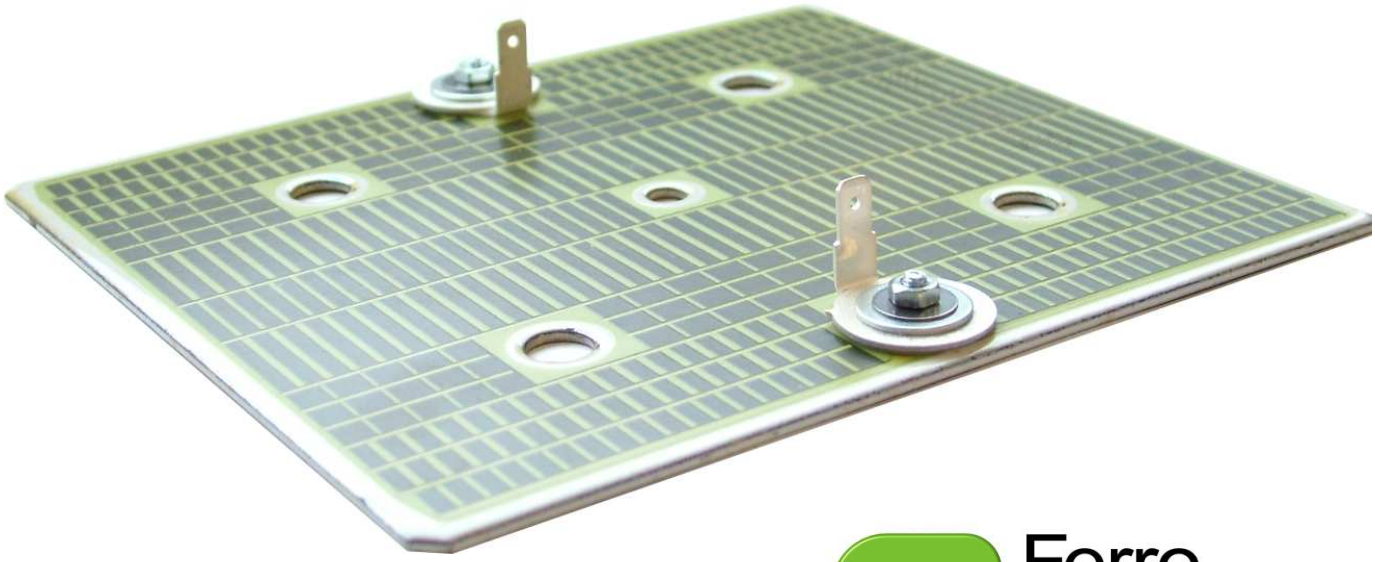
CHE

Contact Heating Element

A Supreme Heating System For:-

Tepan yaki Cooking plates Baking plates Frying pans Deep frying pans Crêpe pans Barbeques



Ferro Techniek

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Designer Pack Modification History

Issue Level	Date	Modification By	E.O. number	Modification	Approved By

Introduction

The Ferro Contact Heating Element (CHE) enables a food service equipment manufacturer to provide the ultimate electric cooking appliance.

The power from the element is dissipated over the entire cooking surface, providing very even heat distribution, without resorting to extreme thickness/mass.

The reduced mass enables accurate temperature control and faster heat up and cool down times than possible with conventional electric heating systems.

The larger area of the heating element and the recommended clamping method transfers the heat very effectively into the steel top plate, keeping the power density low resulting in lower element temperatures than conventional heating elements and greater energy efficiency.

CHE Features

• Power/heat evenly distributed over a large surface area - Less food sticking.

•Less mass required to evenly distribute the heat – Better speed and control

• Rapid heat-up, quick cool - Shorter waiting time.

• Effective heat transfer from the element - Energy saving

• Less accumulated heat – Energy saving

•Ferro Techniek thick film technology: Reliable and safe end of life.

•Application specific surface temperatures, powers, sizes.

•The cooking surface can be split into zones, that can be controlled at different temperature

• Slim-line design and lower external heat losses – Greater Design Freedom

CHE Applications

•Cooking plates

•Baking plates

•Frying pans

•Deep frying pans

•Crêpe pans

•Tepan yaki

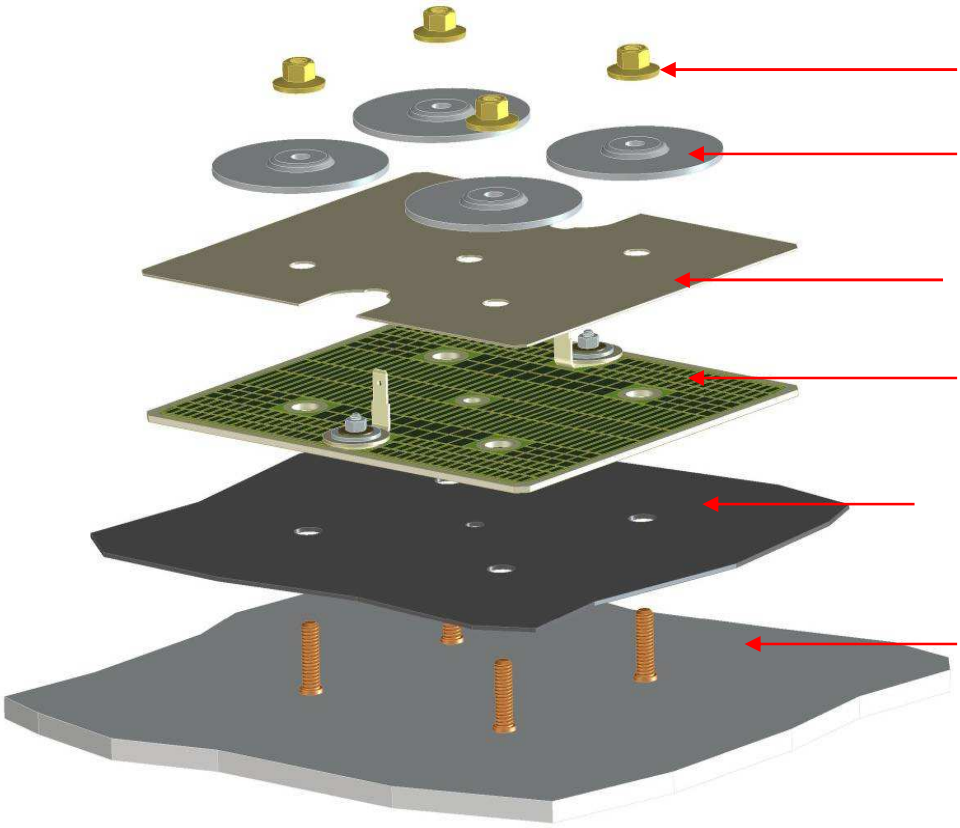
•Panel heating

•Barbeques

Example:

Tepan Yaki Table

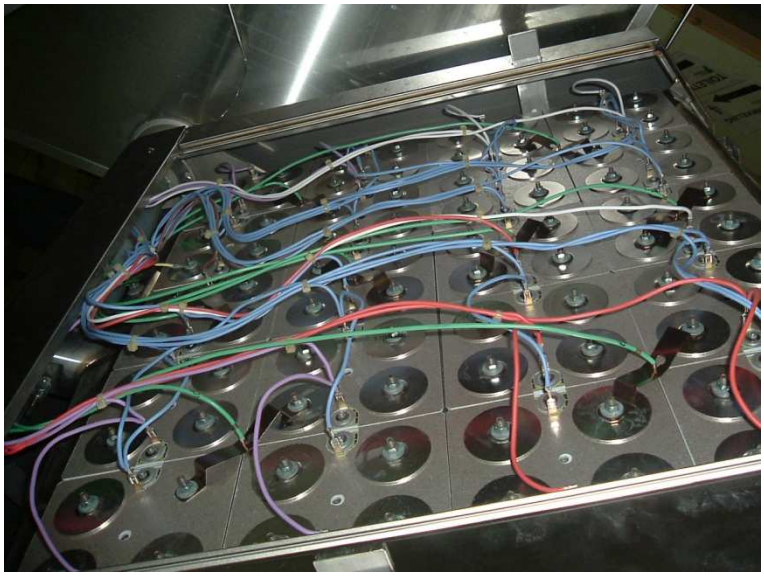
CHE Installation



In addition require:-

Temperature control Sensor(s) mounted against the back of the cooking plate.

