HeatWorks

HeatWorks 20 | www.ceramicx.com

Putting it all together:
Infrared Heat and Ceramicx

ENGINEERING COMPETENCIES

PRODUCT GUIDE   TYPES OF HEATERS

NEW BUILDING

Welcome

A fresh look at a new science

A new factory certainly gives inspiration to take a fresh look at all manner of things.

Such is the case here at Ceramicx and especially with regard to this the 20th issue of our in-house magazine – HeatWorks.

We have chosen to celebrate our newly constructed facilities with a companion issue of the magazine – one that reminds, re-iterates and underscores the fundamentals of the science of Infrared heating.

It is my hope that the reader retains this magazine issue as a regular primer and refresher on these IR heating matters.

Four sections cover the ground;

- Principal types of IR heaters
- Primary Industrial Applications for IR heating
- Energy and radiation fundamentals
- Control and measurement of IR energy and heating.

Make no mistake, Ceramicx is at the forefront of the scientific advancement of Infrared heating: Our commercial successes on five continents simply attest to the superior technical and scientific nature of our manufacturing and our resulting products and heaters. Empirical scientific research backs everything we do. And - as this magazine issue clearly shows - such IR science is not approximate. No 'black art' skills are required here.

Instead, the clean, green and cost-effective energy solution for the C21 is becoming better understood and applied with every passing year.

The new Ceramicx factory and enterprise remains at the cutting edge of that advancement.

Frank Wilson

Managing Director, Ceramicx Ltd.

HeatWorks

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Contents

"World class production demands world class manufacturing facilities" such was the thinking behind our new build and expansion.

Such are the results we witness around us today I am very pleased to note any visitor to our new Ceramicx factory will find great difficulty in discerning the past footprint of the previous space: This has been superseded, reconfigured and elevated into two storeys in many parts. The whole of our enterprise has been effectively doubled in size.

We are very well forward in making this new habitat fit for purpose and in fitting out our new spaces, production halls and systems, physical and virtual; creating a place for everything and having everything in its place.

We have set hard targets for these new facilities. The previous infrastructure succeeded in achieving an average of 15% annual growth figure through the past five years. The new facilities therefore have a high benchmark to out perform.

I am more than confident that we can do it. Wherever we find ourselves Ceramicx maintains a 'can do' spirit that has enabled us to export over 95% of our production to 65 countries worldwide; to exhibit through the year on four continents and to continue to develop world-leading IR heat innovation.

The unsurpassed surroundings of West Cork and our new facilities are, of course, great assets for our business.

The key, however, for our 65 strong enterprise lies in the ever growing technical strength of our IR production together with a widening access to world markets for IR heating solutions.

Our new facilities are there to support these fundamentals and to ever improve our aims for business growth.

Engineering Capabilities

At Ceramicx, we pride ourselves in our ability to make all our components in house. Due to our location, we have become as self-sufficient as possible.

Over the last few years we have steadily grown our business, along with this we have invested heavily in engineering and have become increasingly skilled in our CNC and sheet metal fabrication. Due to our growth we now have enough capacity to allow us to offer the following services.

Custom Punching and Folding

The Trumpf Hydraulic punch machine along with the Safan folding machine and guillotine give us the capability to make almost any component, with any type of material up to 3mm in thickness. Throughout our website you will see a variety of custom ovens and projects, in which every piece of sheet metal is now made in house. Below are a few examples of custom sheet metal parts we have created.

One of the biggest benefits of the Trumpf Punch Machine is our ability to make custom forms. We can;

- thread material
- create a variety of forms, to strengthen the material or just for aesthetics
- engrave a text or design into a sheet
- emboss or stamp a design on top or bottom of a sheet including likes the earth mark or CE logo

All of this can be done on the one machine in the one operation. With our Safan machines we can then cut and fold the part to he required shape and size.

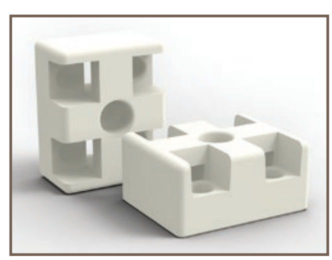
Conclusion

If you have any questions about our proficiencies or need a custom part made please don't hesitate contact us, send through your design and see what we can do for you.

"Electrical Insulation - A full manufacturing service is available of Steatite Products from Ceramicx"

It includes consultancy, design, tooling and the manufacture of specialized Steatite ceramic dust press components on the Ceramicx 6 Ton, 15 Ton and 30 Ton Dorst presses. These capabilities are also deployed in making mainstream Ceramicx products.

Steatite – commonly known as ceramic dust - has proven itself to be the material-of-choice for the manufacture of electrical insulators. It has good mechanical strength with good dielectric properties and a high temperature resistance of up to 1000°C.



Current Ceramicx Steatite production includes beads, connector blocks and additional components for high-temperature infrared heating applications.

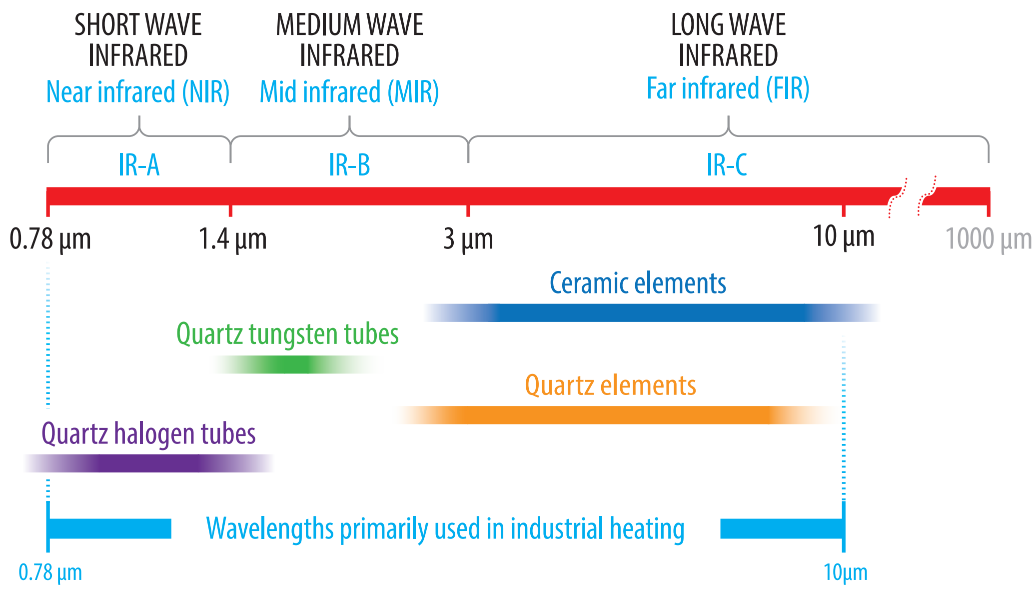
Ceramicx global commercial expertise and services can be included in the Steatite and machining services.

Ceramicx has purchased a new high temperature kiln for Alumina production to further develop this sector for higher temperature components.

The main types of IR heat emitters

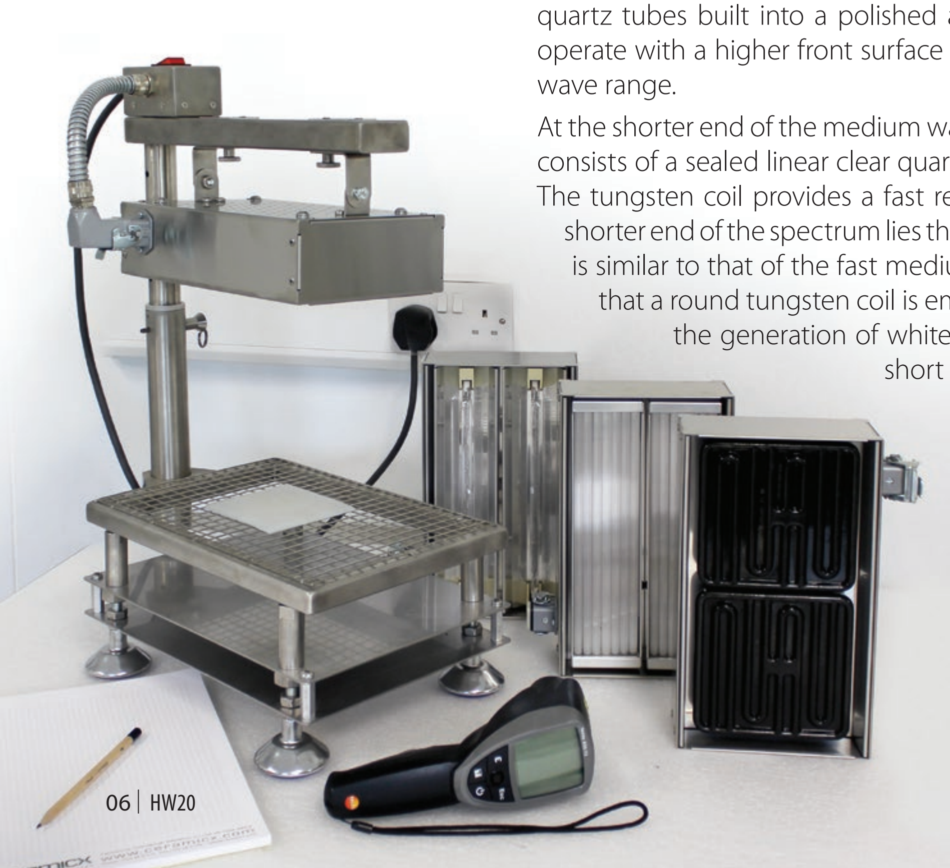
Infrared emitters used in industrial heating generally have a usable peak emission wavelength in the range of 0.75 to 10 µm. Within this range there are three sub-divisions which are long, medium and short wave.

Long wave emitters - also known as far infrared (FIR), have a peak emission range in the 3-10 µm range. This range generally refers to ceramic elements which consist of a FeCrAl resistance coil embedded into either a solid or hollow constructed highly emissive ceramic body. Ceramic emitters are manufactured in a number of industry standard sizes with either flat or curved (trough style) emitting surfaces.



Shorter peak emission wavelengths are achieved by higher using emission sources with higher surface temperatures. Quartz cassette style emitters are available in similar industry standard sizes to that of ceramic and consist of a series of translucent quartz tubes built into a polished aluminised steel housing. These emitters can operate with a higher front surface temperature and emit in the long to medium wave range.

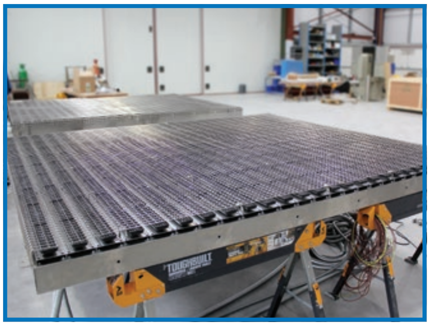
At the shorter end of the medium wave range is the quartz tungsten emitter which consists of a sealed linear clear quartz tube containing a star design tungsten coil. The tungsten coil provides a fast response time with low thermal inertia. At the shorter end of the spectrum lies the short wave halogen range. Basic construction is similar to that of the fast medium wave tungsten emitter with the exception that a round tungsten coil is employed. The higher coil temperature results in the generation of white light and a peak emission wavelength in the short wave range.



This portable test stand allows you to quickly determine the most suitable type of emitter and heating distance for a specific material, with a simple, repeatable test set up.

see page 06 for further details

Ceramic elements 2 to 10 µm



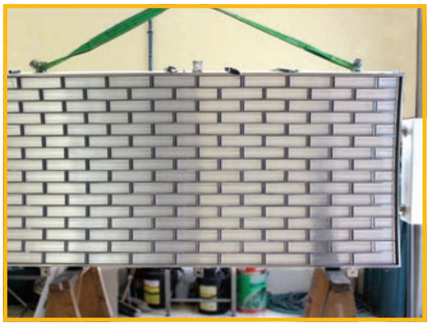
281 kW long wave ceramic heating platen fitted with black ceramic hollow emitter model FFEH. Used to thermoform acrylic sheet for hot tub production.

42 kW long wave ceramic conveyor oven fitted with white ceramic emitter model HTE. Used to cure foam on speaker housings.

75.6 kW long wave ceramic heating platen fitted with black ceramic hollow emitter model SFEH. Used to pre-heat carbon fibre fabric.

Quartz elements 1.5 to 8 µm

3.75 kW medium wave quartz heating platen fitted with quartz emitter model PHQE. Used to heat polyester fabric in footwear manufacture.

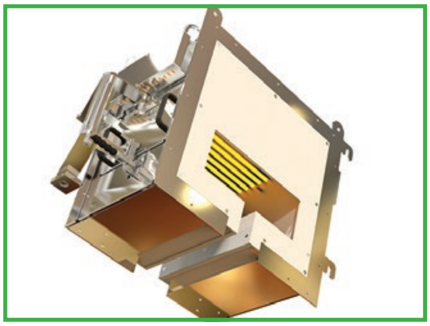


108 kW medium wave quartz heating platen fitted with quartz emitter model FQE. Used to heat PVC coating in calendaring machine.

16.9 kW medium wave quartz heating platen fitted with quartz emitter model PFQE. Used to infrared weld plastic components.

Quartz tungsten tubes 1.6 to 2.0 µm

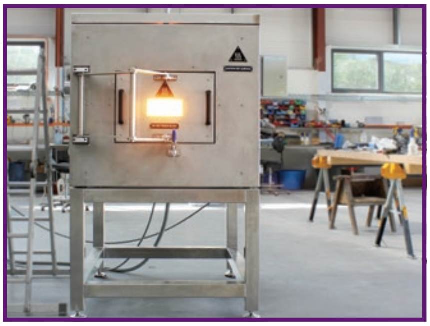
134 kW fast medium tungsten heating platen fitted with custom built curved quartz tungsten emitters. Used to heat plastic substrate in an automotive application.



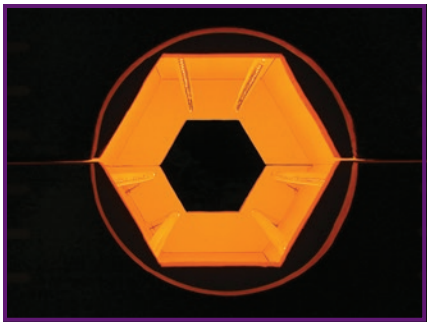
11 kW fast medium tungsten modular oven fitted with custom built quartz tungsten emitters. Used in glass forming application.

24 kW fast medium wave tungsten test oven fitted with quartz tungsten emitters model QTM. Used as a test platform for multiple materials in the automotive industry.

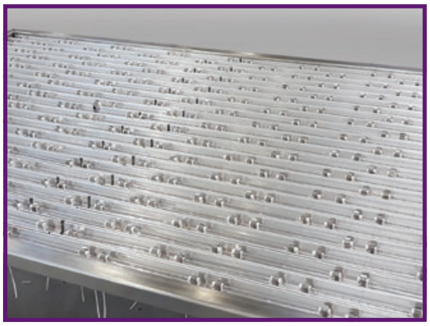
Quartz halogen tubes 1.0 to 1.4 µm



43 kW short wave halogen test oven fitted with custom built curved short wave emitters. Used as a high intensity material test oven in an aerospace application.



2 kW short wave halogen clamshell oven fitted with custom built short wave emitters. Used to heat wire/ round tube up to 100mm in diameter.



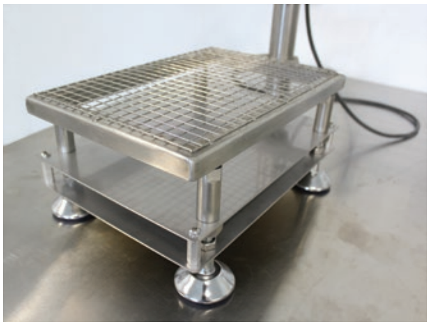
1133 kW short wave halogen heating platen fitted with custom built short wave emitters. Used in retrofit of existing Thermoforming machine.

PORTABLE TEST STAND

Ceramicx' new Portable Test Stand allows for quick and consistent testing of materials. The interchangeable long, medium and short wave Infrared emitters are easily attached to the test stand.

The emitters face down and heat a material that is placed on a stainless steel mesh. The distance between emitter and material can easily be adjusted between 50mm and 200mm, in 50mm intervals.

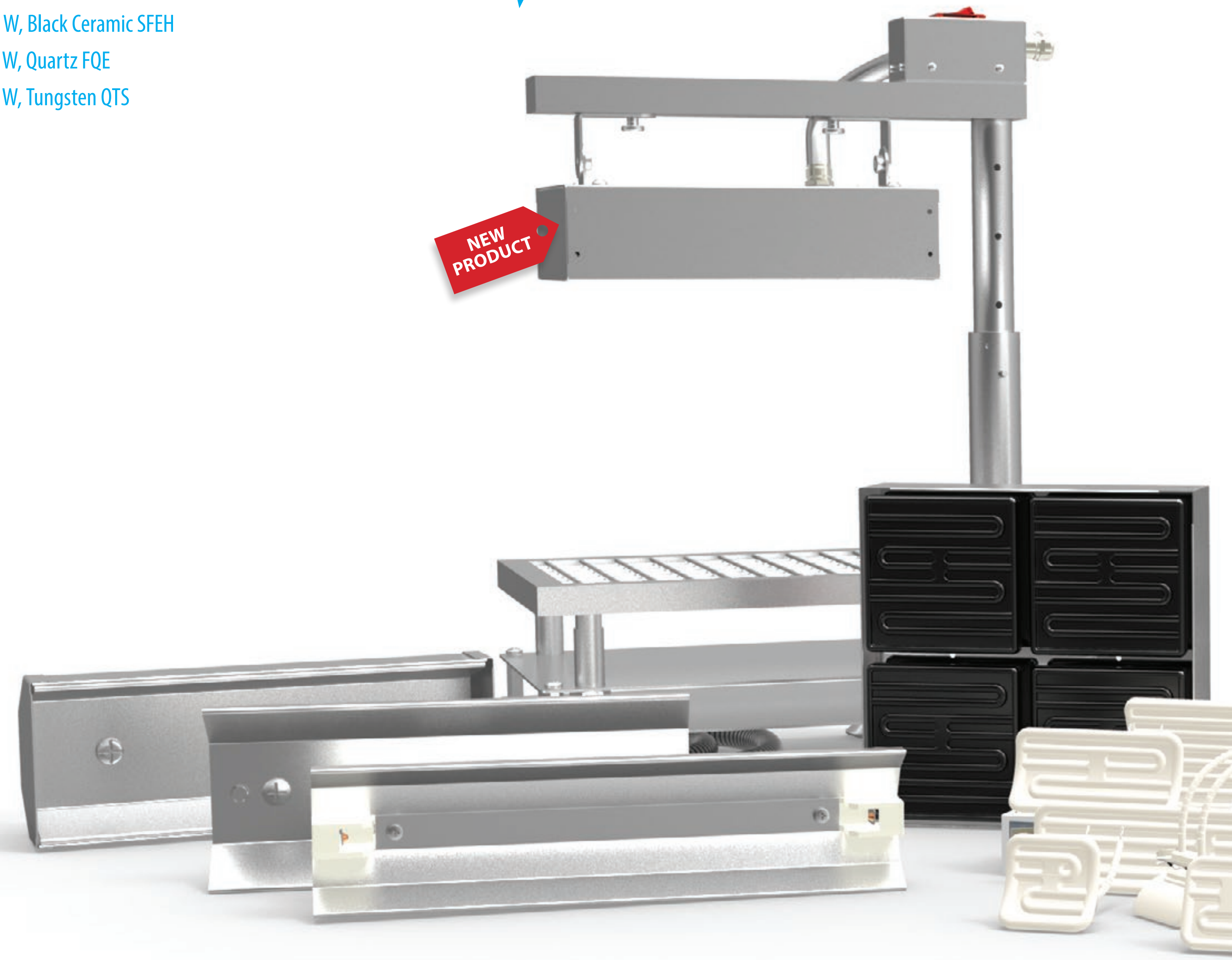
This test stand allows the user to quickly determine the most suitable type of emitter and heating distance for a specific material, with consistent results due to the simple, repeatable test set up.



