	7.96
GR-203025		300	250	550	188	160	3070	8.34
GR-251520	25	150	200	350	117	87	2000	3.78
GR-251525		150	250	400	117	92	2120	3.99
GR-251530		150	300	450	117	98	2250	4.27
GR-252020		200	200	400	157	110	2530	4.78
GR-252025		200	250	450	157	115	2650	4.99
GR-252030		200	300	500	157	121	2780	5.27
GR-252520		250	200	450	196	133	3060	5.78
GR-252525		250	250	500	196	139	3200	6.04
GR-252530		250	300	550	196	144	3310	6.26
GR-253030		300	300	600	235	167	3840	7.26
GR-253035		300	350	650	235	173	3980	7.52
GR-253040		300	400	700	235	179	4120	7.78
GR-253530		350	300	650	274	191	4390	8.31
GR-253535		350	350	700	274	196	4510	8.52
GR-254030		400	300	700	314	214	4920	9 31
GR-302020	30	200	200	400	188	90	2790	2.90
GR-302025		200	250	450	188	91	2820	2.94
GR-302030		200	300	500	188	91	2820	2.94
GR-302520		250	200	450	235	111	3440	3.58
GR-302525		250	250	500	235	111	3440	3.58
GR-302530		250	300	550	235	112	3470	3.61
GR-303030		300	300	600	282	132	4090	4.26
GR-303035		300	350	650	282	132	4090	4.26

Number	Size				Hot Zone surface area	Nominal loading values*		
	External diameter	Hot Zone Length	Cold End Length	Overall Length				
	mm	mm	mm	mm	cm²	Volts	Watts	Ohms
GR-303040	30	300	400	700	282	133	4120	4.29
GR-303530		350	300	650	329	153	4740	4.94
GR-303535		350	350	700	329	153	4740	4.94
GR-303540		350	400	750	329	153	4740	4.94
GR-304030		400	300	700	376	173	5360	5.58
GR-304035		400	350	750	376	173	5360	5.58
GR-304040		400	400	800	376	174	5390	5.62
GR-304530		450	300	750	424	193	5980	6.23
GR-304535		450	350	800	424	194	6010	6.26
GR-305030		500	300	800	471	214	6630	6.91
GR-352020	35	200	200	400	219	89	3260	2.43
GR-352025		200	250	450	219	89	3260	2.43
GR-352030		200	300	500	219	90	3290	2.46
GR-352520		250	200	450	274	109	3990	2.98
GR-352525		250	250	500	274	109	3990	2.98
GR-352530		250	300	550	274	110	4030	3.00
GR-353030		300	300	600	329	130	4760	3.55
GR-353035		300	350	650	329	131	4790	3.58
GR-353040		300	400	700	329	131	4790	3.58
GR-353530		350	300	650	384	150	5490	4.10
GR-353535		350	350	700	384	151	5530	4.12
GR-353540		350	400	750	384	151	5530	4.12
GR-354030		400	300	700	439	171	6260	4.67
GR-354035		400	350	750	439	171	6260	4.67
GR-354040		400	400	800	439	172	6300	4.70
GR-354530		450	300	750	494	191	6990	5.22
GR-354535		450	350	800	494	191	6990	5.22
GR-355030		500	300	800	549	211	7720	5.77
GR-402020	40	200	200	400	251	86	3660	2.02
GR-402025		200	250	450	251	87	3700	2.05
GR-402030		200	300	500	251	87	3700	2.05
GR-402520		250	200	450	314	106	4510	2.49
GR-402525		250	250	500	314	107	4550	2.52
GR-402530		250	300	550	314	107	4550	2.52
GR-403030		300	300	600	376	127	5400	2.99
GR-403035		300	350	650	376	127	5400	2.99
GR-403040		300	400	700	376	127	5400	2.99
GR-403530		350	300	650	439	147	6250	3.46
GR-403535		350	350	700	439	147	6250	3.46
GR-403540		350	400	750	439	147	6250	3.46
GR-404030		400	300	700	502	167	7100	3.93
GR-404035		400	350	750	502	167	7100	3.93
GR-404040		400	400	800	502	167	7100	3.93
GR-404530		450	300	750	565	186	7910	4.37
GR-404535		450	350	800	565	187	7950	4.40
GR-405030		500	300	800	628	206	8760	4.84

* Nominal loading values are measured at 1000°C in open air. The tolerance range is ±20% of center current value by converting into current value.

* Pre-shipment heat generation tests are conducted in open air with the heating element surface temperature at 1000°C.