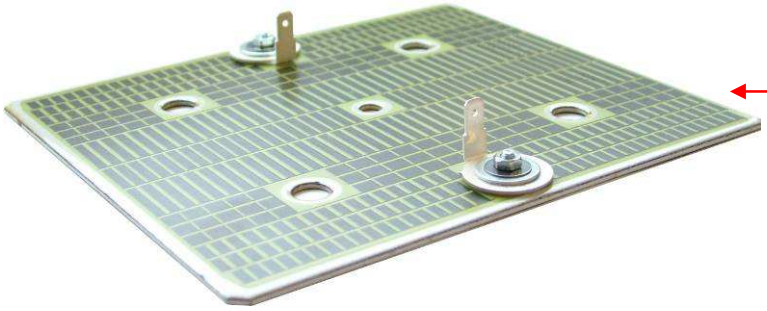
Overheat protection To comply with the relevant section of the approvals standards.



Underside of an application that is in production

CHE Examples

Expectation is to supply custom CHE for different applications

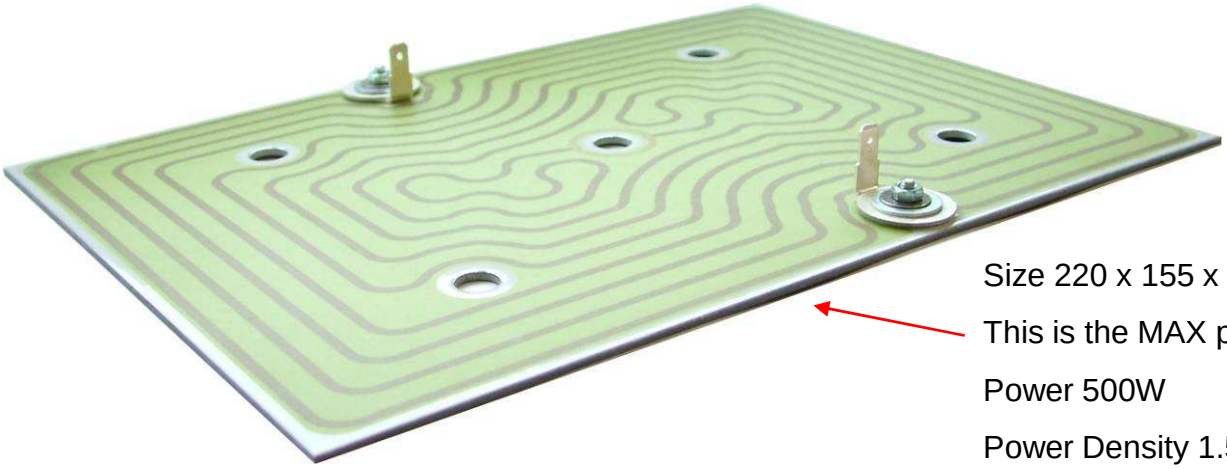


Size 140 x 125 x 1.5 mm

Power 1400W

Power Density 8 W/cm²

This is the MAX power density



Size 220 x 155 x 1.5 mm

This is the MAX possible size

Power 500W

Power Density 1.5 W/cm²

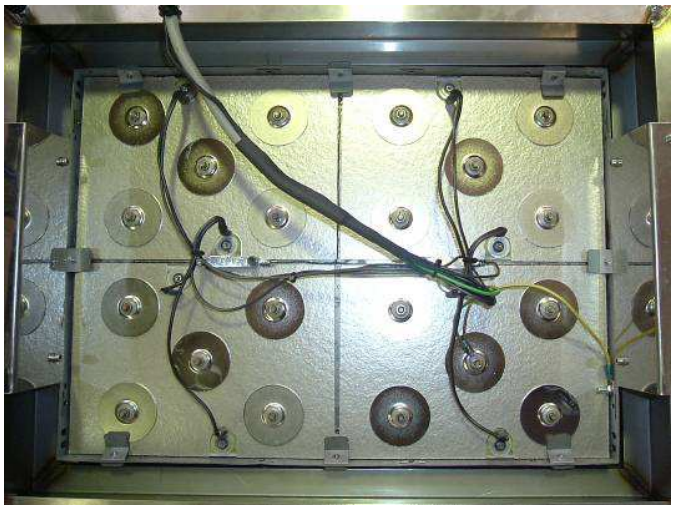
Example Of A 2kW Application, page 1

The CHE's are mounted on a steel top plate with a good heat conductivity and low TCE (Thermal Coefficient of Expansion). The cooking surface has a hardened chromium finish.

The CHE's cover the full surface of the top plate, right up to the edge, to avoid a cold rim.
A cold rim can cause the top plate to bend excessively. In addition, to maintain flatness, the top plate is free to expand in all directions.

Properties:

Size top plate	: 320 X 450 mm
Thickness top plate	: 6 mm
Thickness graphite foil	: 1 mm
Size of the elements	: 152 X 221 mm
Thickness of elements	: 1.5 mm
Power of each element	: 500Watt @ 230Vac
Total Power	: 2kW (domestic unit)
Heating zones	: 2 (2 x 2 CHE's parallel wired and controlled zones)
Controllers	: 2 standard PID's with relay output with K-thermocouple inputs.
Gap between CHE's	: 5 mm