2 x 800 W, Black Ceramic SFEH

2 x 750 W, Quartz FQE

2 x 750 W, Tungsten QTS



Ceramicx Product Guide

Design and specifications are subject to change without prior notice, all information in this guide was believed to be correct at the time of going to publication (17.10.18).
see www.ceramicx.com for latest information.

CERAMIC TROUGH ELEMENTS

Useful wavelength range 2 to 10 µm

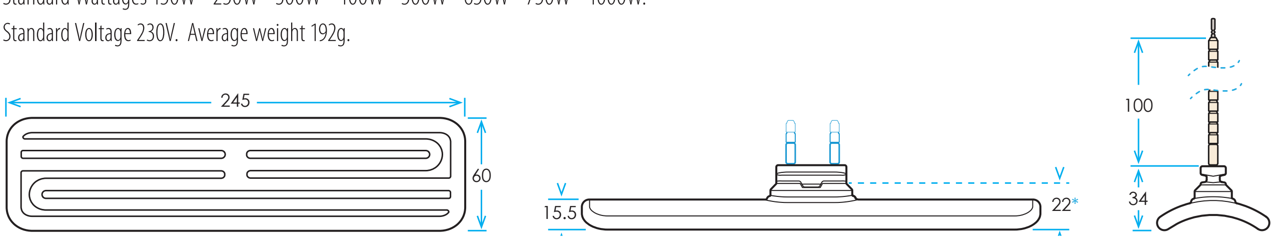
(FTE/HTE/QTE) are industry standard curved ceramic infrared heaters used in a wide range of industrial, commercial and domestic applications. These solid cast elements consist of a high temperature FeCrAL resistance alloy embedded in a specially formulated ceramic body allowing operating temperatures up to 750°C and a maximum power of 1000W (FTE Model Only).

All dimensions mm   Tolerances apply

FTE

Full Trough Element,

Standard Wattages 150W 250W 300W 400W 500W 650W 750W 1000W.
Standard Voltage 230V. Average weight 192g.



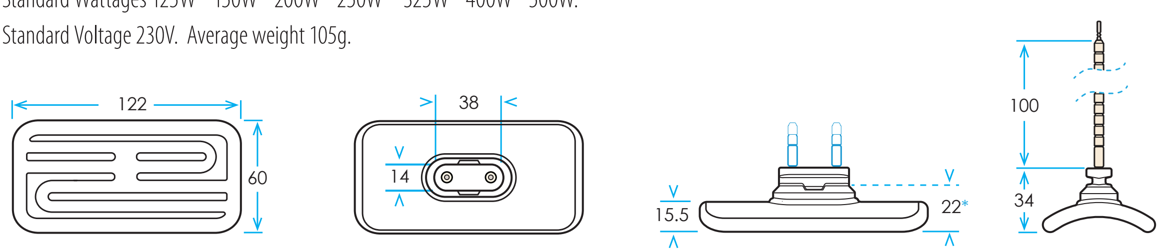
Wattage	150W	250W	300W	400W	500W	650W	750W	1000W
Mean surface temperature	272 °C	351 °C	405 °C	480 °C	515 °C	596 °C	624 °C	726 °C
Max power density	9 kW/m²	15 kW/m²	18 kW/m²	24 kW/m²	30 kW/m²	39 kW/m²	45 kW/m²	60 kW/m²
Radiant Watt density at 100mm	0.10 W/cm²		0.26 W/cm²		0.48 W/cm²	0.69 W/cm²		1.14 W/cm²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

HTE

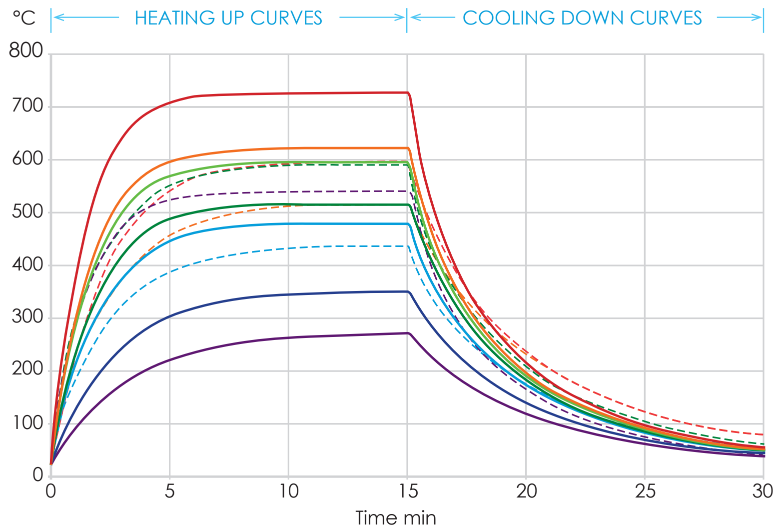
Half Trough Element,

Standard Wattages 125W 150W 200W 250W 325W 400W 500W.
Standard Voltage 230V. Average weight 105g.



Wattage	125W	150W	200W	250W	325W	500W
Mean surface temperature	351 °C	405 °C	480 °C	515 °C	596 °C	726 °C
Max power density	15 kW/m²	18 kW/m²	24 kW/m²	30 kW/m²	39 kW/m²	60 kW/m²
Radiant Watt density at 100mm		0.26 W/cm²			0.69 W/cm²	1.14 W/cm²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)



Heating up cooling down curves based on FTE tests of average surface temperature with an infrared thermometer set at an emissivity of 0.9

(element mounted in an aluminised steel reflector, RAS)

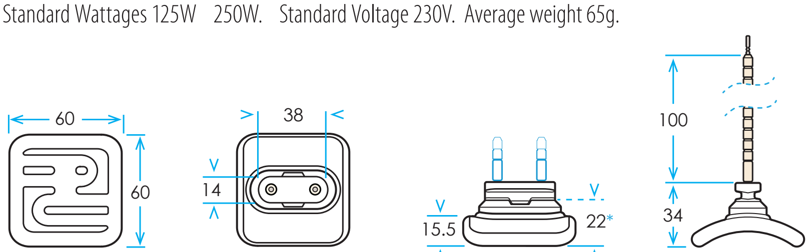
	FTE	HTE	QTE
	1000W	500W	250W
	750W		
	650W	325W	
	500W	250W	125W
	400W	200W	
	250W	125W	
	150W		

- - -	LFTE 1500W
- - -	LFTE 1000W
- - -	QCE 250W
- - -	QCE 150W
- - -	FTEL-LN 1000W

QTE

Quarter Trough Element,

Standard Wattages 125W 250W. Standard Voltage 230V. Average weight 65g.



Wattage	125W	250W
Mean surface temperature	515 °C	726 °C
Max power density	30 kW/m²	60 kW/m²
Radiant Watt density at 100mm		1.14 W/cm²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

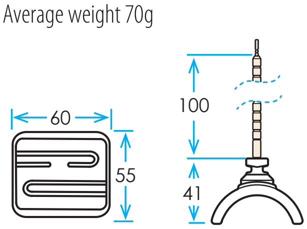
QCE

Quarter Curved Element

Standard Wattages 150W 250W.

Standard Voltage 230V.

Average weight 70g

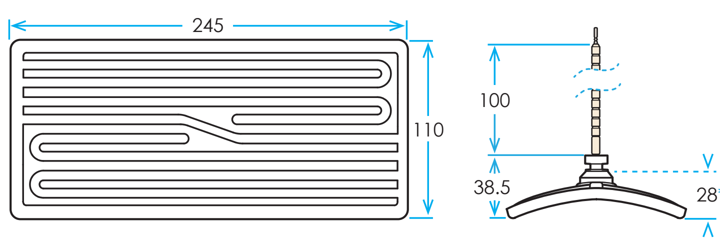


LFTE

Large Full Trough Element

Standard Wattages 1000W 1500W.

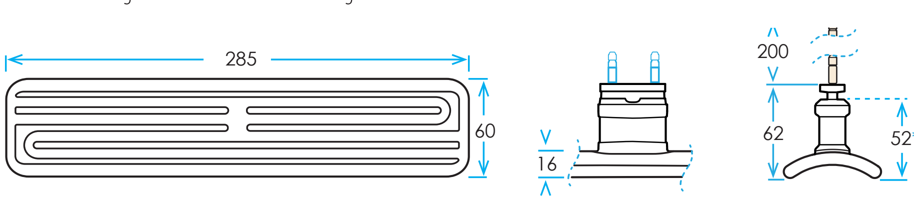
Standard Voltage 230V. Average weight 356g

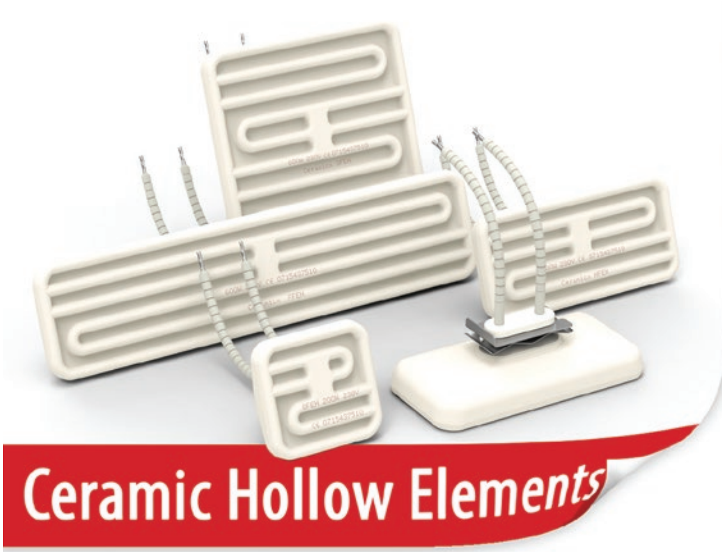


FTEL-LN

Full Trough Element Long - Long Neck,

Standard Wattage 1000W. Standard Voltage 230V.





CERAMIC HOLLOW ELEMENTS

Useful wavelength range 2 to 10 μm

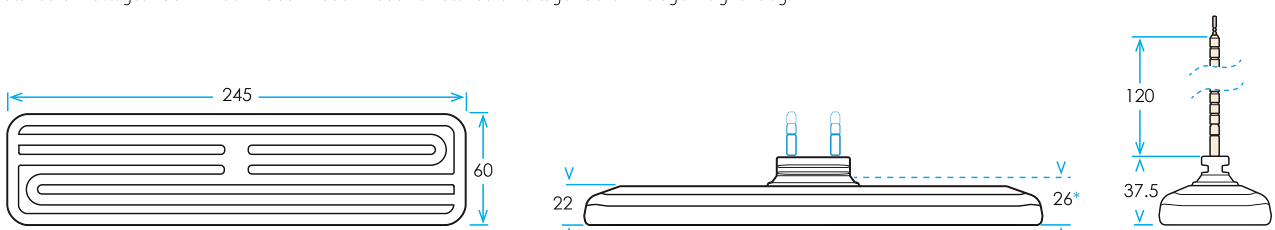
Ceramic Hollow Elements (SFEH, FFEH, HFEH, QFEH) are industry standard ceramic emitters used in a wide range of industrial, commercial and domestic applications. The hollow constructed ceramic element has the advantage of having a shorter heat up time combined with increased energy efficiency. These hollow constructed products consist of a high temperature FeCrAl resistance alloy embedded in a specially formulated light weight hollow cast ceramic body which is subsequently filled with a high density insulating material. This results in a significant reduction in rear heat loss and increased radiant output from the front of the element, the operating temperature is up to a maximum of 750°C and a maximum power of 800W (FFEH and SFEH)

All dimensions mm   Tolerances apply

FFEH

Full Flat Element Hollow,

Standard Wattages 250W 400W 500W 600W 800W. Standard Voltage 230V. Average weight 250g.



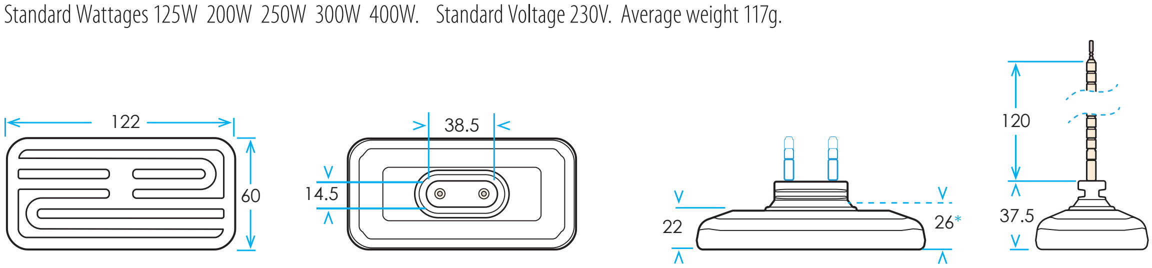
Wattage	250W	400W	500W	600W	800W
Mean surface temperature	390 °C	497 °C	548 °C	602 °C	710 °C
Max power density	15 kW/m²	24 kW/m²	30 kW/m²	36 kW/m²	48kW/m²
Radiant Watt density at 100mm	0.25 W/cm²	0.44 W/cm²		0.73 W/cm²	

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

HFEH

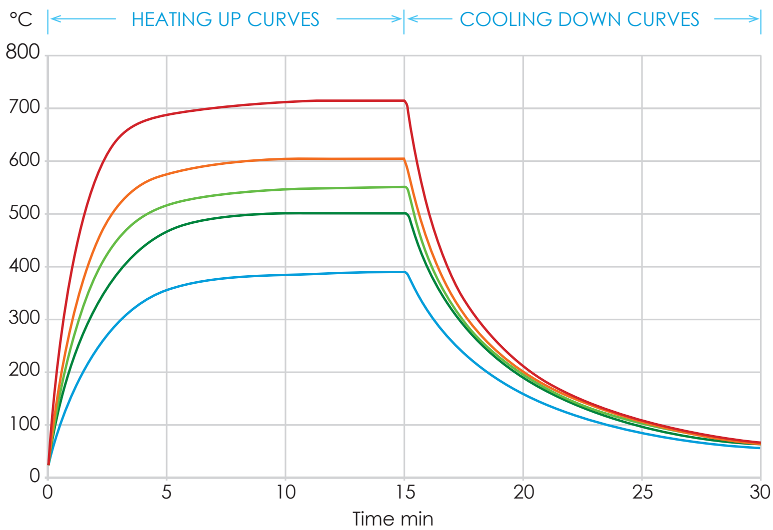
Half Flat Element Hollow,

Standard Wattages 125W 200W 250W 300W 400W. Standard Voltage 230V. Average weight 117g.



Wattage	125W	200W	250W	300W	400W
Mean surface temperature	390 °C	497 °C	548 °C	602 °C	710 °C
Max power density	15 kW/m²	24 kW/m²	30 kW/m²	36 kW/m²	48kW/m²
Radiant Watt density at 100mm		0.31 W/cm²		0.49 W/cm²	

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)



Heating up cooling down curves based on FTE tests of average surface temperature with an infrared thermometer set at an emissivity of 0.9

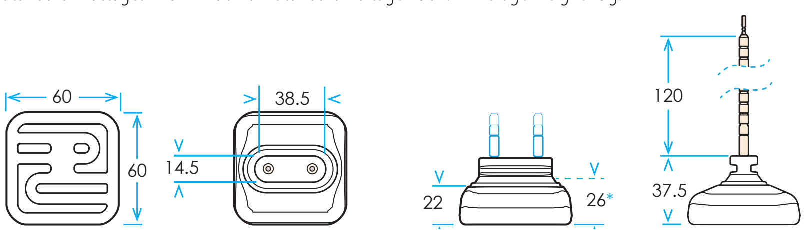
(element mounted in an aluminised steel reflector, RAS)

	FFEH	HFEH	QFEH	SFEH
—	800W	400W	200W	800W
—	600W	300W		600W
—	500W	250W	125W	500W
—	400W	200W		400W
—	250W	125W		250W

QFEH

Quarter Flat Element Hollow,

Standard Wattages 125W 200W. Standard Voltage 230V. Average weight 75g.



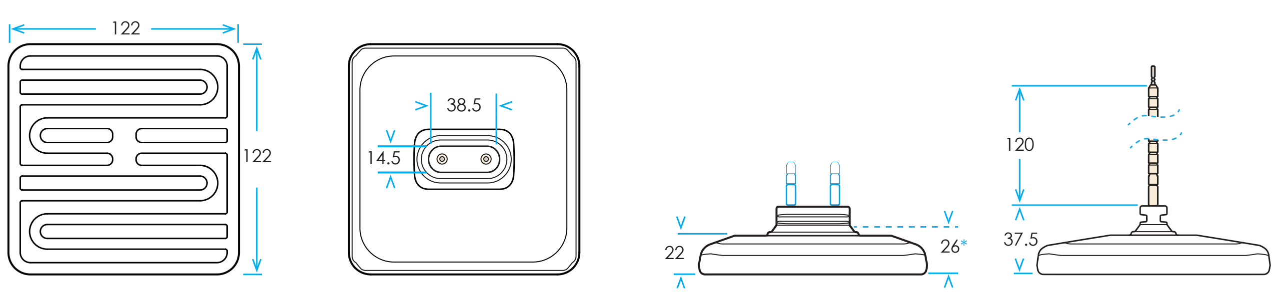
Wattage	125W	200W
Mean surface temperature	548 °C	710 °C
Max power density	30 kW/m²	48kW/m²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

SFEH

Square Flat Element Hollow,

Standard Wattages 250W 400W 500W 600W 800W. Standard Voltage 230V. Average weight 239g.