Type U2



Number	Size				Hot Zone surface area	Nominal loading values*1			Standard pin hole location*2
	External diameter	Hot Zone Length	Cold End Length	Pitch					
	mm	mm	mm	mm	cm²	Voltage	Power	Resistance	
U2-163030	16	300	300	40	301	121	4600	3.18	40
U2-164030		400	300	40	402	160	6080	4.21	
U2-164040		400	400	40	402	163	6190	4.29	
U2-165030		500	300	40	502	200	7600	5.26	
U2-203040	20	300	400	50	376	112	5990	2.09	45
U2-203540		350	400	50	439	130	6960	2.43	
U2-204040		400	400	50	502	147	7860	2.75	
U2-204535		450	350	50	565	164	8770	3.07	
U2-205040		500	400	50	628	183	9790	3.42	
U2-205050		500	500	50	628	185	9900	3.46	
U2-206040		600	400	50	753	218	11700	4.06	
U2-206050		600	500	50	753	220	11800	4.10	
U2-207040		700	400	50	879	253	13500	4.74	
U2-207050		700	500	50	879	256	13700	4.78	
U2-208040		800	400	50	1005	289	15500	5.39	
U2-208050		800	500	50	1005	291	15600	5.43	
U2-254040	25	400	400	60	628	131	9370	1.83	55
U2-254050		400	500	60	628	133	9510	1.86	
U2-254540		450	400	60	706	147	10500	2.06	
U2-255040		500	400	60	785	163	11700	2.27	
U2-255050		500	500	60	785	165	11800	2.31	
U2-255540		550	400	60	863	179	12800	2.50	
U2-256040		600	400	60	942	195	13900	2.74	
U2-256050		600	500	60	942	197	14100	2.75	
U2-257040		700	400	60	1099	227	16200	3.18	
U2-257050		700	500	60	1099	229	16400	3.20	
U2-258040		800	400	60	1256	259	18500	3.63	
U2-258050		800	500	60	1256	261	18700	3.64	
U2-305040	30	500	400	70	942	148	13800	1.59	55
U2-305050		500	500	70	942	150	14000	1.61	
U2-306040		600	400	70	1130	177	16500	1.90	
U2-306050		600	500	70	1130	179	16700	1.92	
U2-307040		700	400	70	1319	206	19300	2.20	
U2-307050		700	500	70	1319	208	19400	2.23	
U2-308040		800	400	70	1507	235	22000	2.51	
U2-308050		800	500	70	1507	237	22200	2.53	
U2-309040		900	400	70	1696	264	24700	2.82	
U2-309050		900	500	70	1696	266	24900	2.84	
U2-301050		1000	500	70	1884	295	27600	3.15	
U2-356040	35	600	400	80	1319	179	19200	1.67	60
U2-356050		600	500	80	1319	181	19400	1.69	
U2-357040		700	400	80	1539	209	22400	1.95	
U2-357050		700	500	80	1539	211	22600	1.97	
U2-358040		800	400	80	1759	239	25600	2.23	
U2-358050		800	500	80	1759	240	25700	2.24	
U2-359040		900	400	80	1979	269	28800	2.51	
U2-359050		900	500	80	1979	270	28900	2.52	
U2-351050		1000	500	80	2199	300	32100	2.80	

*1 Nominal loading values are measured at 1000°C in open air. The tolerance range is ±15% of center current value by converting into current value.
*2 Pin hole diameter is optional.

* Pre-shipment heat generation tests are conducted in open air with the heating element surface temperature at 1000°C.

Metallized Width

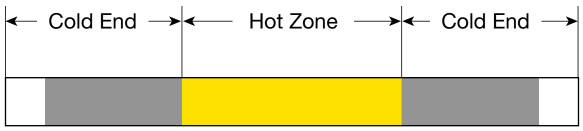
Outside diameter (mm)	Metallized Length (mm)
ø16	(30)
ø20 or more	(50)

Crossbar size

D	16	20	25	30	35
Do	25	30	35	40	45
H	76	90	110	125	140

Note)1. Overall length of U-Type heating element: U-Type nominal length (Cold End Length+ Hot Zone Length) plus Crossbar Do.
2. The value H shows the max. width of U-Type heating elements.

Type SA



Number	Size				Hot Zone surface area	Nominal loading values*		
	External diameter	Hot Zone Length	Cold End Length	Overall Length				
	mm	mm	mm	mm	cm²	Volts	Watts	Ohms
SA-161520	16	150	200	550	75	28	1430	0.55
SA-162020		200	200	600	101	36	1840	0.71
SA-162520		250	200	650	126	44	2240	0.86
SA-163020		300	200	700	150	51	2600	1.00
SA-163025		300	250	800	150	52	2650	1.02
SA-163030		300	300	900	150	53	2700	1.04
SA-164025		400	250	900	200	67	3420	1.31
SA-164030		400	300	1000	200	68	3470	1.33
SA-165025		500	250	1000	250	83	4230	1.63
SA-165030		500	300	1100	250	84	4280	1.65
SA-203020	20	300	200	700	188	43	3050	0.61
SA-203025		300	250	800	188	44	3120	0.62
SA-203030		300	300	900	188	45	3200	0.63
SA-204025		400	250	900	251	57	4050	0.80
SA-204030		400	300	1000	251	58	4120	0.82
SA-205030		500	300	1100	314	71	5040	1.00
SA-206030		600	300	1200	376	85	6040	1.20
SA-207030		700	300	1300	439	98	6960	1.38
SA-208030		800	300	1400	502	111	7880	1.56