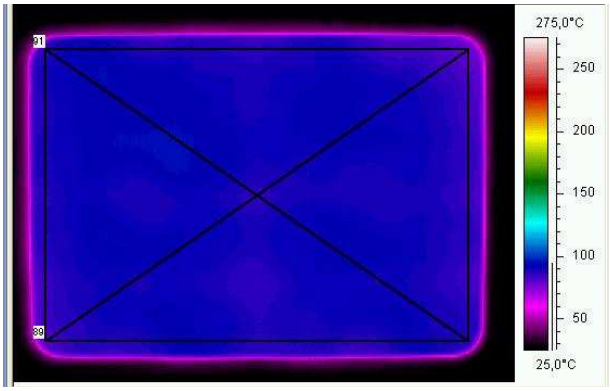


Combination of CHE's whitin the application

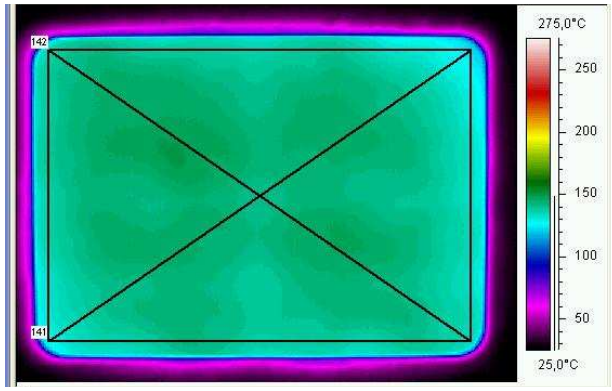
Example Of A 2kW Application, page 2

Infra red images showing speed and even heating of the cooking surface

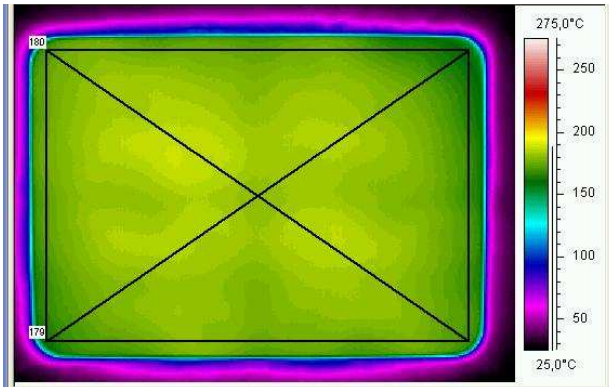
Starting from room temperature



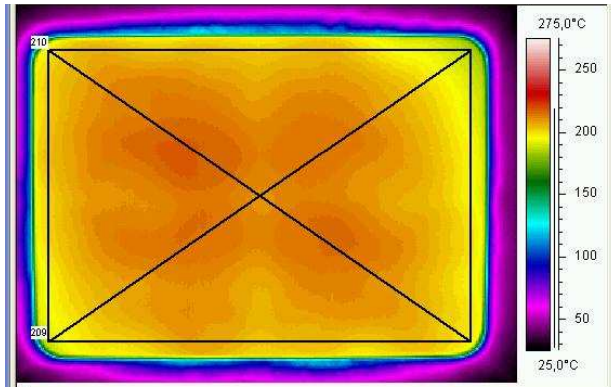
IR image at 2 minutes



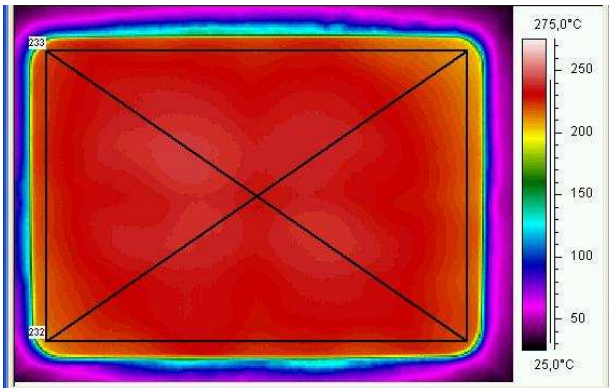
IR image at 4 minutes



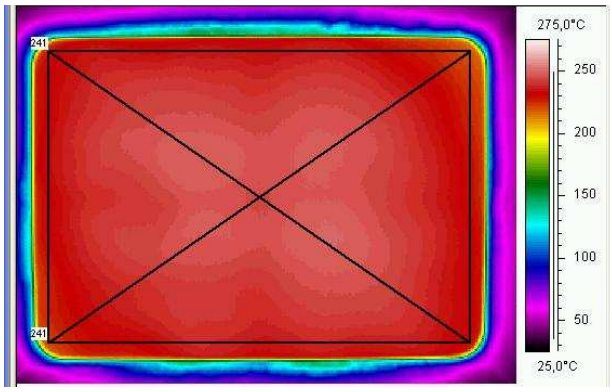
IR image at 6 minutes



IR image at 8 minutes

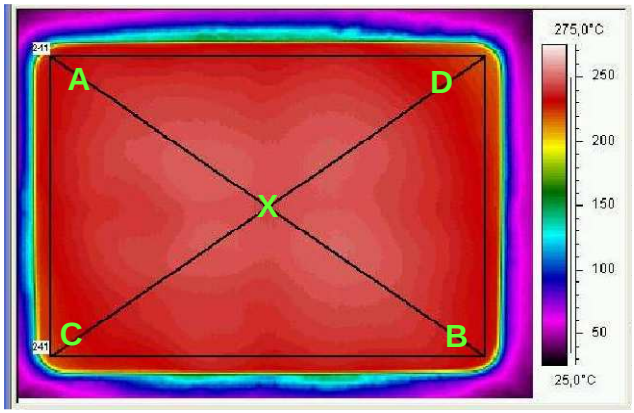


IR image at 10 minutes



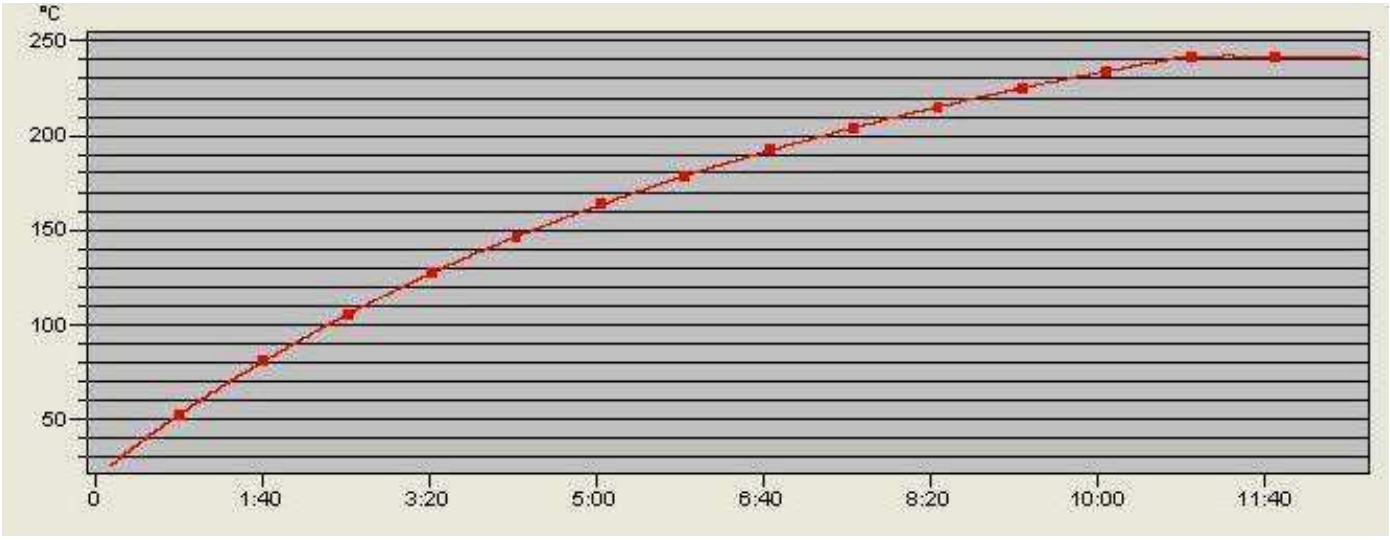
IR image at 12 minutes

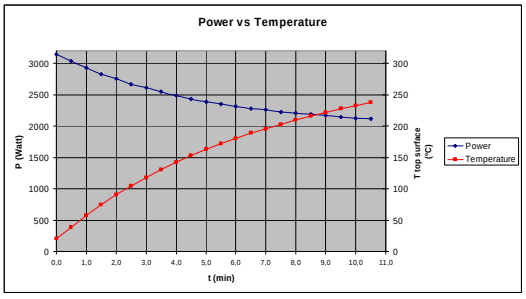
Example Of A 2kW Application, page 3



IR image at 12 minutes

Even heating across the cooking plate after 12 minutes from switching on from cold



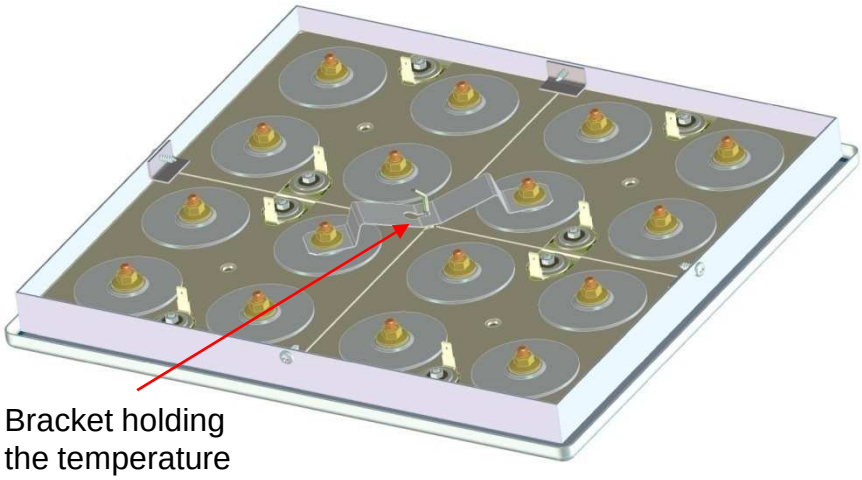


Rate of rise of cooking surface with 4 500W CHE

Power vs temperature rise.