Wattage	250W	400W	500W	600W	800W
Mean surface temperature	390 °C	497 °C	548 °C	602 °C	710 °C
Max power density	15 kW/m²	24 kW/m²	30 kW/m²	36 kW/m²	48kW/m²
Radiant Watt density at 100mm	0.28 W/cm²	0.51W/cm²		0.81 W/cm²	1.18W/cm²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

CERAMIC FLAT ELEMENTS

Useful wavelength range 2 to 10 µm

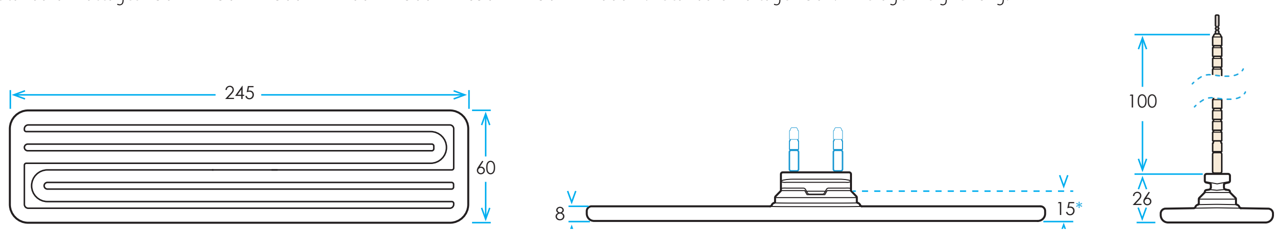
Ceramic IR Flat Elements (FFE/HFE/QFE) are industry standard ceramic emitters used in a wide range of industrial, commercial and domestic applications. These solid cast ceramic elements consist of a high temperature FeCrAl resistance alloy embedded in a specially formulated ceramic body allowing operating temperatures up to 750°C and a maximum power output of 1000W (FFE Model Only). The solid cast heater body is flat, producing a diffuse radiant output to target distance in some applications.

All dimensions mm Tolerances apply

FFE

Full Flat Element,

Standard Wattages 150W 250W 300W 400W 500W 650W 750W 1000W. Standard Voltage 230V. Average weight 182g.



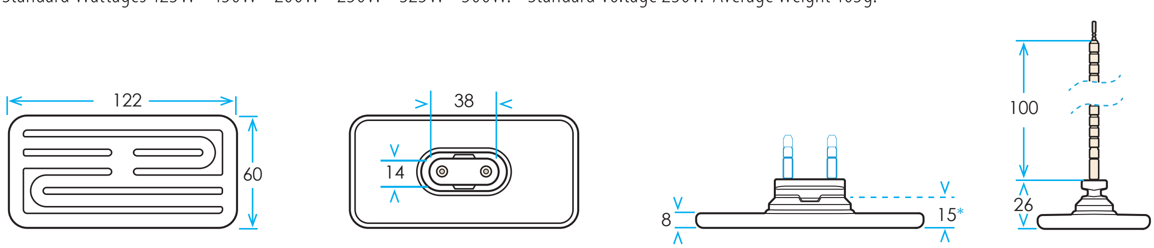
Wattage	150W	250W	300W	400W	500W	650W	750W	1000W
Mean surface temperature	272 °C	351 °C	405 °C	480 °C	515 °C	596 °C	624 °C	726 °C
Max power density	9 kW/m²	15 kW/m²	18 kW/m²	24 kW/m²	30 kW/m²	39 kW/m²	45 kW/m²	60 kW/m²
Radiant Watt density at 100mm	0.10 W/cm²		0.25 W/cm²		0.47W/cm²			

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

HFE

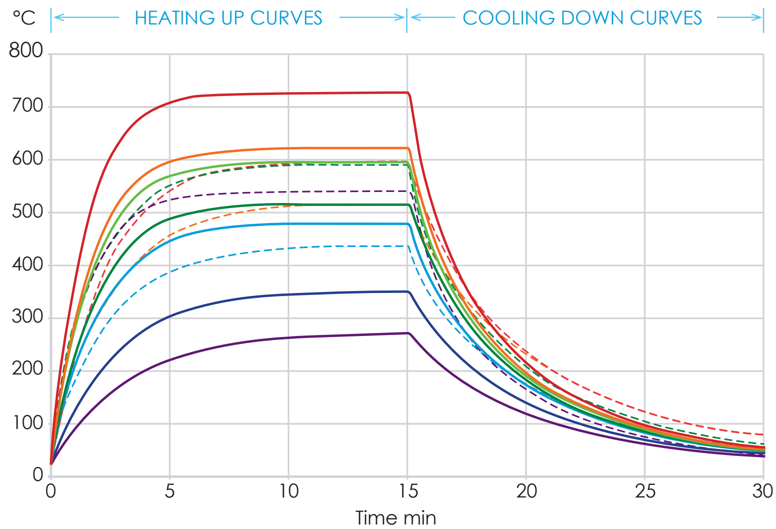
Half Flat Element,

Standard Wattages 125W 150W 200W 250W 325W 500W. Standard Voltage 230V. Average weight 105g.



Wattage	125W	150W	200W	250W	325W	500W
Mean surface temperature	351 °C	405 °C	480 °C	515 °C	596 °C	726 °C
Max power density	15 kW/m²	18 kW/m²	24 kW/m²	30 kW/m²	39 kW/m²	60 kW/m²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)



Heating up cooling down curves based on FTE tests of average surface temperature with an infrared thermometer set at an emissivity of 0.9

(element mounted in an aluminised steel reflector, RAS)

	FTE	HTE	QTE
—	1000W	500W	250W
—	750W		
—	650W	325W	
—	500W	250W	125W
—	400W	200W	
—	250W	125W	
—	150W		

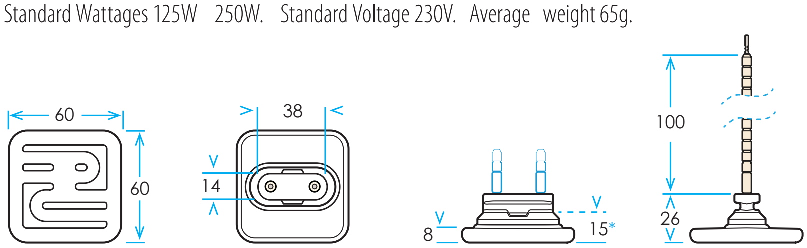
- - -	LFTE 1500W
- - -	LFTE 1000W
- - -	QCE 250W
- - -	QCE 150W
- - -	FTEL-LN 1000W

QFE

Quarter Flat Element,

Standard Wattages 125W 250W. Standard Voltage 230V. Average weight 65g.

CE



Wattage	125W	250W
Mean surface temperature	515 °C	726 °C
Max power density	30 kW/m²	60 kW/m²

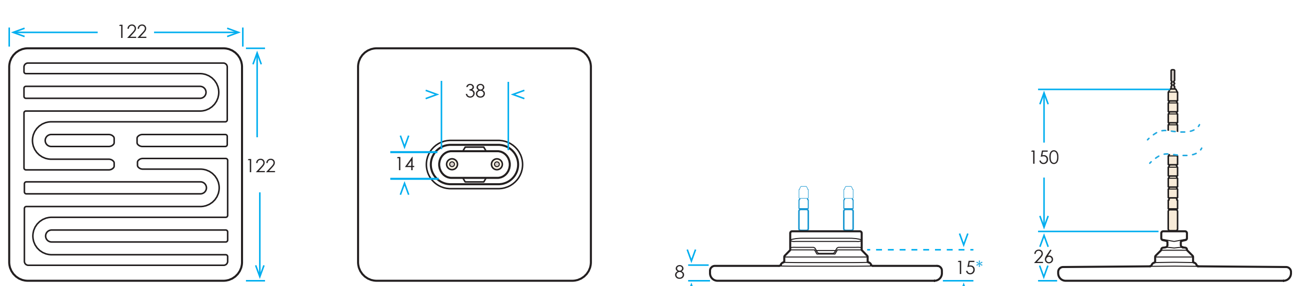
Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

SFSE

Full Flat Solid Element,

Standard Wattages 250W 400W 500W 600W 800W . Standard Voltage 230V. Average weight 192g.

CE



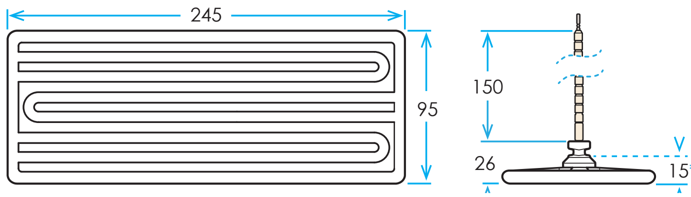
Wattage	150W	250W	300W	400W	500W	650W	750W
Mean surface temperature	272 °C	351 °C	405 °C	480 °C	515 °C	596 °C	624 °C
Max power density	9 kW/m²	15 kW/m²	18 kW/m²	24 kW/m²	30 kW/m²	39 kW/m²	45 kW/m²
Radiant Watt density at 100mm		0.23 W/cm²		0.39 W/cm²		0.71 W/cm²	0.81 W/cm²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

LFFE

Large Full Fat Element,

Standard Wattages 150W 350W 750W 1400W. Standard Voltage 230V. Average weight 342g.



Wattage	150W	350W	750W	1400W
Mean surface temperature	204 °C	338°C	501 °C	667 °C
Max power density	5.4 kW/m²	12 kW/m²	27 kW/m²	50 kW/m²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

CERAMIC EDISON SCREW ELEMENTS

Useful wavelength range 2 to 10 µm

Ceramic Edison Screw Elements (ESEB, ESES, ESER, ESEXL) are industry standard infrared bulbs used primarily in the area of reptile/animal/pet health care. These ceramic bulbs provide the infrared heat required without any of the negative effects of a light output that can disturb the day/night sleeping cycle of the reptile/animal. Ceramicx hollow cast bulbs consist of a high temperature FeCrAl resistance alloy embedded in a specially formulated ceramic body allowing operating temperature up to 530°C and a maximum power of 400W (ESEXL Model Only). The face of the ESEB is circular and convex in design, producing a circular outward trending radiant output.

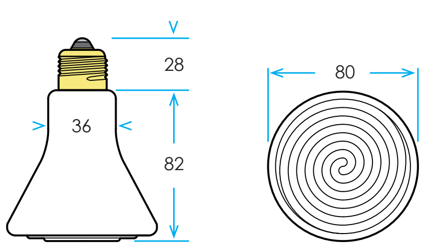
All dimensions mm Tolerances apply

ESES

Edison Screw Element Small,

Standard Wattages 60W 100W.

Standard Voltage 230V. Average weight 113g

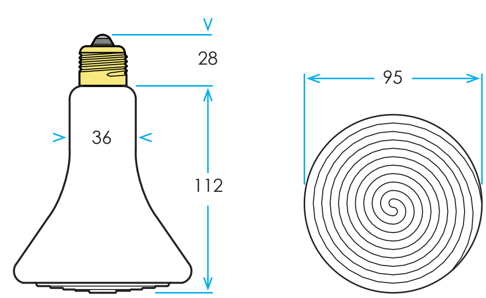


ESES

Edison Screw Element Regular,

Standard Wattages 150W 250W.

Standard Voltage 230V. Average weight 165g

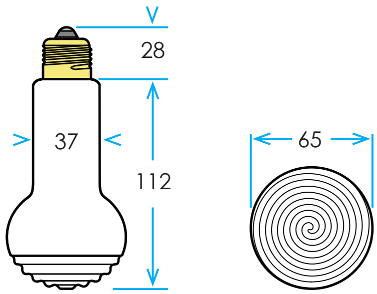


ESEB

Edison Screw Element Bulb,

Standard Wattages 60W 100W.

Standard Voltage 230V. Average weight 112g

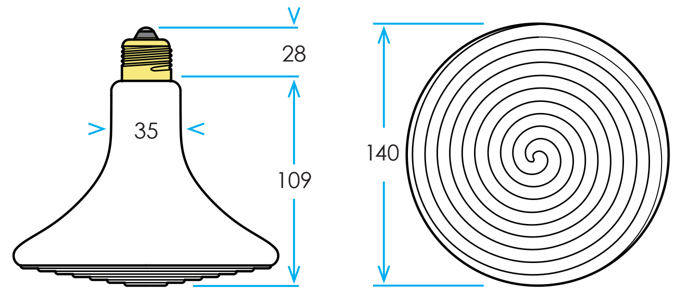


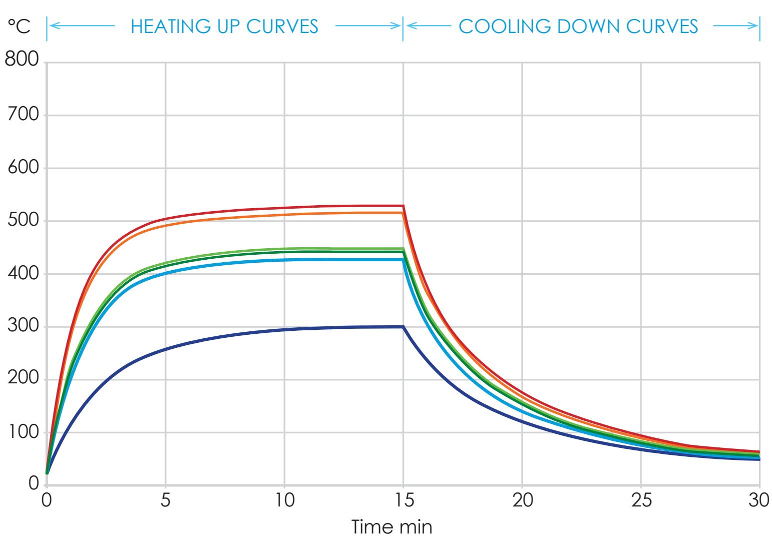
ESEL

Edison Screw Element Large,

Standard Wattages 300W 400W.

Standard Voltage 230V. Average weight 253g



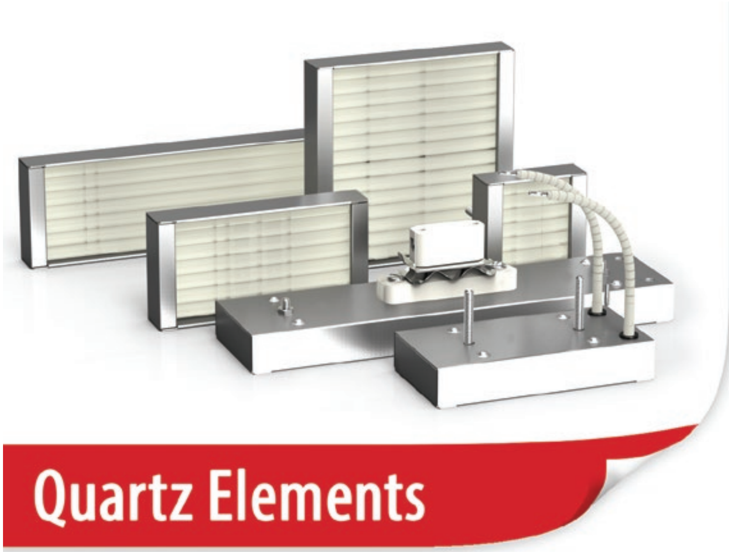


Heating up cooling down curves based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.9 (element mounted in an aluminised steel reflector, RAS)

	ESES	ESER	ESEB	ESEXL
— (red)				400W
— (orange)		250W		
— (light green)				300W
— (dark green)		150W		
— (light blue)	100W		100W	
— (dark blue)	60W		60W	

	ESES		ESER		ESEB		ESEXL	
Wattage	60W	100W	150W	250W	60W	100W	300W	400W
Mean surface temperature	300°C	426 °C	441°C	516 °C	300°C	426 °C	450°C	530 °C
Max power density	7.3kW/m²	12 kW/m²	15kW/m²	25 kW/m²	13.5kW/m²	22.5 kW/m²	22.5kW/m²	30 kW/m²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.9



QUARTZ ELEMENTS

Useful wavelength range 1.5 to 8µm

Quartz infrared heating elements provide medium wave infrared radiation. They are favoured in industrial applications where a more rapid heater response is necessary, including systems with long heater off cycles.

Quartz infrared heating elements are particularly effective in systems where rapid heater response and/or zone controlled heating is required.

They have a broad emission spectrum from around 1.4 to 8 microns, slightly shorter in wavelength than ceramic elements.

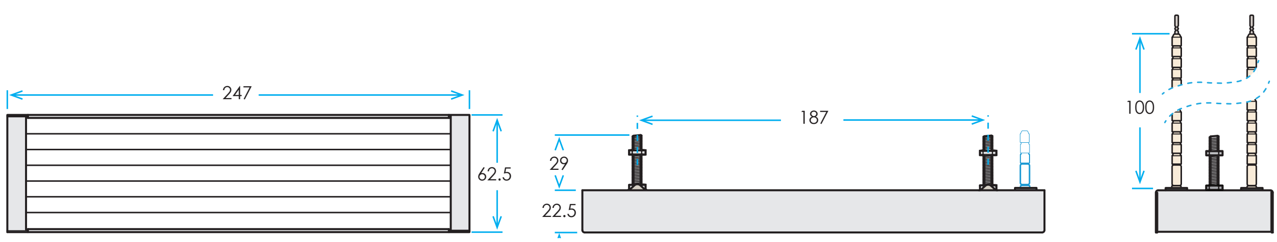
Pillared quartz elements have the same mounting fixture as ceramic elements allowing easy replacement.

All dimensions mm Tolerances apply

FQE

Full Quartz Element,

Standard Wattages 150W 250W 300W 400W 500W 650W 750W 1000W. Standard Voltage 230V. Average weight 403g.