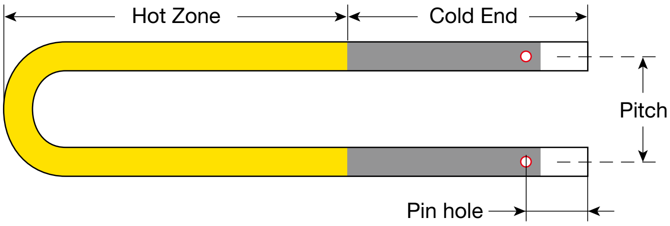
* Nominal loading values are measured at 1000°C in open air. The tolerance range is ±20% of center current value by converting into current value.

* Pre-shipment heat generation tests are conducted in open air with the heating element surface temperature at 1000°C.

Metallized Width

Outside diameter (mm)	Metallized Length (mm)
ø16	(30)
ø20 or more	(50)

Type U3



Feature size

Outside diameter: ø16, 20, 25, 30mm
Hot Zone max. Length: 800mm
Cold End max. Length: 500mm
Available in the above range by 50mm as a unit.
Inside of Hot Zone is solid.
The pitch is the same as that of Type U2

Standard pin hole location (Pin hole diameter is optional.)

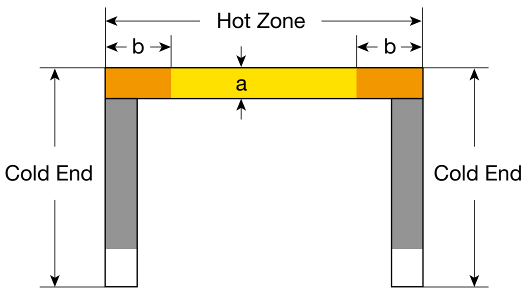
Outside diameter	Pin hole location (mm)
16	40
20	45
25	55

* Non-standard requests will be accepted.

Electric conditions

Same as those of the same size as Type U2

Type M2



Standard length of the low temperature area (b) shall be 1.5 times of the heating element diameter (a).

Feature size

Outside diameter: ø12, 16, 20, 25, 30mm
Length: 400mm or less × 700mm or less or 700mm or less × 400mm or less
(Hot Zone x Cold End for the above both)

Electric conditions

Same as those of the same size of Type E2.

Type E7, F7 & U7

Feature size

Outside diameter: ø16, 20, 25, 30, 35, 40mm
Hot Zone max. Length: 1000mm
Cold End max. Length: 500mm
Size of Types E2, F2 and U2 are available in the above range.

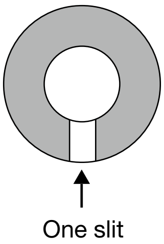
Electric conditions

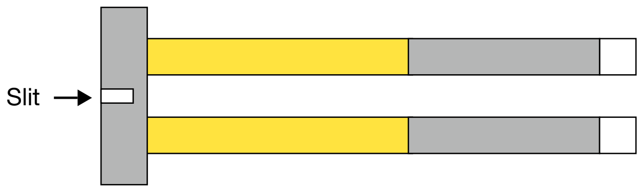
Same as that of the same size of Types E2, F2 and U2.

Identification Method

Identify by the following method as Types E2, F2 and U2 are not identifiable by appearance.

Type E7 and F7 have slits on their end surface.



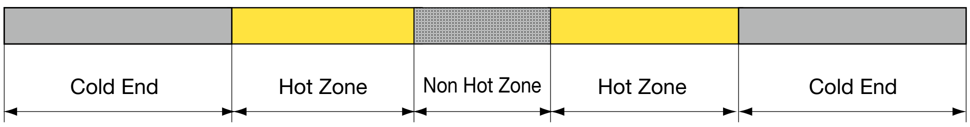


Type U7 has a slit at the center of the crossbar.

Caution:

As their temperature rise is slightly different from that of other general heating elements,
do not use them by combining with Types E2, F2 or U2 in the same circuit.

Type SDL2



(Nominal designation example)	SDL2	25	×	500	×	200	×	400
	Type	Outside diameter		Hot Zone length		Non-hot zone length		Cold end length

Feature size

Diameter: ø14, 16, 20, 25, 30, 35, 45, 50mm
Please feel free to contact us for the Hot Zone length and Cold End length.

Electric conditions

The same as Types E2 and F2 in the case of the same total length like the following example.

Example)	SDL2	25	×	500	×	200	×	400	The same electric conditions
	E2	25	×	1000	×	500			

Please contact us for details.

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Note: The description in the catalog may be changed without notice for the purpose of improvement.

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