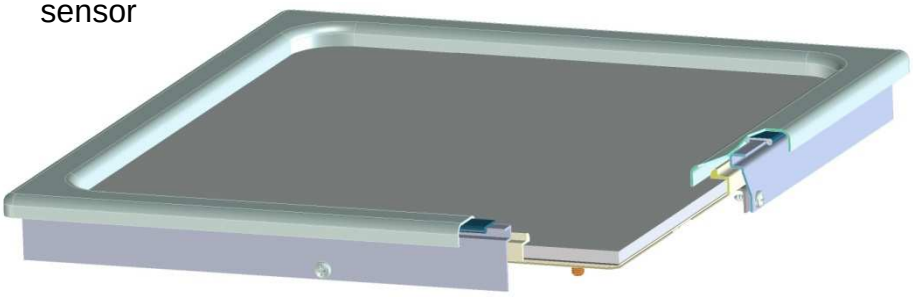
Effect due to PTC of selected heater track material.

Example Of A 2kW Application, page 4

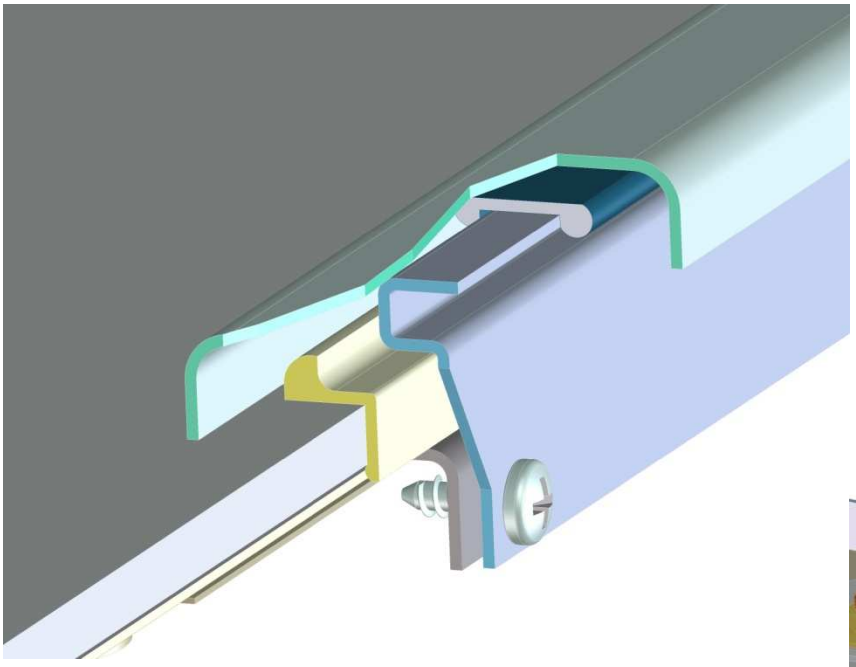


Bracket holding the temperature sensor

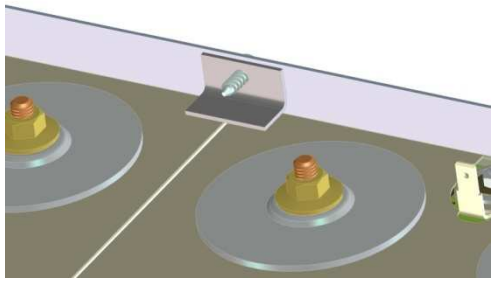
A good installation showing the CHE covering the entire area of the cooking plate.



The cooking plate is not constrained by the rim assembly.

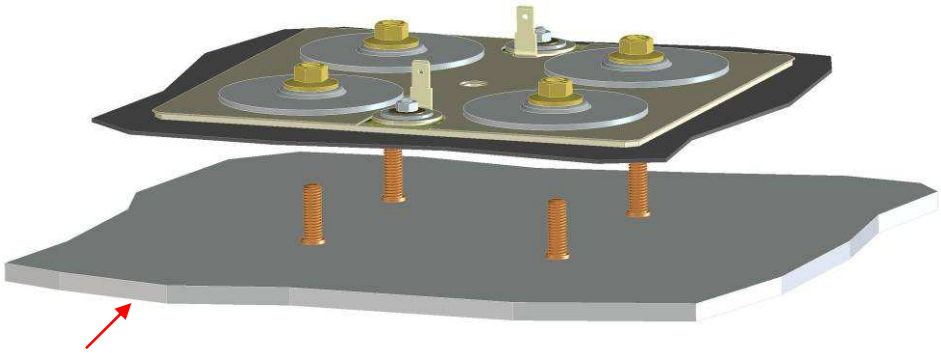


These points are important to maintain flatness of the thinner cooking plate.



More Detail About The Typical Construction of a CHE Installation, page 1

The Cooking Plate:



The cooking plate:-

*food approved baking surface

*easy to clean finish

To maintain flatness:-

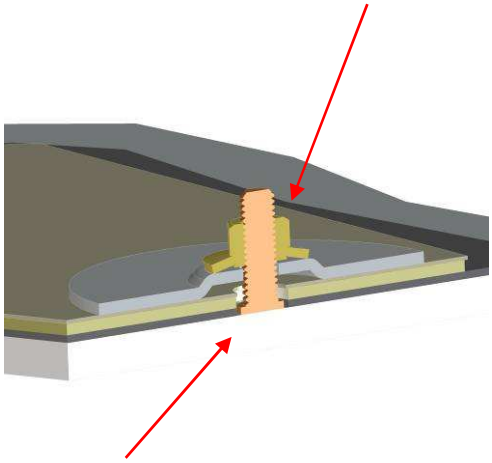
*material thickness 4 – 8mm (if steel)

*low thermal coefficient of expansion

*good heat conductivity

*thickness required dependent upon various aspects of the application

Tightening moment on M5 nut: 4 Nm



M5 X 16 weld stud, Steel 4.8.

Welding current typically 90 - 100Amps.

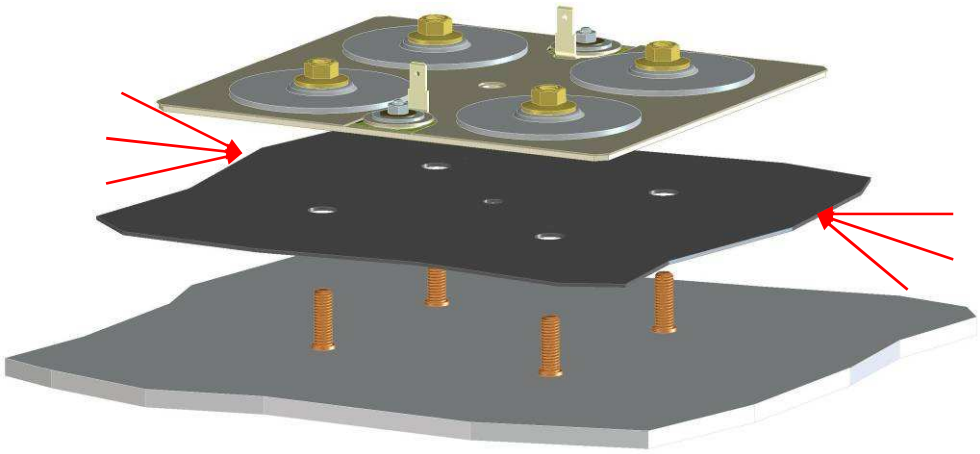
The studs will have a rim at the feet.