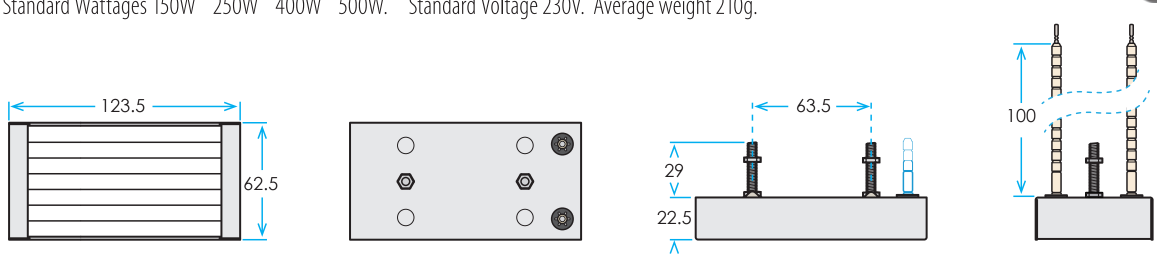
Wattage	150W	250W	300W	400W	500W	650W	750W	1000W
Mean surface temperature	343 °C	438 °C	477 °C	542 °C	593 °C	664 °C	690 °C	772 °C
Max power density	9 kW/m²	15 kW/m²	18 kW/m²	24 kW/m²	30 kW/m²	39 kW/m²	45 kW/m²	60 kW/m²
Radiant Watt density at 100mm	0.10 W/cm²		0.26 W/cm²		0.48 W/cm²	0.69 W/cm²		1.14 W/cm²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

HQE

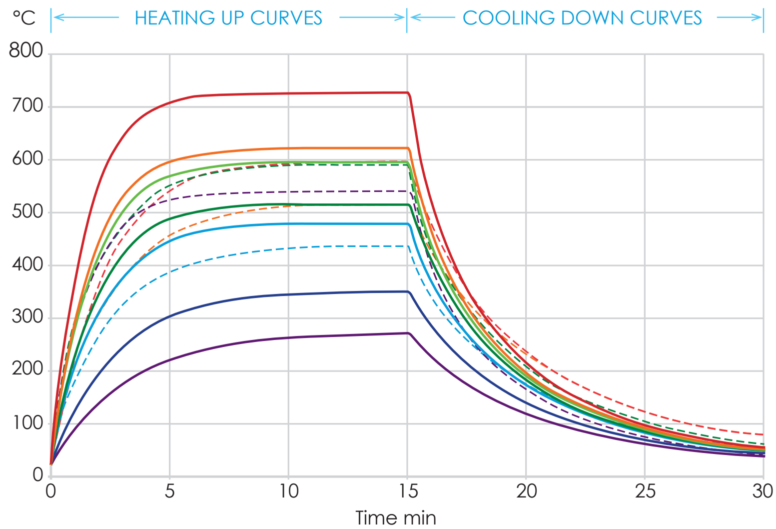
Half Quartz Element,

Standard Wattages 150W 250W 400W 500W. Standard Voltage 230V. Average weight 210g.



Wattage	150W	250W	325W	400W	500W
Mean surface temperature	477 °C	493 °C	644 °C	709 °C	772 °C
Max power density	18 kW/m²	30 kW/m²	39 kW/m²	48 kW/m²	60 kW/m²
Radiant Watt density at 100mm	0.26 W/cm²		0.69 W/cm²		1.14 W/cm²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)



Heating up cooling down curves based on FTE tests of average surface temperature with an infrared thermometer set at an emissivity of 0.9

(element mounted in an aluminised steel reflector, RAS)

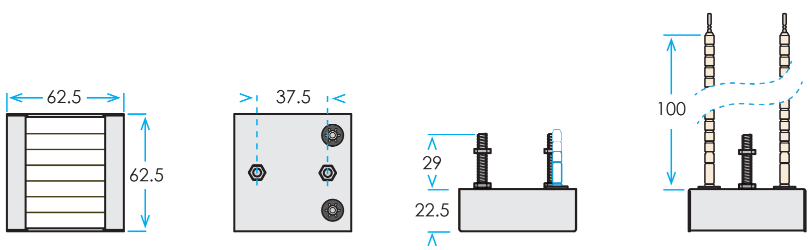
	FTE	HTE	QTE
—	1000W	500W	250W
—	750W		
—	650W	325W	
—	500W	250W	125W
—	400W	200W	
—	250W	125W	
—	150W		

- - -	LFTE 1500W
- - -	LFTE 1000W
- - -	QCE 250W
- - -	QCE 150W
- - -	FTEL-LN 1000W

QQE

Quarter Quartz Element,

Standard Wattages 150W 250W. Standard Voltage 230V. Average weight 144g.



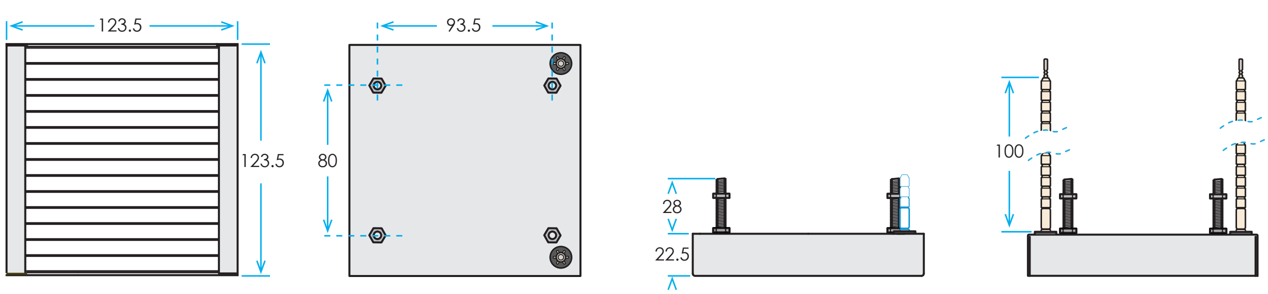
Wattage	150W	250W
Mean surface temperature	642 °C	772 °C
Max power density	36 kW/m²	60 kW/m²
Radiant Watt density at 100mm		1.14 W/cm²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

SQE

Square Quartz Element,

Standard Wattages 150W 650W, 1000W. Standard Voltage 230V. Average weight 401g.



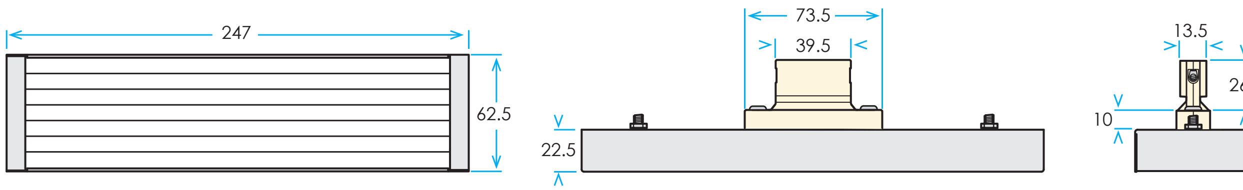
Wattage	150W	250W	300W	400W	500W	650W	750W	1000W
Mean surface temperature	343 °C	438 °C	477 °C	542 °C	593 °C	644 °C	690 °C	772 °C
Max power density	9 kW/m²	15 kW/m²	18 kW/m²	24 kW/m²	30 kW/m²	39 kW/m²	45 kW/m²	60 kW/m²

Based on tests of average surface temperature with an infrared thermometer set at an emissivity of 0.95 (element mounted in an aluminised steel reflector, RAS)

PFQE

Pillared Full Quartz Element,

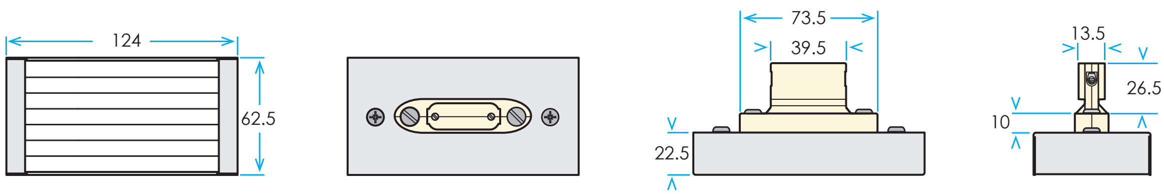
Standard Wattages 150W 250W 400W 500W 650W 750W 1000W. Standard Voltage 230V. Average Weight 403g



PHQE

Pillared Half Quartz Element,

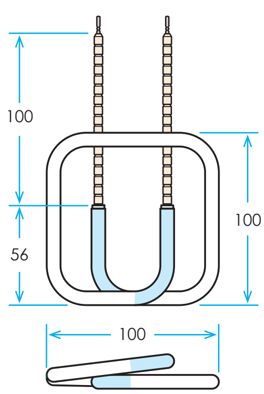
Standard Wattages 150W 250W 400W 500W. Standard Voltage 230V. Average Weight 268g



STQH 100

Single Tube Quartz Heater 100,

Standard Wattage Range 150W - 400W Standard Voltage 230V.

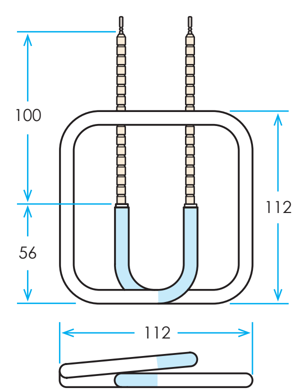


Unheated area

STQH 112

Single Tube Quartz Heater 112,

Standard Wattage Range 150W - 400W Standard Voltage 230V.

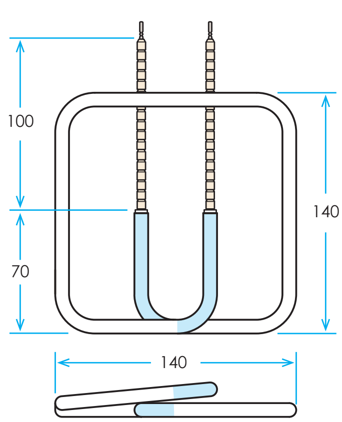


Unheated area

STQH 140

Single Tube Quartz Heater 140,

Standard Wattage Range 150W - 650W Standard Voltage 230V.

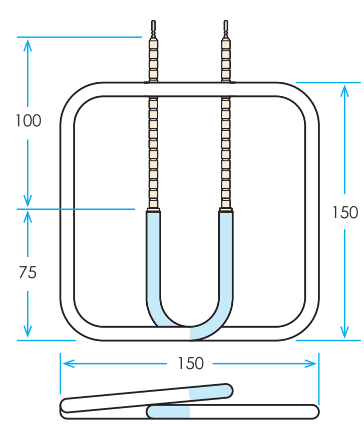


Unheated area

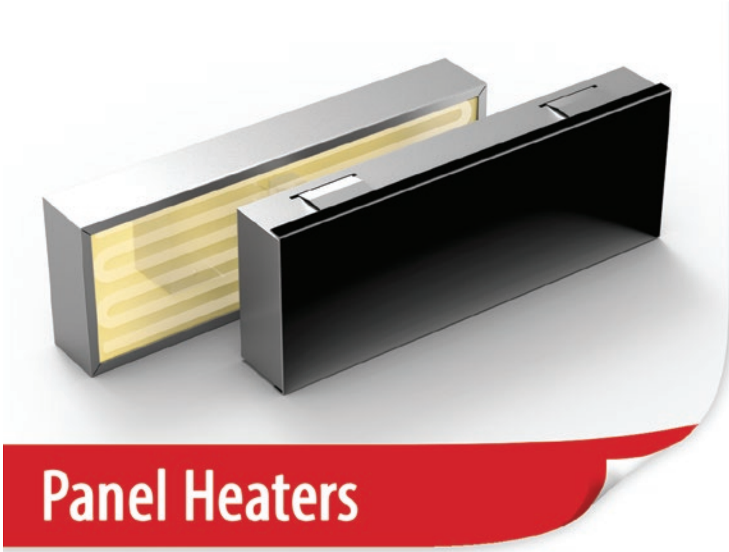
STQH 150

Single Tube Quartz Heater 150,

Standard Wattage Range 150W - 650W Standard Voltage 230V.



Unheated area



PANEL HEATERS

Useful wavelength range 4 to 6µm

They are a neat, easily mounted and readily expanded heating solution.

Infrared panel heaters are custom built infrared heaters operating primarily in the long wave range. The basic construction consists of a resistance coil embedded into a ceramic fibre board which is then located behind an emitting surface of either anodised aluminium or glass ceramic. This is then placed inside a 75mm high aluminised steel housing which normally contains 50mm of thermal insulation to reduce heat loss through the rear of the unit.

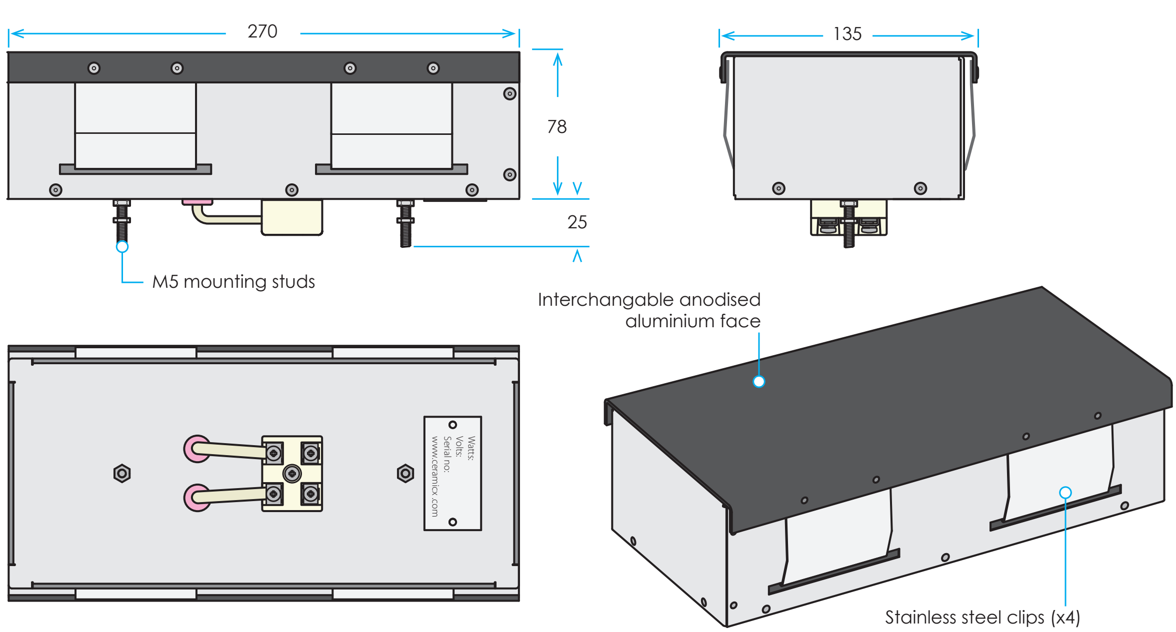
All dimensions mm   Tolerances apply

STANDARD OPTIONS (Other options available on request. Please contact us for further details.)

Emitting surface	**Anodised aluminium face -** Good radiant efficiency, very robust, surface sheet can be easily cleaned or replaced if damaged by molten material.
	Glass ceramic face - Very good radiant efficiency, high percentage transmission of radiant output in medium to short wave range, surface can be easily cleaned.
Electrical terminations	Open 2P terminal block, Terminal block with cover, M6 or 1/4" threaded stud, Type K thermocouple with fixed high temperature socket and removable plug
Fixing studs	M5/M6/M8/0.25" x 25mm long

Sample panel heater,

Black anodised aluminium face, 270 x 135mm, 500W, 230V, with open 2P terminal block connection.



QUARTZ TUNGSTEN/ QUARTZ HALOGEN TUBES

The tungsten filament used in these quartz tungsten heaters is the porcupine or star type coil, which can be operated at temperatures up to 1500°C (2732°F), with a peak wavelength emission of approximately 1.6 microns. It reaches top temperatures within seconds.

Halogen heaters are filled with a halogen gas to allow the supported tungsten filament to reach temperatures as high as 2600°C (4712°F). Peak emissions for these tubes is around 1 micron.

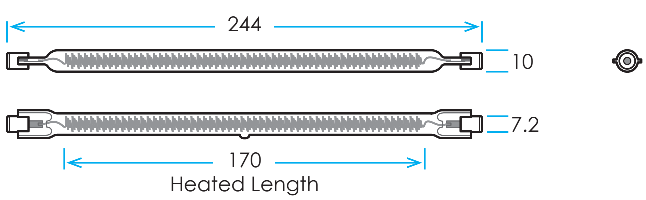
These emitters heat up and cool down within seconds making them particularly suitable for systems requiring short cycle times.

All dimensions mm Tolerances apply

QTS

Quartz Tungsten Short,

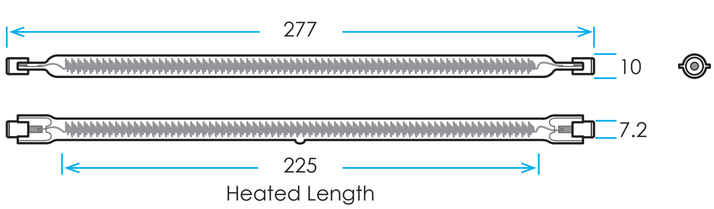
Standard Wattage 750W. Standard Voltage 240V.



QTM

Quartz Tungsten Medium

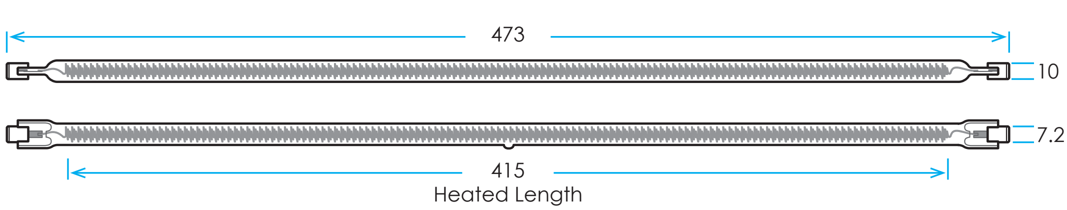
Standard Wattage 1000W. Standard Voltage 240V.



QTL

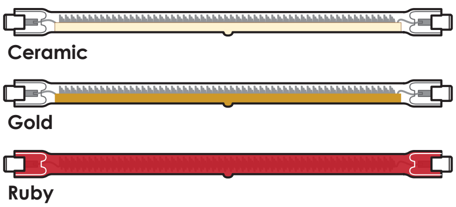
Quartz Tungsten Long

Standard Wattage 1500W 1750W 2000W. Standard Voltage 240V.

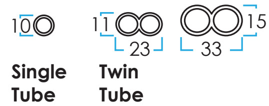


ELEMENT TYPE	WATTS	MAX COIL TEMPERATURE
QTS	750W	1450°C
QTM	1000W	1450°C
QTL	1500W	1270°C
QTL	1750W	1470°C
QTL	2000W	1500°C
QHS	750W	2410°C
QHM	1000W	2410°C
QHL	2000W	2250°C

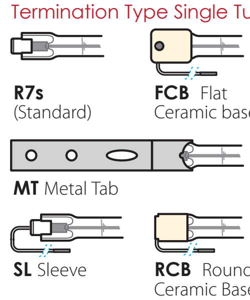
Coatings



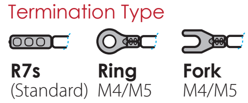
Tube Sizes



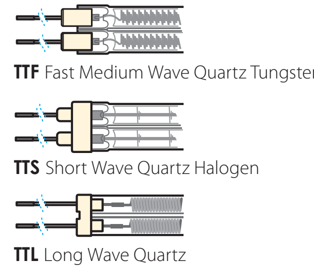
Termination Type Single Tube



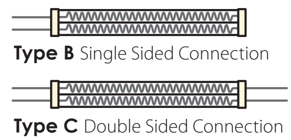
Termination Type



Coil Type Twin Tube



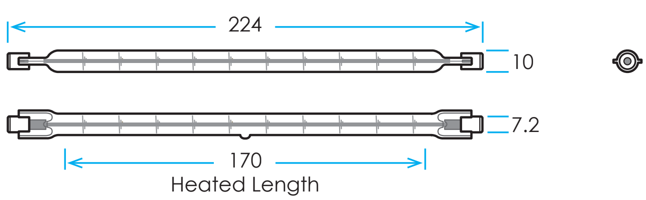
Coil Type twin tube



QHS

Quartz Halogen Short,

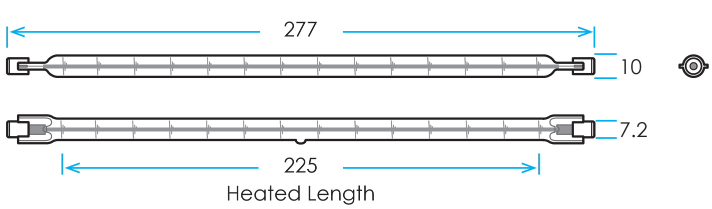
Standard Wattage 750W, 1000W. Standard Voltage 240V.



QHM

Quartz Halogen Medium

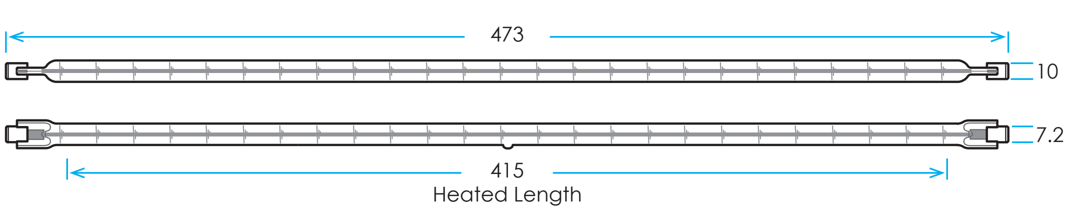
Standard Wattage 1000W. Standard Voltage 240V.



QHL

Quartz Halogen Long

Standard Wattage 2000W. Standard Voltage 240V.



Reflectors and Projectors

REFLECTORS AND PROJECTORS

Highly reflective aluminised steel projectors and reflectors

At Ceramicx, our reflectors are designed to cater for a wide range of ceramic and quartz infrared emitters. Units can be mounted individually or side-by-side forming infrared heat panels.

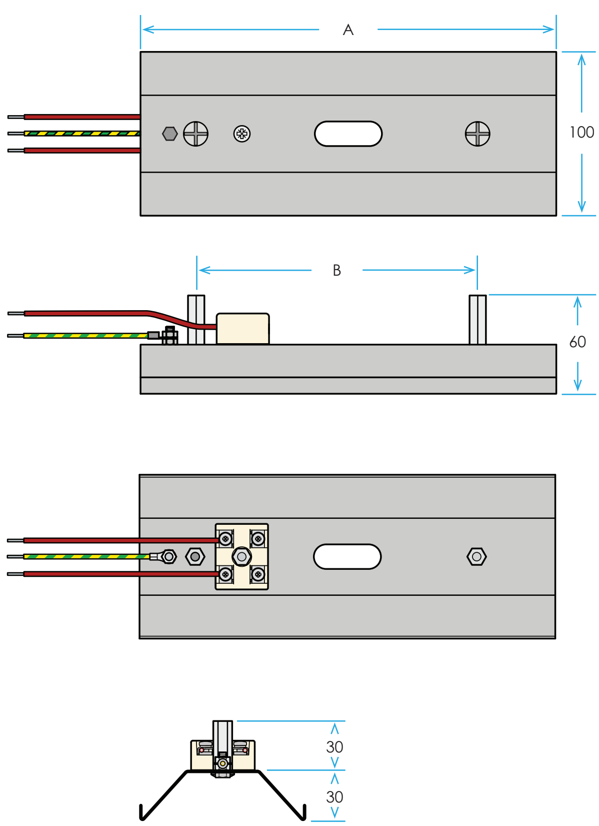
Our projectors are designed to cater to a wide range of ceramic elements and are the ideal solution where positional heat is required economically, efficiently and quickly.

All dimensions mm   Tolerances apply

RAS

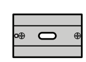
Reflector Aluminised Steel

Reflector material 0.75mm polished aluminised steel. Mounting studs with M6 internal thread. 300mm high temperature leads.

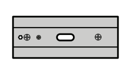


RAS 1 shown as example

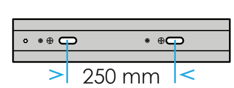
RAS 0.5 Suitable for HTE, HFEH and HFE elements.
Overall length A = 160 mm   Distance between fittings B = 131 mm



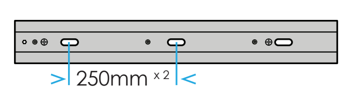
RAS 1 Suitable for FTE, FFEH and FFE elements.
Overall length A = 254 mm   Distance between fittings B = 175 mm



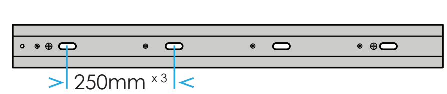
RAS 2 Suitable for FTE, FFEH and FFE elements.
Overall length A = 505 mm   Distance between fittings B = 278 mm



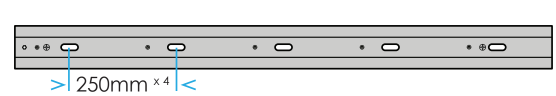
RAS 3 Suitable for FTE, FFEH and FFE elements.
Overall length A = 754 mm   Distance between fittings B = 528 mm



RAS 4 Suitable for FTE, FFEH and FFE elements.
Overall length A = 1,004mm   Distance between fittings B = 778 mm



RAS 5 Suitable for FTE, FFEH and FFE elements.
Overall length A = 1,254 mm   Distance between fittings B = 1,028 mm



QTR

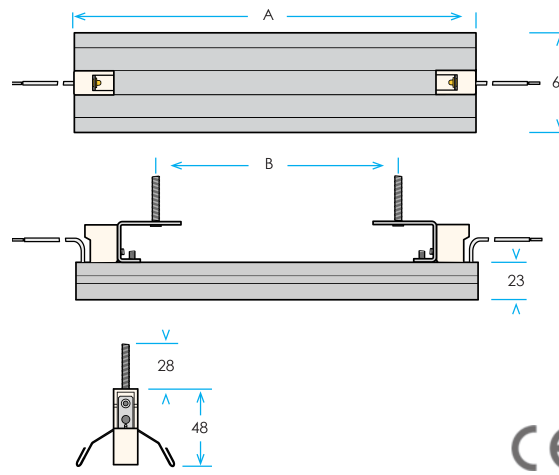
Quartz Tungsten / Halogen Reflectors

Reflector manufactured from 0.75 mm polished aluminised steel.
2 x M5 fixing bolts
R7s holders with 200mm leads Ø 0.75mm with PTFE-insulation

QTSR Quartz Tungsten Halogen Short Reflector
Suitable for QTS/QHS tubes with R7s terminations
Overall length A = 250mm   Distance between fittings B = 153mm

QTMR Quartz Tungsten Halogen Medium Reflector
Suitable for QTM/QTL tubes with R7s terminations
Overall length A = 300mm   Distance between fittings B = 203mm

QTLR Quartz Tungsten Halogen Long Reflector
Suitable for QTL/QHL tubes with R7s terminations
Overall length A = 497mm   Distance between fittings B = 400mm

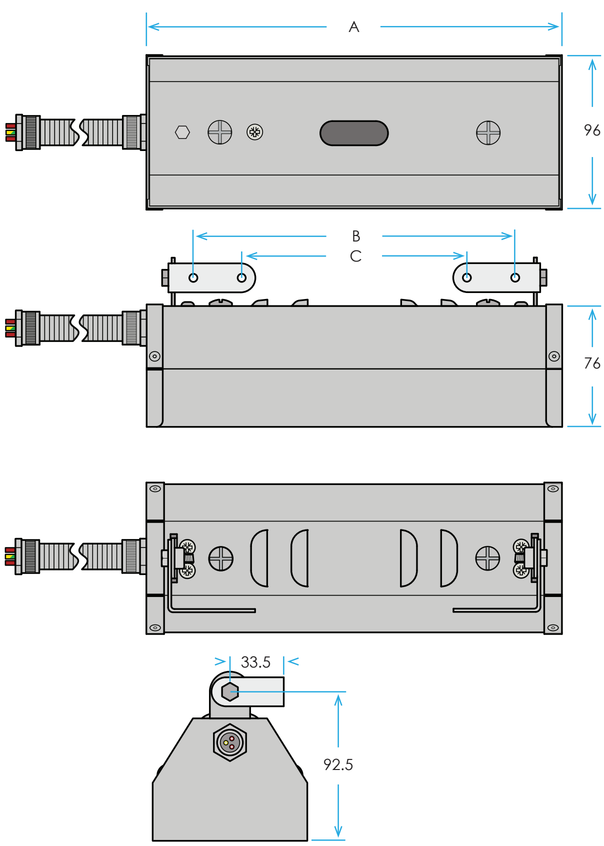


QTSR shown as example

PAS

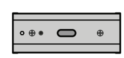
Projector Aluminised Steel

Reflector material 0.75mm polished aluminised steel.
Ø16 mm metal conduit, length 1.5m

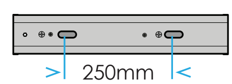


PAS 1 shown as example

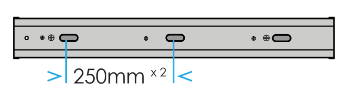
PAS 1 Suitable for FTE, FFEH and FFE elements.
Overall length A = 258 mm   B = 200mm   C = 140mm



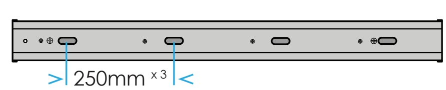
PAS 2 Suitable for FTE, FFEH and FFE elements.
Overall length A = 508 mm   B = 450mm   C = 390mm



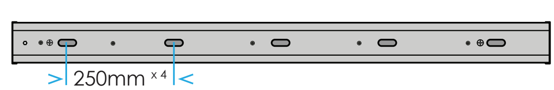
PAS 3 Suitable for FTE, FFEH and FFE elements.
Overall length A = 758 mm   B = 700mm   C = 640mm



PAS 4 Suitable for FTE, FFEH and FFE elements.
Overall length A = 1,008 mm   B = 950mm   C = 890 mm

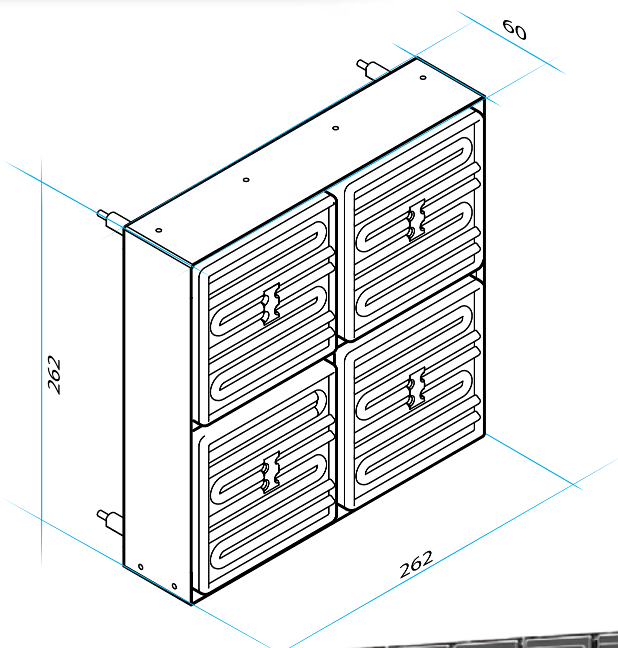


PAS 5 Suitable for FTE, FFEH and FFE elements.
Overall length A = 1,258 mm   B = 1,200mm   C = 1,140mm



MODULAR IR HEATER

Modular IR Units



Modular IR 260 – Modular long wave infrared heater allowing multiple units to be arrayed with equal element spacing

Dual voltage 480/240 V (elements can be connected in series or parallel)

Two power output options – 2.4 kW and 1.6 kW

Robust high temperature resistant construction

Fitted with high efficiency black ceramic hollow emitter model SFEH (x 4)

Stainless steel housing

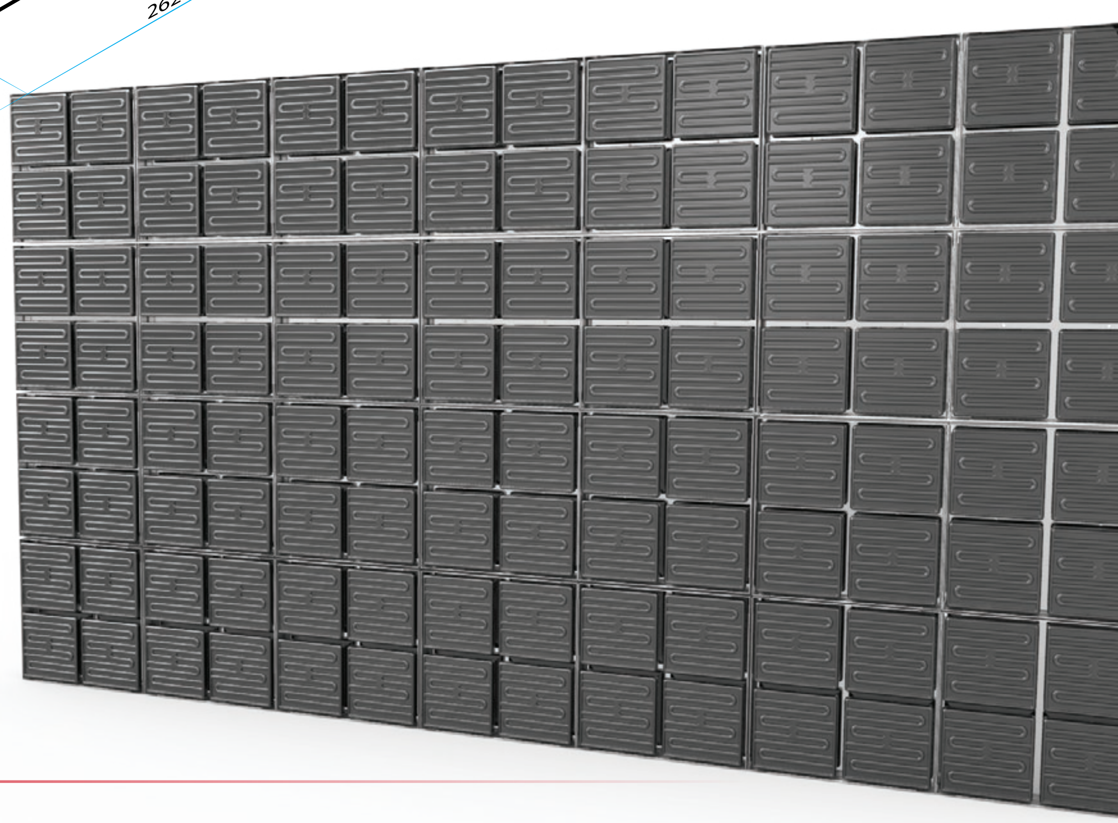
High reflectivity polished aluminised steel reflector plate

Fixed using 4 stainless steel stand off's with M6 threaded screw and fixing nut

Optional type K thermocouple in one of the ceramic emitters

Thermocouple (if installed) connected using removable ceramic type K plug (supplied)

The Modular IR 260 units are designed to maintain equal element spacing when mounted in an array



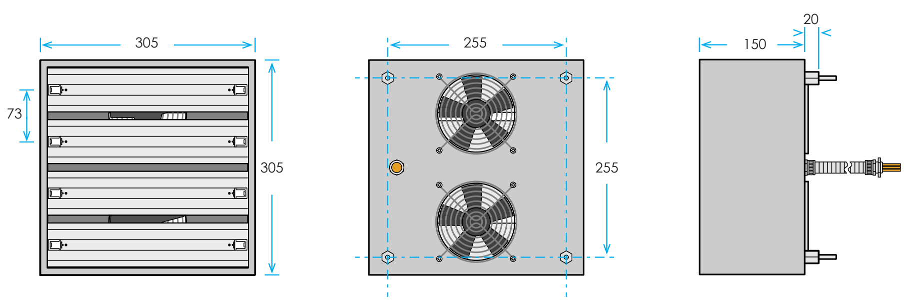
FAST IR

These compact robust systems form an ideal installation for quartz heating elements - quartz tungsten/halogen glass tube emitters. Optimum efficiency is achieved by highly polished aluminium steel reflection and rear mounted axial flow fans, which eliminate rear convection losses and keep the reflectors cool for better directional quality on the infrared output. The external body which is manufactured from aluminium can be maintained at “touch safe” temperature.

All dimensions mm   Tolerances apply

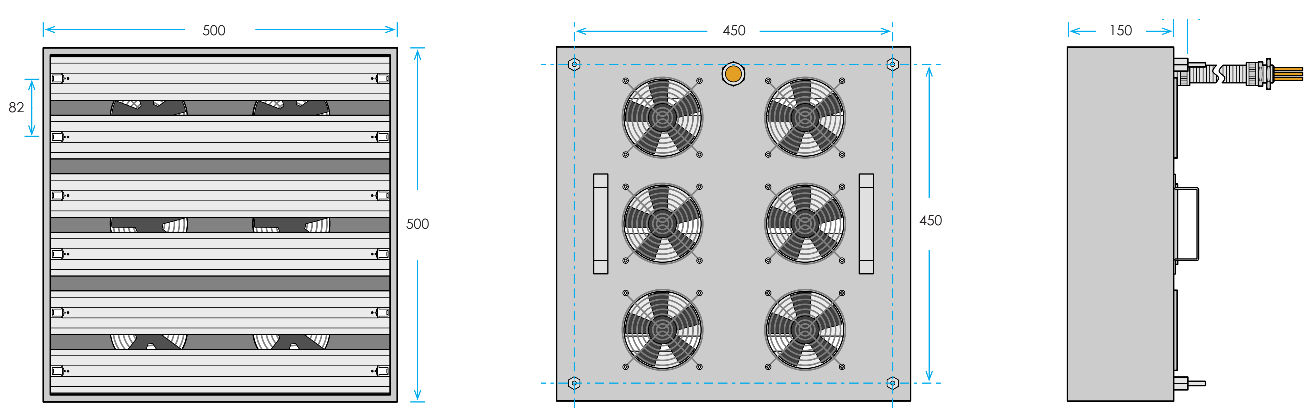
FAST IR

FASTIR 305 Suitable for 1000W Quartz tungsten/Halogen heaters QTM or QHM. Standard FastIR 305 designed to hold 4 tubes (4kW), also available as 5 tube (5kW).



4 x Aluminium stand off with M6 threaded screw with fixing nut.
Electrical termination made via 1.5m of 20mm diameter flexible metal conduit with additional 0.5m of glass fibre insulated NPC conductors. 2 rear mounted axial flow fans.
Suitable for heater type QTM (Quartz Tungsten Medium) or QHM (Quartz Halogen Medium) tubes with R7s termination, 240V (1000W maximum)
See pages 52/53 for full details of tubes

FASTIR 500 Suitable for 1500W, 1750W, 2000W Quartz Tungsten heaters QTL or 2000W Quartz Halogen heaters QHL. Standard FastIR 500 designed to hold 6 tubes (12kW) also available as 7 tube (14kW).