Be careful: the mounting holes of the heating elements must be clear of this rim when assembled!!!!

If not, the resulting pressure on the element will damage the heater track!!

More Detail About The Typical Construction of a CHE Installation, page 2

The Graphite Foil:



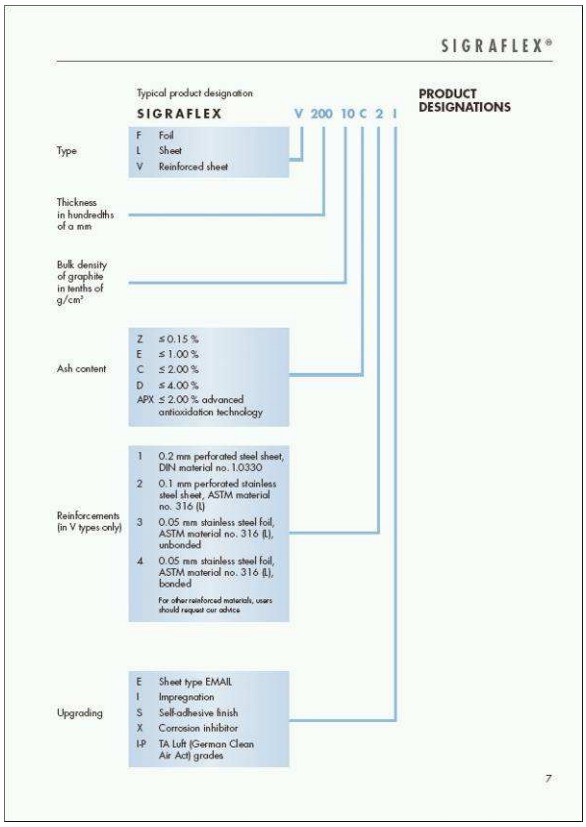
Graphite foil: SIGRAFLEX L10010C

The graphite foil transfers the heat into the top plate.

The foil is ductile and adapts to heat contact irregularities, like scratches and stud welding remains.

It has to be cut to the same size as the CHE.

Suitable Supplier:
SGL Carbon Group
URL: www.sglgroup.com



Material data of SIGRAFLEX® STANDARD

Material type			L10010CI	L15010CI	L20010CI
Thickness		mm	1.0	1.5	2.0
Dimensions		m		1.0 x 1.0	
Bulk density of graphite		g/cm³		1.0	
Ash content of graphite (DIN 51903)		%		≤ 2.0	
Total chloride content		ppm		≤ 25	
Residual stress (DIN 52913) $\sigma_{D\ 16\,h,\ 300\,°C,\ 50\ N/mm^2}$		N/mm²		≥ 47	
Gasket factors (DIN E 2505/DIN 28090-1)					
Gasket width b_D = 20 mm					
$\sigma_{VU/0.1}$ at an internal pressure of	10 bar	N/mm²	11	12	14
	16 bar	N/mm²	13	15	17
	25 bar	N/mm²	16	19	22
	40 bar	N/mm²	20	26	30
m			1.3	1.3	1.3
σ_{VO}		N/mm²	160	140	120
$\sigma_{BO\ at\ 300°C}$		N/mm²	140	120	100
Compression factors (DIN 28090-2)					
Compressibility	ε_{KSW}	%		40 - 50	
Recovery at 20 °C	ε_{KRW}	%		4 - 6	
Hot creep	ε_{WSW}	%		< 3	
Recovery at 300 °C	ε_{WRW}	%		3 - 4	
Young's modulus at 20 N/mm² (DIN 28090-1)		N/mm²		700	
ASTM	"m" factor			2	
	"y" factor	psi		1500	
Compressibility	ASTM F36	%		40 - 50	
Recovery		%		15 - 20	
The gasket factor conversion formulas as per AD Merkblatt B7 are as follows:				$k_0 \cdot K_D = \sigma_{VU} \cdot b_D$ $k_1 = m \cdot b_D$	

Definitions

$\sigma_{VU/0.1}$ Minimum gasket assembly stress needed to comply with leakage class L 0.1 (according to DIN 28090-1)
Recommended gasket assembly stress: ≥ 20 N/mm² up to σ_{BO}

σ_{BU} Minimum gasket assembly stress in service, where σ_{BU} is the product of internal pressure p and gasket factor m for test and in service ($\sigma_{BU} = p \cdot m$)

σ_{VO} Maximum permissible gasket stress at 20°C

$\sigma_{BO,\ 300°C}$ Maximum permissible gasket stress in service

m σ_{BU} / p_i

"m" factor Similar to m, but defined according to ASTM, hence different value

"y" factor Minimum gasket stress in psi

k_0 In mm, factor for gasket assembly stress

k_1 In mm, factor for gasket stress in service

K_D In N/mm², max. gasket stress-bearing capacity under assembly conditions

ε_{CSW} Compression set under a gasket stress of 35 N/mm²

ε_{SRW} Gasket recovery after reduction in gasket stress from 35 N/mm² to 1 N/mm²

ε_{WSW} Gasket creep compression under a gasket stress of 50 N/mm² at 300°C after 16 h

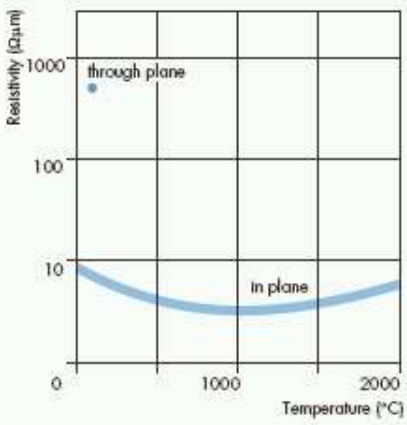
ε_{WRW} Recovery after reduction in gasket stress from 50 N/mm² to 1 N/mm²

The percentage changes in thickness of ε_{CSW}, ε_{SRW}, ε_{WSW} and ε_{WRW} are relative to the initial thickness.