4 x Aluminium stand off with M6 threaded screw with fixing nut.
Electrical termination made via 1.5m of 25mm diameter flexible metal conduit with additional 0.5m of glass fibre insulated NPC conductors. 6 rear mounted axial flow fans.
Suitable for heater types QTL (Quartz Tungsten Long) or QHL (Quartz Halogen Long) tubes with R7s termination, 240V (2000W maximum).
See pages 52/53 for full details of tubes. Please note other configurations are available on request.

ACCESSORIES

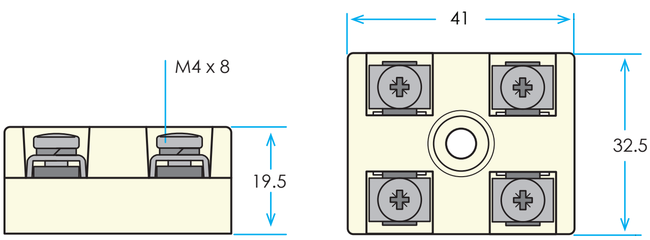
Ceramicx manufactures a range of accessories, including steatite press components.

Steatite ceramic dust has proven itself to be the material-of-choice for the manufacture of electrical insulators thanks to its good mechanical strength, ideal dielectric properties and high temperature resistivity of up to 1000°C

All dimensions mm Tolerances apply

CERAMIC TERMINAL BLOCKS

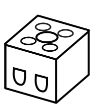
2P Ceramic terminal block
Stainless steel fittings, body Steatite C-221



Maximum voltage:	500 V
Maximum temperature:	450 °C
Maximum current:	20 A*
Maximum cable CSA (solid):	4.0 mm sq.
Maximum cable CSA (stranded/with ferrule)	2.5 mm sq.

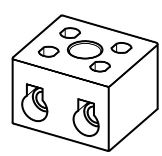
*Up to 30A permissible at lower temperatures.

2P Mini Ceramic terminal block



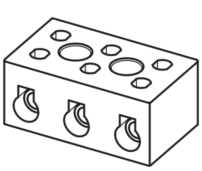
Nickel galvanised brass inserts.
Zinc plated steel screws.
21 x 18 x 15 mm

TB2 Ceramic terminal block



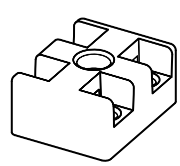
Plated brass inserts.
Nickel galvanised screws.
34 x 30 x 22 mm

TB3 Ceramic terminal block



Plated brass inserts.
Nickel galvanised screws.
51 x 30 x 22 mm

2P Ceramic terminal block no fittings

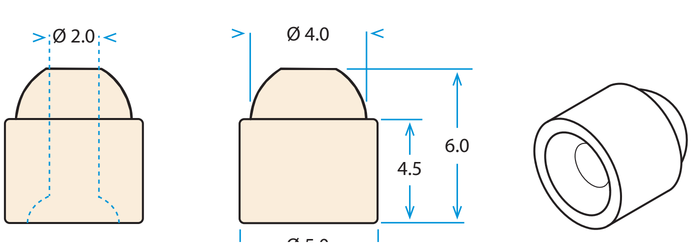


41 x 32.5 x 9.5 mm

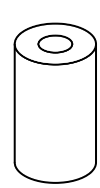
CERAMIC BEADS

Ceramic beads 1 Kg bag

Material: Steatite C-221

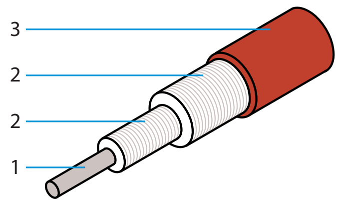


Ceramic tubes



Ø5 x 11.5 mm
Material: Steatite C-221

High temperature NPC cable

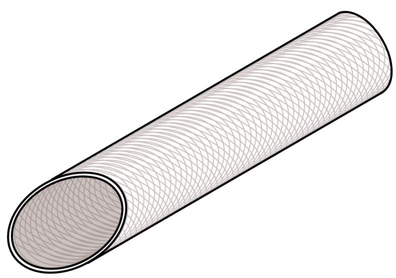


1. Flexible nickel plated copper core
2. Multiple silicone-impregnated glass lapping
3. Silicone - coated fibreglass braid

Continuous working temperature: -60°C to +280°C
Peaks at 350°C
Working voltage: 300/500V

Nominal core cross -section	Nominal core stranding	Outer cable diameter	Linear weight approx
0.75 mm^2	11 x 0.30	2.4 mm	11.9 kg/km
1.50 mm^2	21 x 0.30	2.8 mm	20.5 kg/km
2.50 mm^2	35 x 0.30	3.2 mm	32.2 kg/km
4.00 mm^2	56 x 0.30	4.0 mm	50.1 kg/km

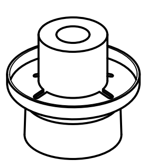
Fibre glass braided sleeving



Fibre glass braided sleeving non-impregnated
Continuous working temperature: -60°C to +450°C

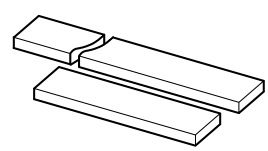
Nominal Inner diameter	Min. wall thickness	Linear weight approx
2 mm	0.20	3.10 kg/km
4 mm	0.30	7.60 kg/km
6 mm	0.30	12.00 kg/km

Grommet set



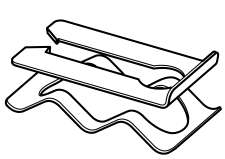
Ceramic grommet and star-lock fastener set, used as insulator in sheet metal with 6mm hole
9.5 x 7.5 mm

Stainless steel buss bar



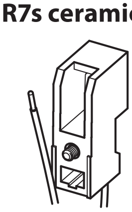
Used with the ceramic terminal block to produce a flexible power distribution system
8 x 2 x 1000 mm

Steel wave and spring clip



Used in the mounting and instillation of all Ceramic and pillared quartz elements

R7s ceramic holder



For standard quartz tungsten tubes and quartz halogen tubes

2.1 Putting it all together - ceramic

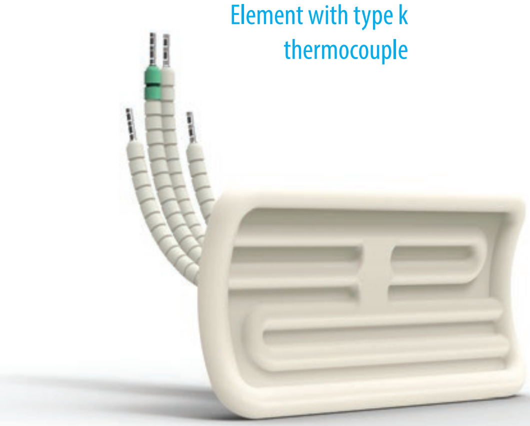
A UK based Tier 1 automotive supplier approached Ceramicx about upgrading their thermoforming heating system. They were having some productivity issues. Specifically, they were looking for uniformity of heat to ensure repeatability and consistency of product. Quality and yield are two of the pillars of any manufacturing facility, and if they can be improved a manufacturing site gains both in cost and morale.

Ceramicx developed and customised the infrared heating system to the material, temperature, power, and time requirements of the process.

Ceramicx designed and built a top and bottom infrared heating system using HTE long wave ceramic heaters. A total of 18 zones of control were outlined by the customer, and a series of HTE 300W ceramic long wave heaters were used around the perimeter of each heating system, platen, to minimised edge loss.

The key features of the oven heating system included:

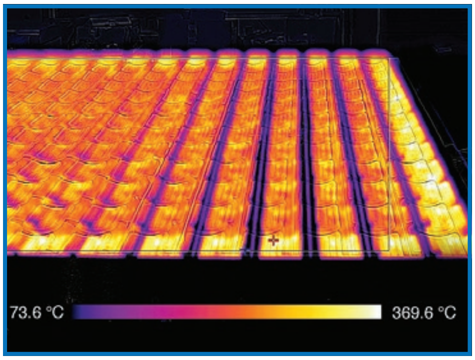
Long wave ceramic heating element HTE, Half Trough Element with type k thermocouple



See page 10 for more details on our range of standard Ceramic heating elements.

Oven Frame	Stainless Steel Box Section
Reflectors	Special Aluminised Steel
Upper Platen Element Type	Long Wave Ceramic model HTE
Lower Platen Element Type	Long Wave Ceramic model HTE
Maximum Operating Temp	250˚C (Element Temperature)
Controller	SIEMENS S7 1500
Control Type	36 zone closed loop control with T/Ck feedback
Control Feedback	Type K thermocouples integrated into ceramic element
Sheet temperature monitoring	Pyrometer
Total Heating Power	124kW
Oven Size	2.08m x 1.80m

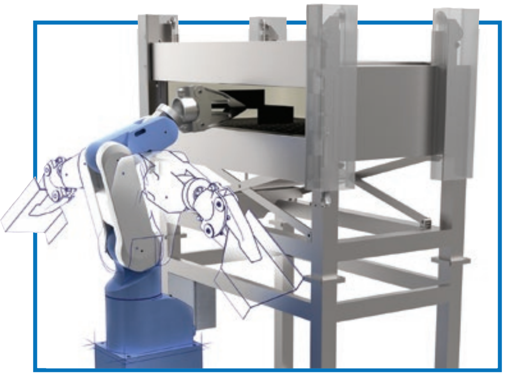
The process was a cut sheet process for the thermoforming of car interior liners – in this case the boot space. Black carpet onto black plastic sheet was robotically loaded onto a moving table and then moved across into the heated zone. The infrared heating system is applied to the top and bottom of the part for a specified



time. The sheet then gets moved on to the surface where it is slowly pressed into the required shape. The component then cools down inside the mould, before it is removed and the trimming and finishing process takes place.

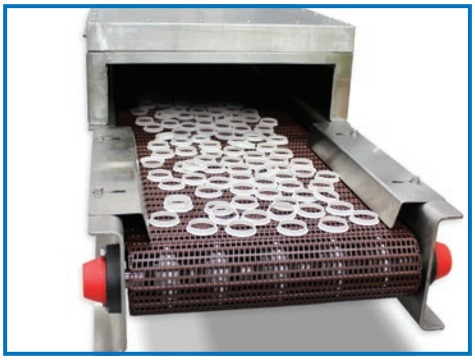
The result was that the customer was extremely impressed with how fast the ceramic heaters got to their required temperature, and the ease at which the IR heaters found and remained at the required temperature set-point. Ceramicx has since worked on another project with this supplier and supplied them with a second infrared heating system for a different manufacturing facility in the UK.

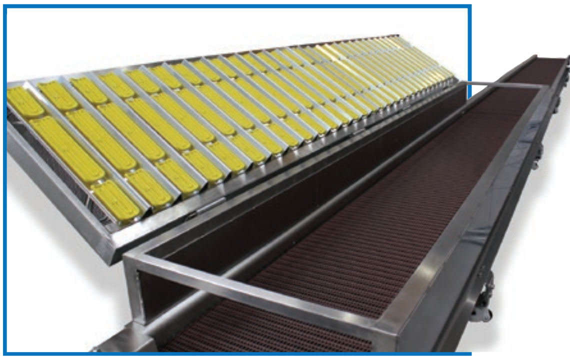
Ceramicx developed a composite curing oven, which was embedded in a robotic press cell for a variety of composite systems. The oven used ceramic long-wave heaters, which were mounted in a stainless steel framework with Ceramicx propriety reflector material used to increase the efficiency. The power use of this product is only a fraction of that which is quoted due to the high efficiency of the long-wave emitters, which were employed. Ceramicx control system integrated seamlessly with the robotic press's system enabling recipes to be defined and executed from one overall HMI.



Annealing and Stress relief on Injection Molded Parts

Ceramicx supplied three tunnel ovens with an intergrated 30 metre conveyor system to a customer in the U.S. Fast Moving Consumer Goods sector. Ceramicx long-wave emitters and closed loop feedback systems mean these ovens integrated seamlessly with the customers existing machinery. The conveyors employed are variable speed with 2-way drive and used a stainless steel belt system





2.2 Putting it all together - quartz

> *"Our partnership involved the development of 2 new quartz-based resistors for the STCS-evo500 machines, with the objective of providing a more robust form of heating."*

Contract manufacturing

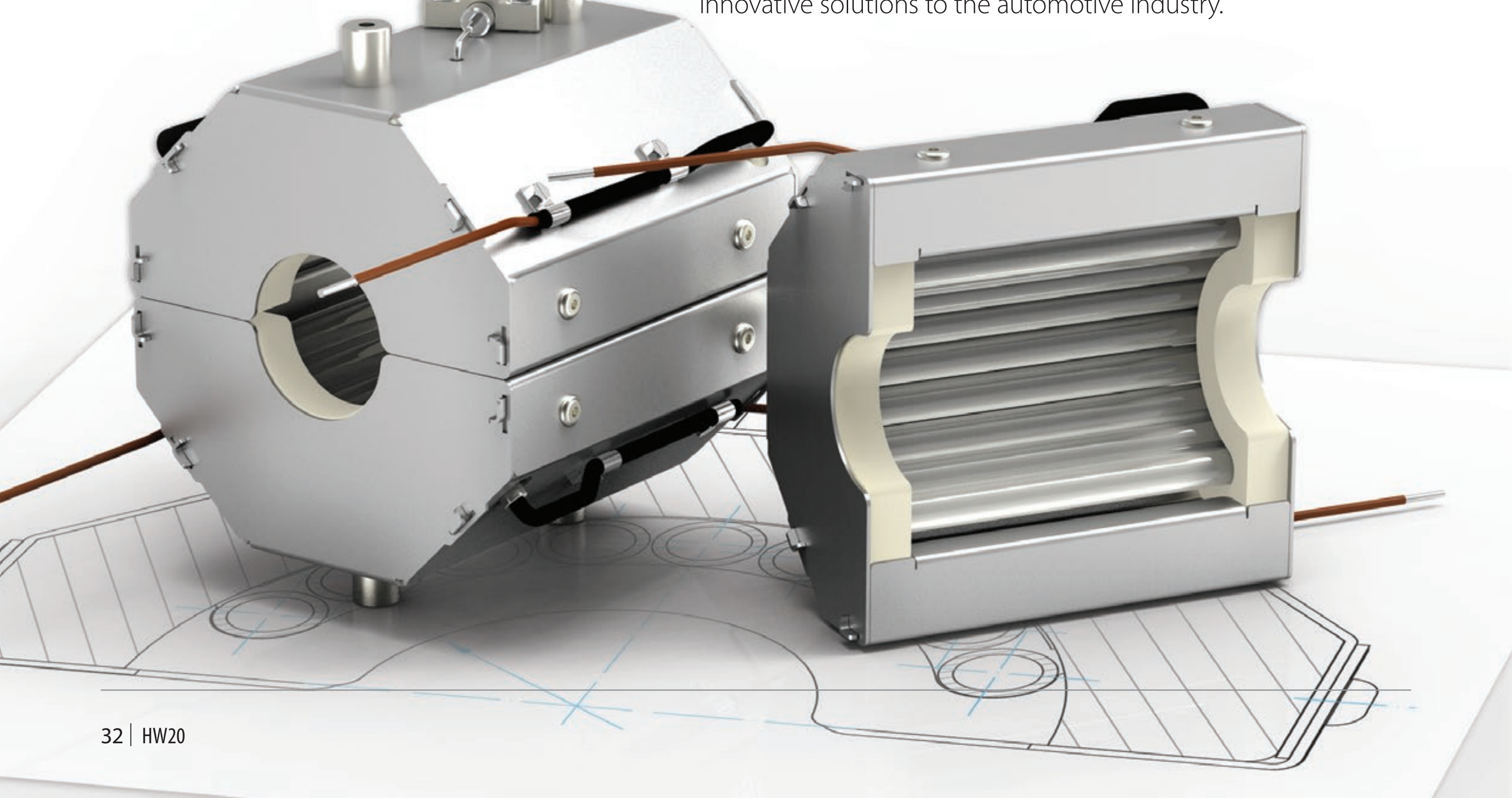
Mecalbi, a company founded in Portugal in 2006, design and develop state of the art shrinking systems. These systems apply heat to a thermoplastic in order to shrink it, and are used primarily by the automotive industry.

Previously, Mecalbi used convective heating to heat the thermoplastics to the required temperature for them to shrink. Ceramicx partnered with Mecalbi to introduce the idea of using Infrared radiation to heat the material. The proposed Infrared heaters were to be used in-line with the Mecalbi STCS (shrink tube control system). Initial advantages of Infrared over convective heating were that the Infrared heaters were more energy efficient, as well as providing the capability of higher temperatures.

Mecalbi required heaters for their STCS-evo500 machines. Ceramicx developed a unique clam shell shaped quartz heater for this project. As well as Infrared heating, Ceramicx applied extensive knowledge in the design and manufacture of this heater, from fabrication to machining to metal and dust pressing. An essential aspect of this project was the design of a thermally and electrically insulated end cap. A new die was designed for use in Ceramicx' in-house dust press, which allowed this end cap to be manufactured. This was completed by compressing a steatite mixture into shape, and subsequently firing it in Ceramicx' kiln.

The new heater produced by Ceramicx was more robust than the previous heater used, which had been easily damaged by the heated cable's terminals. Ceramicx also developed a small Infrared oven for Mecalbi's machines. Mecalbi used the new Infrared oven for a project for one of their major customers, the results of which were as desired and passed all validation tests.

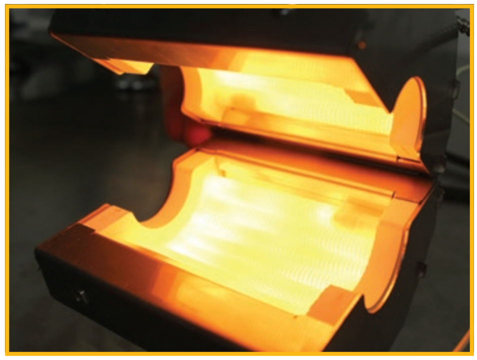
According to Mecalbi "We can honestly say, after this first partnership, that Mecalbi's machines have been given added-value by the Ceramicx IR heating know-how and that we expect to reap rewards with direct consequences in our image and future sales. We expect to continue and reinforce this partnership with Ceramicx, providing together new and innovative solutions to the automotive industry."



(left) Quartz infrared element under testing.

(right) The Mecalbi STCS-evo500 is used for processing heat shrink tubes. Based on infrared resistors it is designed for workbench applications and processes one part at a time.

It has built-in communication with ultrasonic welding machines and several operating modes.



Our customer wanted us to develop an IR-heating application to preheat Aramid fibre. Aramid is a heat and solvent resistant synthetic fibre that has an exceptionally good strength to weight ratio.