Graphite datasheet

SIGRAFLEX®

OTHER PHYSICAL PROPERTIES



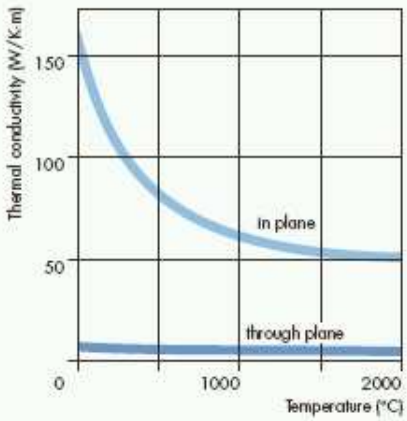
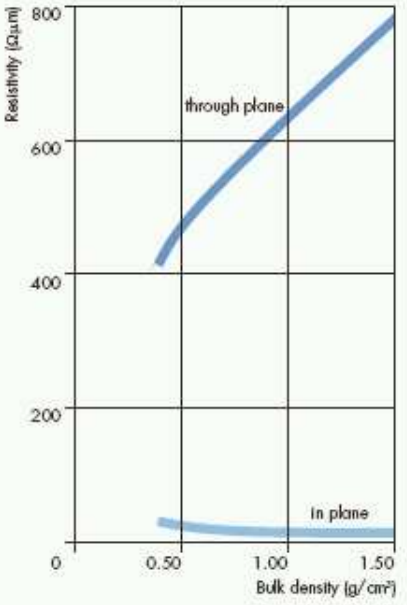


Fig. 2:
Resistivity as a function of temperature, bulk density 1.0 g/cm³

Fig. 3:
Thermal conductivity as a function of temperature, bulk density 1.0 g/cm³



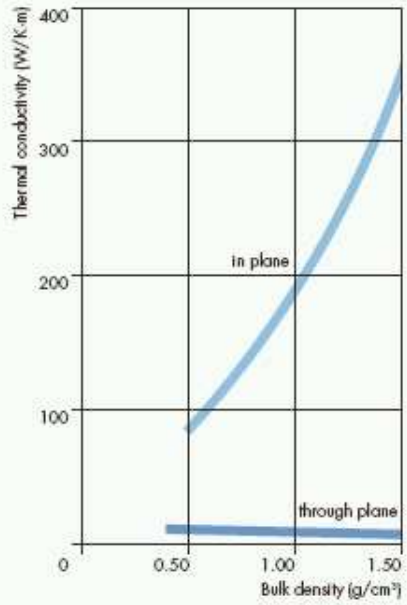


Fig. 4:
Resistivity as a function of bulk density

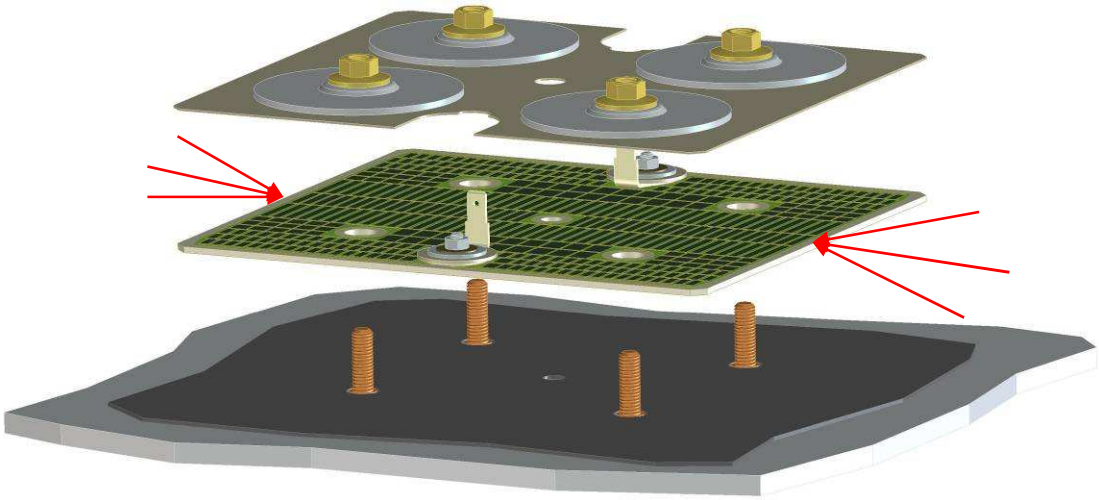
Fig. 5:
Thermal conductivity as a function of bulk density

10

Graphite thermal & resistance propperties

More Detail About The Typical Construction of a CHE Installation, page 3

The CHE Element:



The CHE is a Thick Film element.

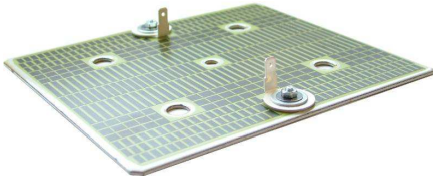
The composition is:-

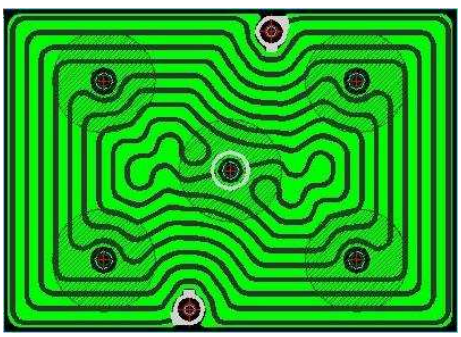
•Stainless steel substrate. 1mm or 1.5 mm thick.
Max dimensions 22cm x 15.5cm

•Dielectric enamel layer.
Electric strength > 1 min 1250V AC.

•Screen printed resistor track.
Max power density 8W/cm²
Max track temperature 350℃

•Power rating tolerance is -10 / +5% at nominal voltage, determined when boiling water using the heating element. Please ask availability of wattages and voltages.

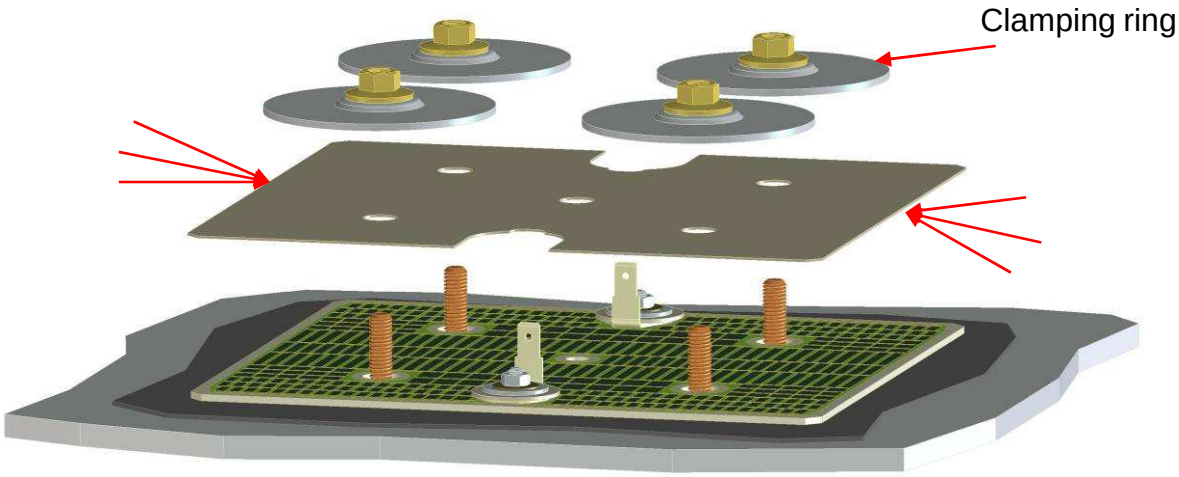




Example of a 2D element design

More Detail About The Typical Construction of a CHE Installation, page 4

The Mica Insulation:



The sheet of mica is used to electrically insulate the CHE heater tracks from the clamping rings.

The dimension of the mica is equal to the CHE element, with an open area at the electrical contacts.

The assembly of the clamping rings, with the M5 nuts to the M5 x16 mm studs, ”pull” the CHE’s against the cooking plate. The large diameter of the clamping rings is to spread the force over a large area of the mica sheet.

Suitable Supplier:

Cogebi
URL www.cogebi.com

See the following data sheet for suitable material

COGEMICANITE 505

Composition

Cogemicanite 505 Series of Rigid Heater Plates consist of approximately 90 % Cogemica Muscovite, alternatively Cogemica Phlogopite, impregnated with a unique "in-house" developed high temperature resistant silicone resin. The final binder content being approximately 10%.

ASBESTOS FREE

Properties and Applications

Five different grades available:
Cogemicanite 505.2 - Muscovite:
A special low smoke and blister-free grade. It fully resists the extreme high temperature cycles typically encountered for example, in automatic toasters.
Cogemicanite 505.3 - Muscovite:
The standard grade for all heating elements for hair dryers, hair setters, irons, tumble dryers, band heaters, nozzle heaters, etc.
Cogemicanite 505.4 - Muscovite:
A higher density grade with smoother surfaces. Most suitable for punching highly detailed pieces or when imprinting is required.
Cogemicanite 505.2P Phlogopite:
A special low smoke and blister-free grade, softer and more heat resistant. For extreme high temperature applications.
Cogemicanite 505.3P - Phlogopite:
The standard grade for heating elements operating in an extreme temperature range.

Punchability

Cogemicanite 505 Series of Rigid Heater Plates can be easily punched. Tools for punching difficult parts, however, should be provided with spring loaded hold-down plates.

Availability

Sheets of 1000 x 1200 mm
500 x 1200 mm
1000 x 600 mm
Strips and punched parts according to drawings.
Thickness 0,1 to 1,5 mm.

Storage

Unlimited shelf life in a dry place at room temperature.

Characteristics

	Test Procedures		505.2	505.3	505.4	505.2P	505.3P
Mica content	%	IEC 371-2	ca. 90	ca. 90	ca. 90	ca. 90	ca. 90
Bond content	%	IEC 371-2	ca. 10	ca. 10	ca. 10	ca. 10	ca. 10
Density		IEC 371-2	2,15	2,15	2,25	2,15	2,15
Heat Resistance							
continuous service	°C		500	500	500	700	700
intermittent service	°C		800	800	800	1000	1000
Edge Strength	Kg/0,1 mm	In house	1,3	1,4	1,7	0,9	1,0
Tensile Strength	N/mm²	ISO 527	140	150	150	100	110
Flexural Strength	N/mm²	ISO 178	200	230	230	150	170
Water absorption	%	ISO 62	<1	<1	<1	<1	<1
Dielectric Strength	KV/mm	IEC 243	>20	>20	>20	>20	>20
Insulation Resistance 23°C	Ω · cm	IEC 93	$>10^{17}$	$>10^{17}$	$>10^{17}$	$>10^{17}$	$>10^{17}$
Insulation Resistance 550°C	Ω · cm	IEC 93	$>10^{12}$	$>10^{12}$	$>10^{12}$	$>10^{12}$	$>10^{12}$
Heat Loss at 500°C	%	IEC 371-2	<1	<1	<1	<1	<2
at 700°C	%	IEC 371-2				<2	<2
Thermal Expansion							
perpendicular to Layer	10^{-6}/K		100	100	100	100	100
parallel to Layer	10^{-6}/K		10	10	10	10	10

Data are average results of laboratory tests conducted under standard procedures and are subject to variation. These do not constitute a warranty or representation for which we assume legal responsibility.

COGEBI
EXCELLENCE IN MICA

Cogebi
Huymanslaan, 65
B-1651 Lot Belgium
Phone: +(32) 2 380 91 11
Fax.: +(32) 2 378 12 09
mica@cogebi.com

Cogebi s.r.o.
Vozka 2104
390 02 Tabor - Czech Republic
Phone: +(420) 381 281 111
Fax.: +(420) 381 281 567
sales@cogebi.com

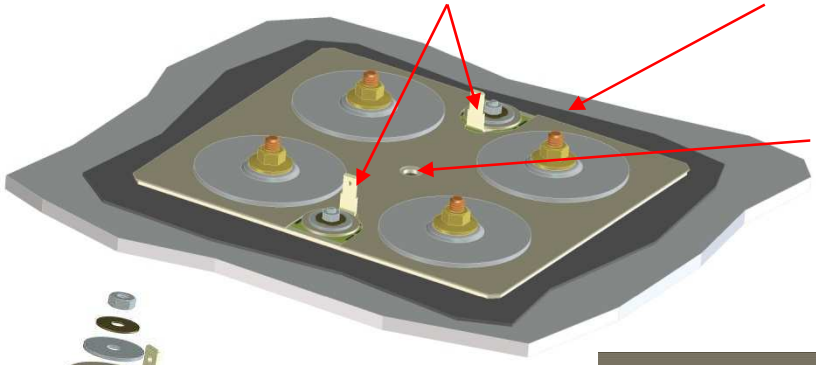
Cogebi Inc.
Crosby Road Industrial Park
14 Faraday Drive Dover N.H.
03820 - USA
Phone: +(1) 603 749 6896
Fax: +(1) 603 749 0958
mica@cogebiusa.com

Cogebi Asia Sdn Bhd
Lot 252, No. 3, Jalan Sub 3
Sg. Penaga Industrial Park,
47610 Subang Jaya,
Selangor, Malaysia.
Phone: +(603) 5635 0800
Fax.: +(603) 5638 2100
cogebi.asia@gmail.com

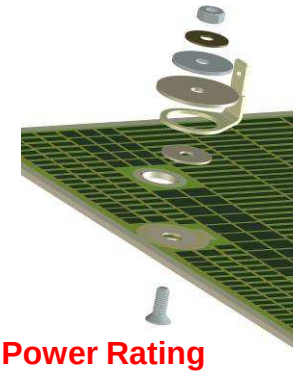
Datasheet Mica

More Detail About The Typical Construction of a CHE Installation, page 5

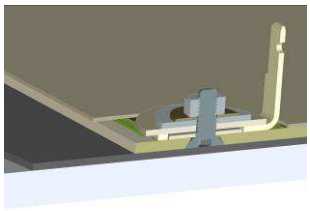
FTH Electrical Connections



The temperature sensor(s) can be positioned against the cooking plate either between the CHE or through the central hole.



Exploded view of contact assembly



Cross section of contact assembly

Power Rating

Power rating tolerance is -10 / +5% at nominal voltage, determined when boiling water using the heating element. Please ask availability of wattages and voltages

Element connections:

The element (L,N) connections shall be made with 4.8 x 0.8mm receptacles, type “Faston” (Tyco/Amp/PA) or compatible in Sn plated Brass (not low insertion force). To IEC standard 1210. Earth connection to any given place on cooking plate.

Wiring of connections:

Wires shall be flexible to prevent stress on terminals And should have high temperature insulation. Multi-stranded is recommended to ensure good crimping. The cross sectional area of the element wires needs to be according to the power rating.

Temperature Control

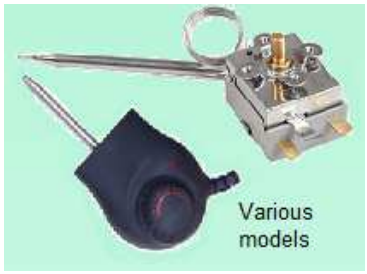
Sophistication required depends on application. CHE is ok from bimetal thermostat to PID and fuzzy controllers, which can compensate for the response time between element and application temperature. The cooking area can be divided into zones controlled at different temperatures. A zone can be as small as one CHE.

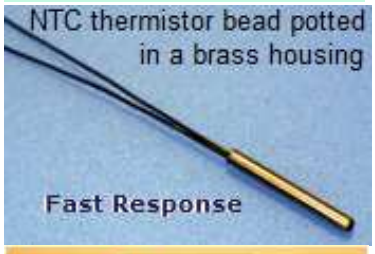
Overheat protection

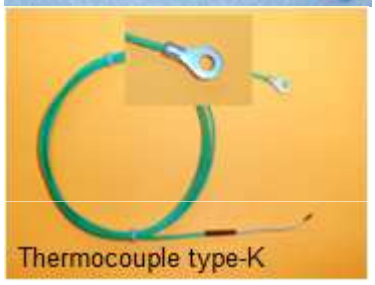
To comply with the relevant approvals standards.