In the process 16 fibre threads 0,4 diameter needed to be preheated to a temperature between 150º and 250ºC before impregnation and forming into fibre cables.

The 16 fibre threads pass two IR-heating platens in mounted back to back in a vertical orientation.

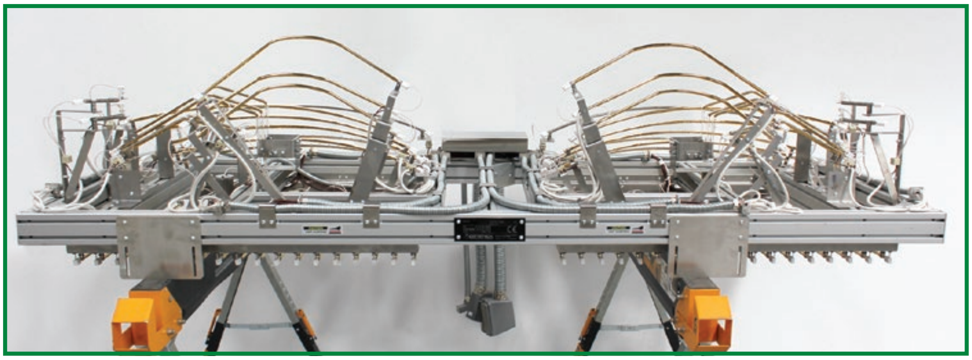
Quartz heaters type FQE were used giving a shorter response time and faster cool down properties for more reliable control and less risk to burn the fibre threads.

See page 18 for more details on our range of standard Quartz heating elements.

Oven frame	Stainless steel
Element type	Full Quartz E element
Control type	6 Zones
Control feedback	Type k thermocouple in each zone
Total power	9.75 kW x 2
Oven size	1.1 x 0.3 m

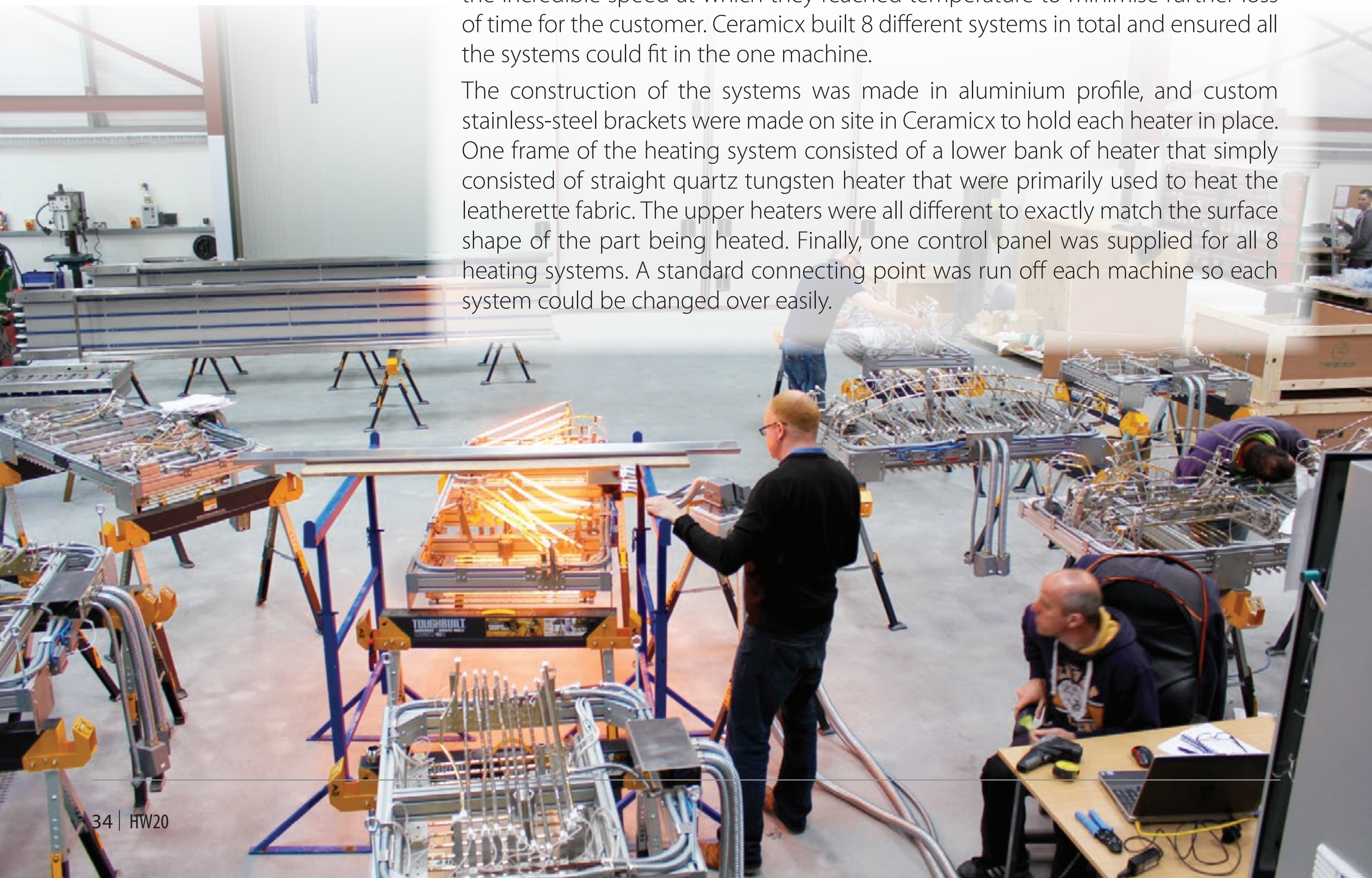
2.3 Putting it all together - Quartz Tungsten/ Halogen

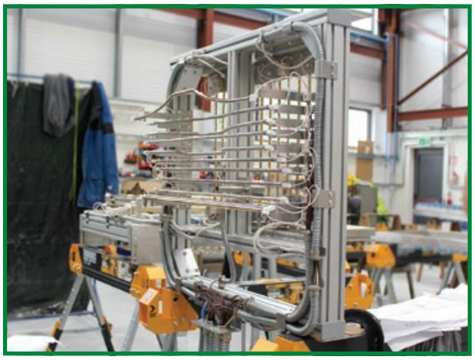
One of the leading US automotive companies were looking for a more automated solution to their production process. Their Tier 1 supplier made contact with our business partner in the United States, Weco International. They wanted specifically an infrared heating system to bond leatherette materials to the interiors of automotive passenger doors for the cars that they were producing. They had multiple parts, so they needed multiple heating systems.



Ceramicx designed and built the infrared heating system to suit this automotive thermoforming application. Ceramicx designed a one-of-a-kind heating system that consisted of 37 custom heaters that suited the shapes that the customer wanted. This ensured uniformity of heating over the entirety of the part. Ceramicx designed these custom short-wave, Quartz Tungsten Tubular heaters, to suit the material that the customer was processing to ensure it was the most efficient way of heating the material. An additional benefit incorporated in to these heaters was the incredible speed at which they reached temperature to minimise further loss of time for the customer. Ceramicx built 8 different systems in total and ensured all the systems could fit in the one machine.

The construction of the systems was made in aluminium profile, and custom stainless-steel brackets were made on site in Ceramicx to hold each heater in place. One frame of the heating system consisted of a lower bank of heater that simply consisted of straight quartz tungsten heater that were primarily used to heat the leatherette fabric. The upper heaters were all different to exactly match the surface shape of the part being heated. Finally, one control panel was supplied for all 8 heating systems. A standard connecting point was run off each machine so each system could be changed over easily.





The key features of the oven heating system included:

See page 22 for more details on our range of standard Quartz Tungsten / Quartz Halogen heaters

Oven Frame	Aluminium Profile
Reflectors	None
Upper Element Type	Individual Custom Quartz Tungsten Tubular Heaters
Lower Element Type	Quartz Tungsten Tubular Heater
Controller	Siemens S7 1500 PLC
Control Type	48 Zones
Control Feedback	IR Sensor
Total Power	Approx. 150kW
Oven Size	8 heating systems with footprint of 2.2 x 0.8m

Currently this short wave infrared heating system has been in production for over 1 year, and the report so far is that the end user is satisfied with the result. Our custom built system fit into the footprint that they had available, each system can be changed out easily, the heaters heat the required part uniformly, they are efficient both in response and heating the targeted material, and lastly it is clean energy.

Ceramicx builds a select number of research and development ovens in order to progress client opportunities. This 30 kW short wave mobile infrared platen is used for composite heating in the aerospace industry.

Ceramicx Herschel lights the way….

Over one hundred years after its discovery the world of Infrared (IR) heating – a spectrum of radiant energy - is still much misunderstood and misapplied. The opportunities for clean and green IR technology are simply waiting in the wings; the current challenge is to raise the world's adoption of this valuable energy source – in industry and in society at large.

Sometimes described as 'sunshine without light' the IR heating sector, although ubiquitous, has in times past perhaps suffered for the 'invisible' nature of the energy spectrum.

The Ceramicx Herschel test instrument has now radically changed that perception. Launched in 2013 The Herschel machine test instrument is now a part of daily life at the company, and is at the heart of the company's heat work laboratories in the new factory.

In partnership with Trinity College Dublin, Ceramicx took the Herschel project to fruition in order to further establish empirical science and provable method in the measurement and management of the IR heat spectrum.

The machine is a world first in IR test instrumentation: It literally brings research matters into the light by mapping and measuring the previously invisible IR energy field in 3D space. Making the IR heat spectrum visible in this way cannot be understated. In March 2017 the Herschel won Ireland's Collaborative Research Impact Award under the Knowledge Transfer Ireland (KTI) initiative, beating competitors such as Intel Ireland, Microsoft Ireland and DCU.

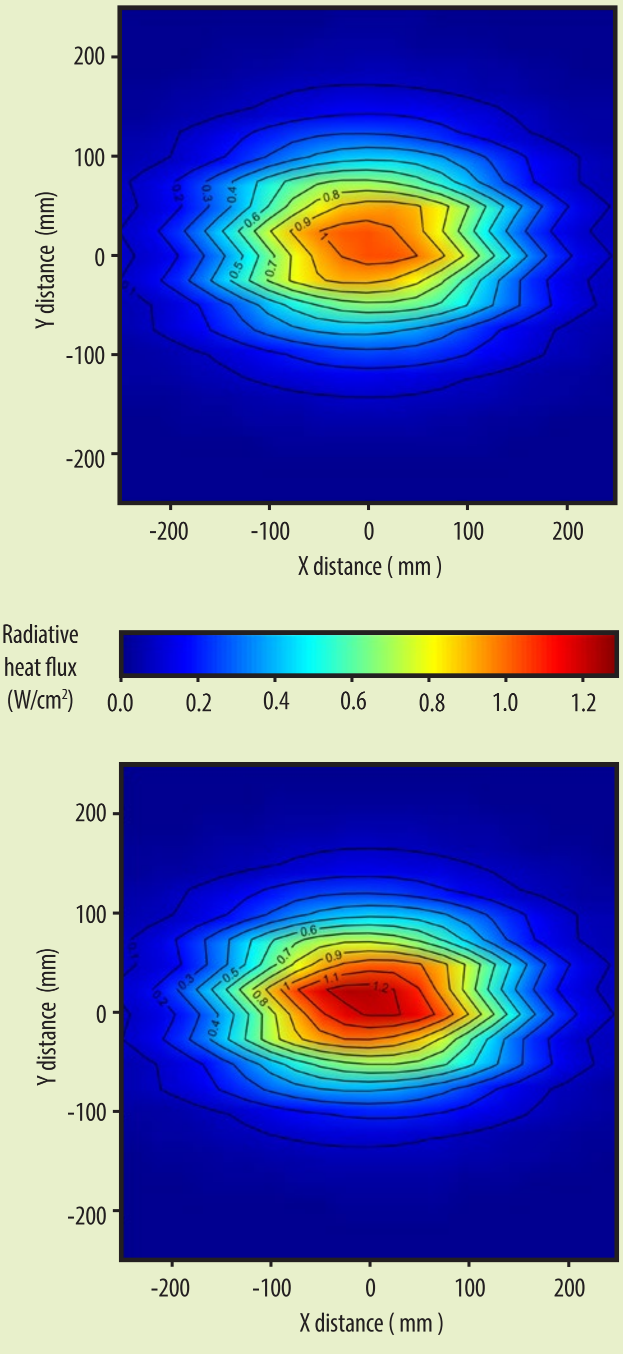
The Herschel test instrument has become an integral part of C^2I^2 Ceramicx Centre for Infrared Innovation

As part of our expansion the Ceramicx Centre for Infrared Innovation (C^2I^2) has a new location on the first floor

In house testing

With regard to in house testing, the Herschel's benefits are realised in aiding with the design and selection of suitable reflectors. In this case, one element (e.g. an 800W FFEH) is tested multiple times, each time supported by a different reflector. The Herschel can numerically and graphically display the results, clearly indicating the type of reflector which results in the most amount of radiative energy directed towards the target sensor. This information allows us to determine the effectiveness of new reflector geometries, or a new reflector material, for example.

Figure 1 : Energy intensity as a function of distance



The Herschel also allows us to test the emissive output of all Ceramicx heating elements, creating a suitable comparison by keeping the reflector consistent in each test.

The Herschel Ir sandwich test

Knowing how a target material absorbs Infrared energy is essential in selecting the right type of heating element for the job. A smaller test set up within the Herschel, the IR Sandwich Test, allows us the accurately measure the temperature of a material as it is being heated by a specific

heating element. In this set up, a material (often a type of plastic) is place on a stainless steel mesh, with heating elements located a fixed distance above, below, or above and below the material. Four non-contact pyrometers accurately determine the surface temperatures of the material.

By implementing multiple tests on a material, using different types of heating elements, we can determine the element most suitable for a specific job. The obtained results provide invaluable knowledge on how materials react to short, medium, and long wave Infrared radiation.

Figure 1 - Heat flux maps provided by the Herschel.
A comparative test can clearly display the more suitable reflector.
The lower of the 2 heat flux maps indicates a greater amount of Infrared radiation directed towards the target sensor.

3.0 The application of IR heating – clean, green and cost effective

It is hard to overstate the social and industrial benefits of Infrared heating. The technology is widely used but often misunderstood – not least by engineers who may default to treating IR in the same manner as convectional heating – where heat temperature measurement is the only consideration.

The most popular consumer application for IR heating to date can currently be seen in the built environment where IR heaters are a mainstay of comfort in public and municipal places and also in the home environment. Healthcare uses – in saunas, therapeutic treatments and veterinary care are other places of high visibility.

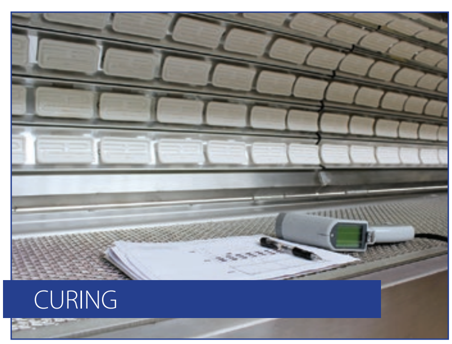
However, much of the primary benefits of IR heating are now realised in industry and manufacturing.

IR heat creates no convectional side effects of dust and smell; IR heat consumes less energy than alternatives – automatically lowering the impact on the environment and the carbon footprint of the heat process. IR heat is precise, controllable and manageable, thus further conserving energy resources.

The next section of this publication therefore outlines three key areas of manufacturing where these IR heat positives apply:

- In today's process industries
- In drying, curing and coating applications
- In mechanical fabrication and in bonding and welding

DRYING

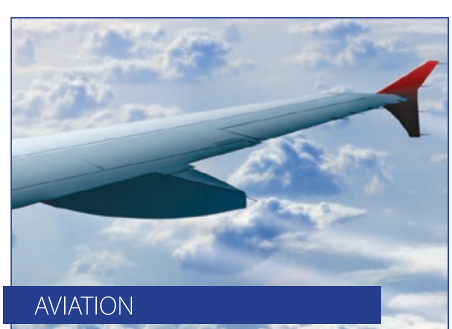

CURING


COATING

IR heating is advancing and sustaining all of today's manufacturing sectors – from aerospace to packaging, from automotive to baking, from medical and healthcare to construction and oil and gas.

IR heat technology is set to further grow and change the way the industrial world works.


AUTOMOTIVE


AVIATION


PACKAGING

Where is infrared used in industry?

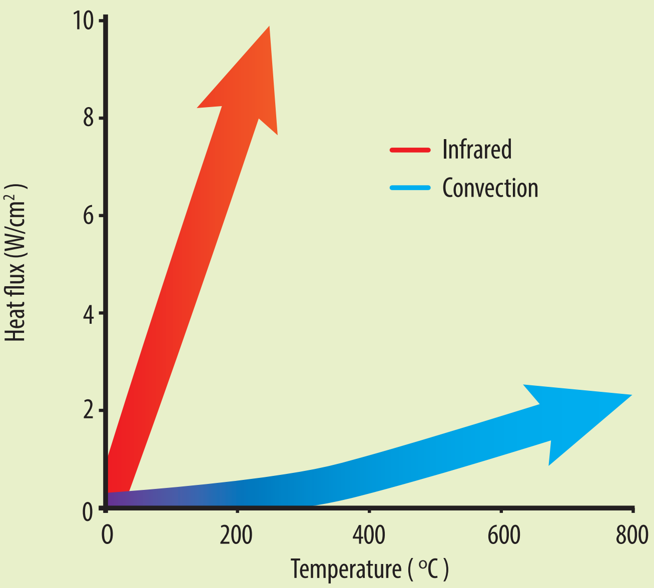
Process	Application	Equipment	Industry
Curing and Forming	Coating, Polymer Production, Enamelling	Various Furnace Types, Ovens, Kilns, Lehrs, Infrared, UV, Electron Beam, Induction	Ceramics, Stone, Glass, Primary Metals, Chemicals, Plastics and Rubber
Forming	Extrusion, Moulding	Various Ovens and Furnaces	Rubber, Plastics, Glass
Drying	Water and Organic Compound Removal	Fuel-Based Dryers, Infrared, Resistance, Microwave, Radio-Frequency	Stone, Clay, Petroleum Refining, Agricultural and Food, Pulp and Paper, Textile
Fluid Heating	Food Preparation, Chemical Production, Reforming, Distillation, Cracking, Hydro-treating, Vis-breaking	Various Furnace Types, Reactors, Resistance Heaters. Microwave, Infrared, Fuel-based Fluid Heaters, Immersion Heaters	Agricultural and Food, Chemical Manufacturing, Petroleum Refining
Heating and Melting, Low-Temperature	Softening, Liquefying, Warming	Ovens, Infrared, Microwave, Resistance	Plastics, Rubber, Food, Chemicals
Metals Reheating	Forging, Rolling, Extruding, Annealing, Galvanizing, Coating, Joining	Various Furnace Types, Ovens, Kilns, Heaters, Reactors, Induction, Infrared	Primary Metals, Fabricated Metal Products
Other Heating Processes	Food Production (including Baking Roasting and Frying) Sterilisation, Chemical Production	Various Furnace Types, Ovens, Reactors, and Resistance Heaters. Microwave, Steam, Induction, Infrared	Agricultural and Food, Glass, Ceramics, Plastics and Rubber, Chemicals

Advantages of Infrared over Convection

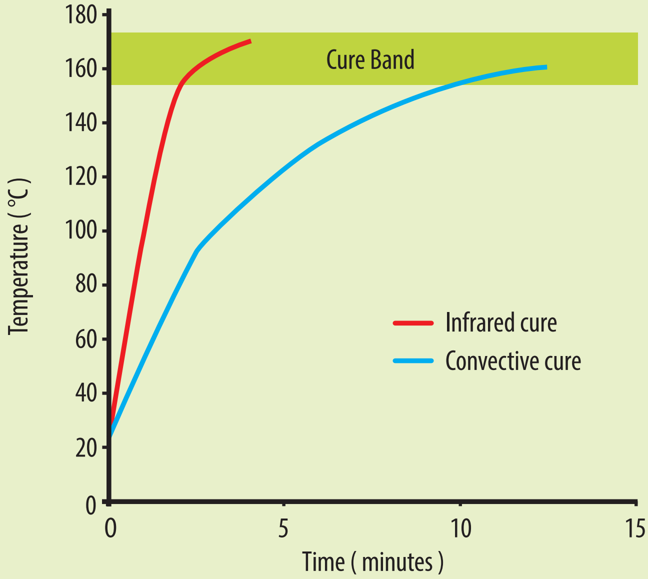
In most applications, infrared heating offers numerous advantages over convection heating including:

- *Higher rate of heat transfer* • *Higher efficiency*
- *Floor space savings* • *Lower maintenance*
- *Fast response* • *Control accuracy*
- *Zoned temperature control* • *Lower capital expense and installation cost*

Infrared heating is generally more efficient than convection as a higher percentage of the input energy goes into the product instead of to the surrounding air or through a vent or flue. In addition, infrared ovens produce heat much faster than convection ovens which require pre-heat. During these periods, a significant amount of energy is consumed without any product being produced.