More Detail About The Typical Construction of a CHE Installation, page 6

Temperature control:







Several temperature control methods are suitable for CHE.

Capillary control

Advantage: Cheap, no extra electronics needed

Disadvantage: Mechanical limitation (size and position),
Wider temperature spread and hysteresis

NTC

Advantage: Low cost, small size component

Disadvantage: Electronics needed for switching CHE

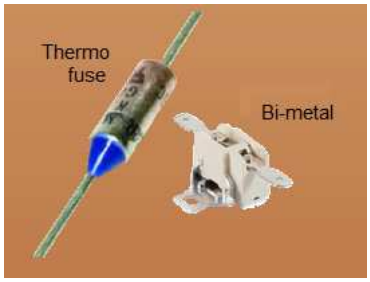
Thermocouple

Advantage: Standard control, very accurate

Disadvantage: More expensive sensor and control

Over temperature protection:

CHE must be protected for over temperatures to comply with the relevant section of the approvals standards. Standard bimetal or thermal fuse cut-outs are suitable with CHE.



Bimetal

A bimetal disc is used as a temperature sensing element.

As soon as the preset temperature is reached the bimetal disc operates and opens the electrical contact, interrupting the circuit. These are reset-able devices (auto or manual)

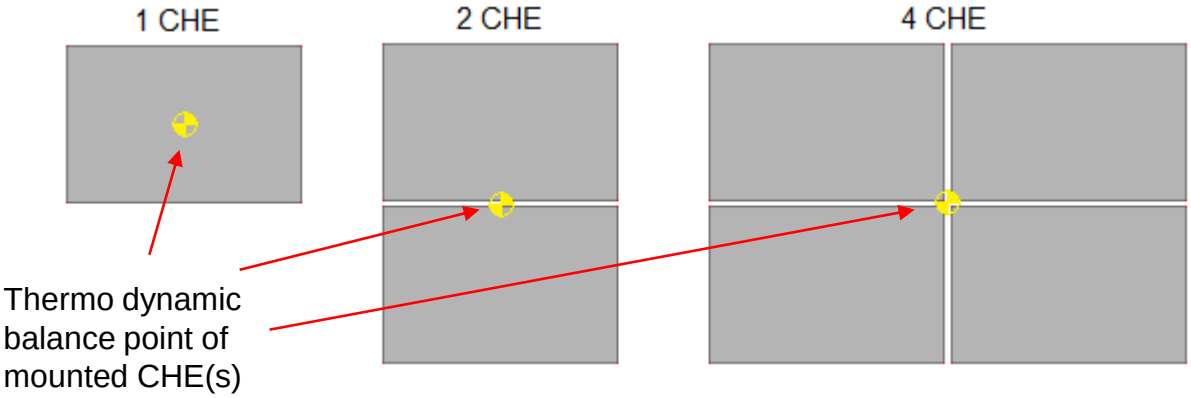
Thermal Fuse

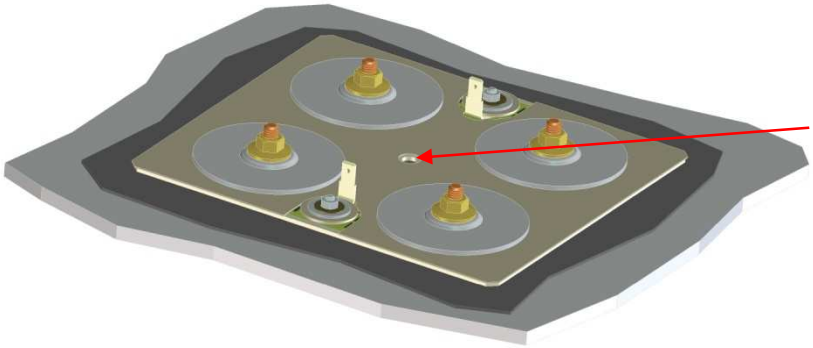
This protection device will interrupt the circuit permanently, when the preset temperature is reached. This is a low cost, non reset-able solution.

More Detail About The Typical Construction of a CHE Installation, page 7

Position of temperature sensor:

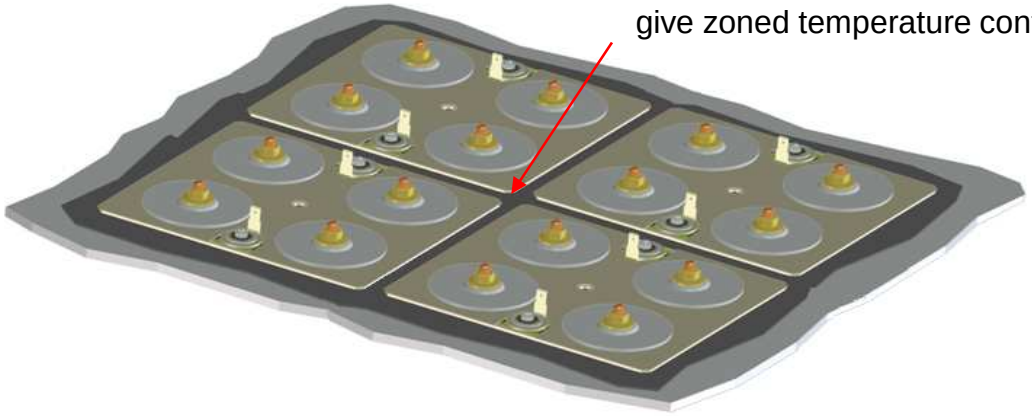
Optimum performance of the appliance is achieved by good positioning of the temperature sensor directly against the heated medium (the steel cooking plate). If more then one CHE is used the optimal position of the sensor is the thermo dynamic balance point of all the CHE(s).





The temperature sensor(s) can be positioned against the cooking plate either between the CHE or through the central hole.

A single temperature sensor can either be positioned between the CHE, or for a better response, each CHE can have its own sensor and can give zoned temperature control.



Conclusion

•This document has introduced the Ferro Techniek Contact Heating Element, explained its benefits of speed, control and even heat distribution over the entire cooking surface, plus shown how it is installed.

•Should you be interested in manufacturing a top of the range appliance using the Ferro Techniek Contact Heating Elements, please contact:-

Stephen Hollick – Otter Sales Manager, Ferro Products

s.hollick@ottercontrols.com

Desk +44 1298 762334

•The process will then start identifying the CHE dimensions and power that would best suit your application. This may result in doing a custom designed CHE. Samples will be produced for testing on the proposed cooking plate. The Ferro Techniek engineers will work closely with you throughout the project.

The appliance and/or drawings tested and/or evaluated and referred to in this Report has/have been modelled or otherwise adapted to incorporate an Otter Controls Group (“Otter”) product (“the Otter product”).

The purchaser is solely responsible for the choice of a suitable calibration and method of installation and to ensure that all relevant safety standards are met.

Any recommendations or modifications detailed in this Report and provided by Otter should be tested by the purchaser and implemented prior to the commencement of production.

It is the sole responsibility of the purchaser at all times to ensure that the relevant safety requirements are met and no liability whatsoever shall be incurred by Otter in respect of any representations whether written or otherwise made by Otter or its agents relating to the safety or fitness of the appliance or the suitability of the Otter Product as a result of this report.

The information supplied herein shall be treated as confidential and shall not be disclosed to third parties without the express prior written consent of Otter.

For the purposes of this Warning, the term “purchaser” and “products” shall have the same meaning as set out in Otter’s Terms and Conditions of Sale (“the Conditions”) and the term “purchaser” shall include the purchaser’s servants, agents and employees.

This Warning should be read in conjunction with Clause 1 of the Conditions which shall continue to apply at all times.