Radiation V's Convection.

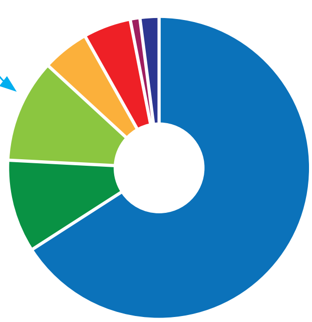


Heat fluxes can be much higher in radiative heating, thus process speeds can be faster. In practice, combination methods using radiation and some convective component of heating are often used, especially in non flat or complex parts.

3.1 Infrared heat conversion for the world's process industries

"What is your energy cost ? have you measured ? - to measure is to manage"

Typical Energy Cost in a Polymer Processing Site



- Plastics processing **66**%
- Compressed air **10**%
- Chillers **11**%
- Water pumps **5**%
- Lighting **5**%
- Offices **1**%
- Heating **2**%

Operation of machinery and ancillary equipment – 90% total energy bill

Process industries convert raw materials such as foodstuffs, chemicals, pharmaceuticals and polymers into usable products.

Production is generally continuous and relevant factors are typically ingredients and bulk materials rather than individual units. A borderline area would be the work involved in composite structure manufacturing from ovens or cut sheet thermoforming operations.

IR heating both catalyses and improves the heat work involved in the world's process industries. Time is of the essence in manufacturing and IR heat sources generally reduce cycle time; bringing materials to the required transitional states much more quickly and effectively than alternative energy sources.

The IR heat flux also offers a much more effective and penetrative rate of heat transfer than alternatives, again saving time and therefore cost.

The IR heat is generally delivered (see next section) via a variety of especially designed ovens, heating platens and furnaces types for the heating and transformation of foods, chemicals and polymer types of all kinds.

IR heat sources are favoured by the world's process industries not only for their manufacturing effectiveness but also for their clean and green properties, as outlined in the previous chapter.

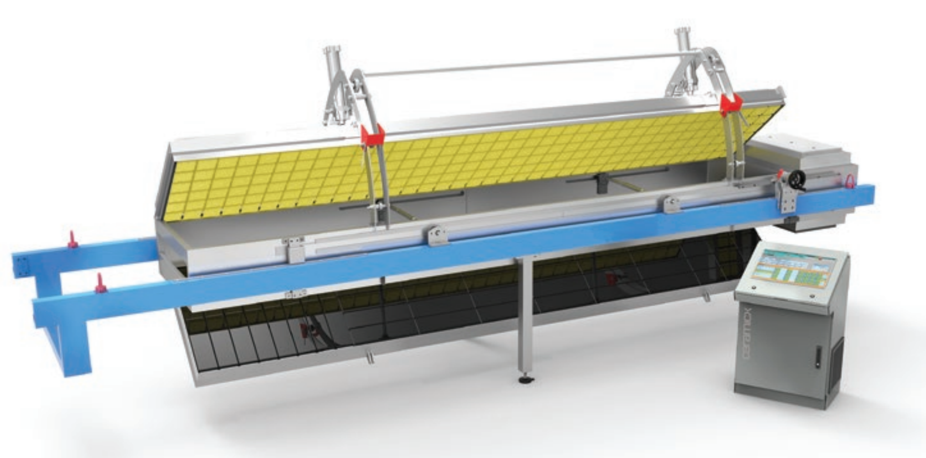
Heat in Plastics Processing

Commodity Polymers		
Polymer	Melting Temperature	Processing Temperature
LDPE	110°C	190°C
LLDPE	120°C	210°C
HDPE	135°C	220°C
PP	165°C	230°C
EVA	100°C	170°C
PP/PE Copolymers	120°C	200°C
PVC	180°C	190°C

Engineering Polymers		
Polymer	Melting Temperature	Processing Temperature
Nylon 6	180°C	260°C
PET	230°C	270°C
PEEK	265°C	360°C
PC	150°C	280°C
PBT	220°C	270°C
PA 66	230°C	275°C
PPS	190°C	350°C

Table source: NPIA (Northern Ireland Polymers Association)

Melting time is dependent on Polymer thermal characteristics such as thermal conductivity, specific heat capacity, enthalpy of melting etc. In convective cases, the heat transfer coefficient is also important.

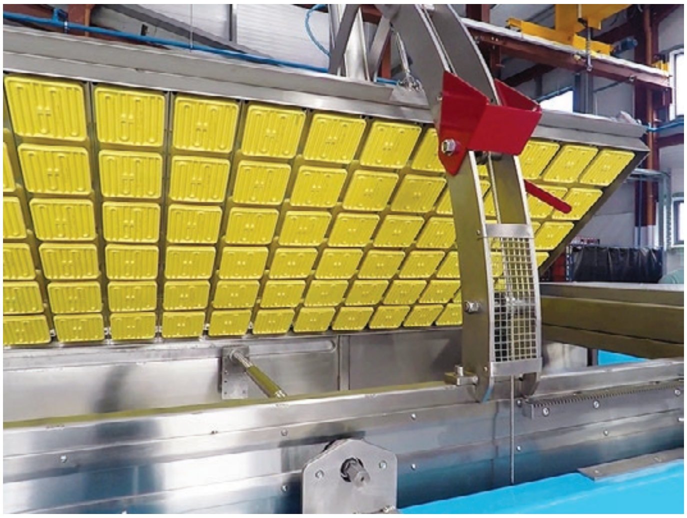


Thermoforming Energy Saving Comparison

40% energy savings for an infrared heating system when compared to a conventional (calrod-based) heating system on an identical thermoforming machine.

Direct comparisons between two thermoforming lines were undertaken using identical tools, products and cycle times. The measuring equipment used for all electrical testing was the Elcomponent SPC Pro. This is a device that measures all three-phases of the complete incoming supply to the thermoforming machine. It uses a single phase supply (phase to neutral) as a reference voltage for the calculations.

The Ceramicx based heating systems showed a decrease in the average power drawn from 56.16 kW to 32.85 kW, representing a 41.6% reduction.



Figures were also taken that showed a direct comparison between the two oven systems. With the machine base loads removed, the Ceramicx system then showed a measured energy saving of 45.8%. Additional study work undertaken showed that yet further improvements and energy savings would be available using the new Ceramicx-based system. (Please see Table 1 and Table 2 for more data) Both machines were directly comparable and both are part of two in-line and fast cycling systems at the customer,

loaded with the same tools both making the same polystyrene-based products for the Fast Moving Consumer Goods (FMCG) and food service markets.

Ceramicx infrared oven assembly and control system have a total of eight temperature sensors built into the system. These can be selected individually or grouped for control purposes. Additionally the infrared heaters can be subdivided into as many as 132 separate zones, thus giving a wide range of control options.

The oven assembly itself is fitted with pneumatic cylinders which are operated manually via two solenoid valves. The lower platen is used as a counterweight, using steel rope and pulleys. The control systems offer the processor a choice of both open and closed loop control, together with cost-saving procedures in start-up and fault monitoring in addition to in-line process energy control.

3.2 Infrared – heat conversion for drying, curing and coating

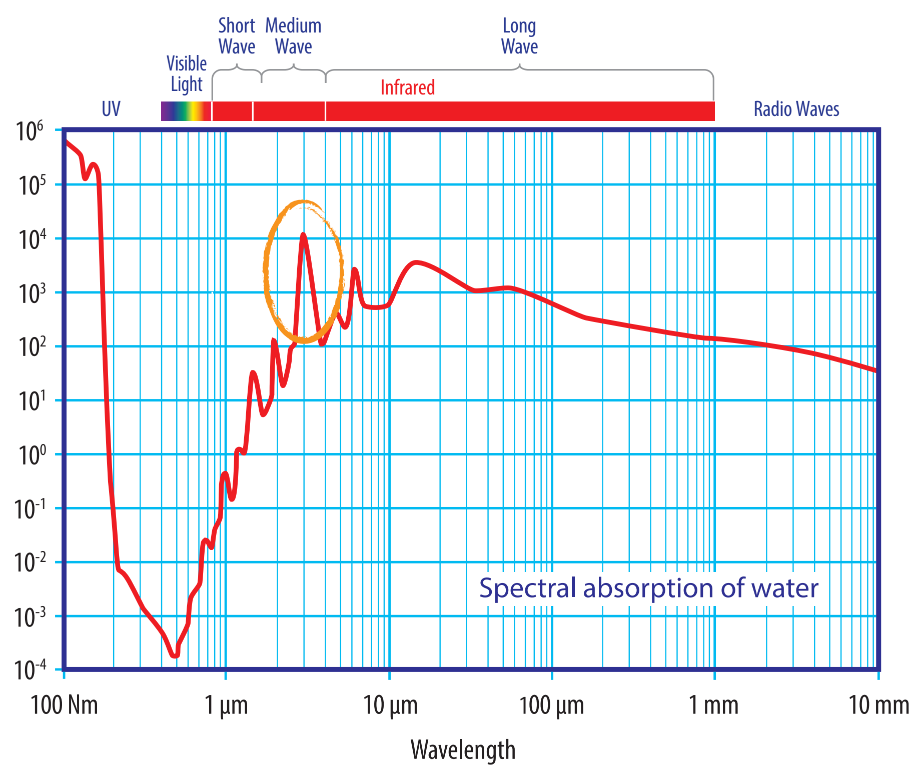
Naturally, the function of heat is to dry. However, IR heat sources dry in a different manner and their use is ubiquitous in drying ns curing paints, polymers, fabrics and also food-based substances.

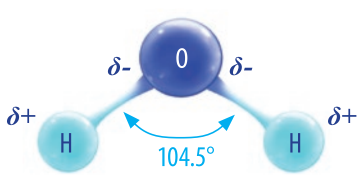
Several advantages are counted over convection heating:

- Only the coating is heated – not the entire part. The coating can achieve a much higher temperature before the substrate begins to heat.
- Infrared heating is applied 'in line of sight'. Areas for heat requirement can thus be very precisely targeted.
- Infrared systems are not subject to the air currents associated with convective heating systems. Dust and contamination is therefore minimised.
- IR heat can often effect a more complete and stable curing process, resulting in harder and tougher chemical linkages.

Medium-wavelength electric IR heating is especially well suited to the curing and drying of coatings, paints and inks. These wavelengths correspond with the absorption bands for water, which many coatings contain.

The graph of the spectral absorption of water shows a high peak in the infrared range at around 3 microns.





Infrared radiation causes molecular vibration. The different molecules vibrate at different frequencies depending on the frequency of the Infrared radiation.

Many such IR ovens are often zoned for this purpose, containing flash off (removing solvents); pre-heat and holding stages.

Large flat surfaces are also highly suitable for IR heating of powder coatings. Again, this is economical since only the surface powder is irradiated, not the entire part.

Inks and fabrics are also usually deposited on flat surfaces and therefore IR emitters are ideal heat applicators. Very uniform heating of the substrate and inks is made possible and continuous throughput through a high heat flux zone makes for rapid drying.

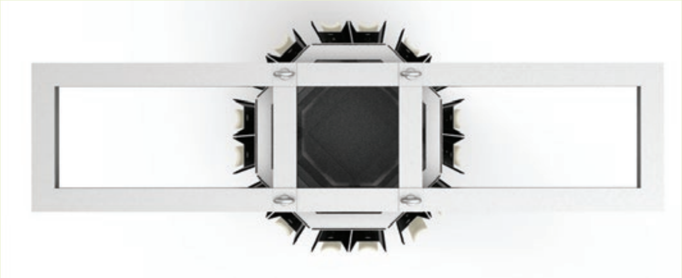
A Swiss Industrial company approached our distributor in Germany Friedr-Freek about a drying system for concrete pipes using only infrared technology.

The Construction company provided Ceramicx with clear details of what they thought would be required. The internal diameter of the pipe was 1.4 m with height of 2.30 m. The customer also wanted a control unit with IR temperature sensor to read the surface temperature of the concrete pipe.

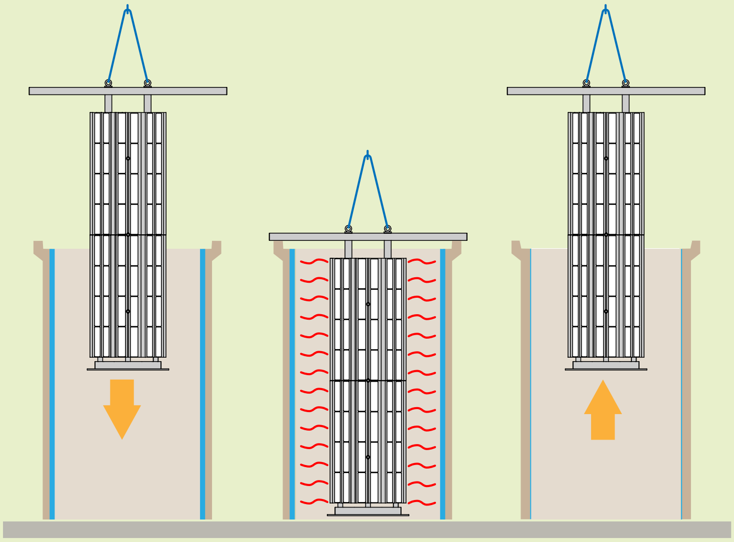
Friedr-Freek and Ceramicx collaborated on the design. The decision was to provide the customer with an overall octagonal shape in stainless steel frame, with the ceramic infrared heaters facing out to the heat internal section of the pipe. The system consisted of 3 control zones with feedback from Micro Epsilon pyrometers. During the design the customer came back to us with another inclusion in that they wanted the unit to be able to be lifted into the pipework using a crane hook.

Ceramicx built the infrared heating system from scratch, all the work was done in house from welding, fabricating, ceramic heater manufacturing, terminal block manufacturing, wiring, and building the control panel.

Ceramicx tested the infrared heating system in house to ensure that



the unit was properly calibrated before packing and shipping. Ceramicx also provided the system with an electrical connection via flexible metal conduit and a quick connect plug and play socket. We sent all drawings and operating documentation to the customer too. All of this ensures that Ceramicx doesn't have to do any unnecessary commissioning of the heating system therefore providing another saving to the customer.



Oven Frame	Stainless steel box section
Reflectors	Special aluminised steel
Element Type	FTE white - long wave ceramic infrared element
Controller	KR1 controller
Control Type	Closed loop feedback
Control Feedback	Pyrometer
Total Power	Approx. 40 kW
Oven Size	1.4 x 2.3 m

3.3 Infrared heat in fabrication; material bonding; welding and joining

IR heating sources are ideally suited to the joining of diverse surfaces – via adhesives, welding or other forms of bonding technology.

These applications are particularly noteworthy in the world's automotive and construction industries.

The automotive sector also continues to supply considerable demand for the heat shrink manufacture of harnesses; plastic-coated cable and wiring products.

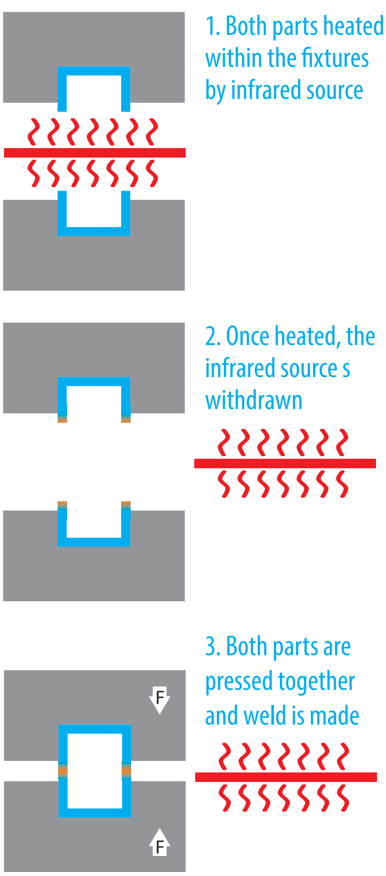
In this application insulating polymers are extruded over the central copper conductors. In many cases the process needs heat in order to cure the coating and are sometimes flashed in order to initiate curing.

Infrared heat is highly suitable for this purpose and an even coverage of material is needed in order to ensure a consistent cure. Clamshell type IR heater designs completely surround the target product in this regard.

Pure metal fabrication is the building of structures and products through cutting, bending, shaping and assembling of metal products. The superior heat flux in IR sources, again, can save time and resource in all of these operations.

Infrared heat welding is also included in this category. It is a relatively new process which applies to many polymeric materials and which also results in a high strength sealing solution.

Infrared welding technique is applicable to many polymetric materials



4. After cooling parts released

Infrared heating of billet winder. In this process, HDPE is extruded at the point of wrapping and directly wound onto a metal framed mandrel to create large diameter pipes. A 36kW Fast medium wave modular infrared heater is used to heat the already formed pipe shape to prepare the surface before overlaps thus ensuring a good fusion bond is made with the underlying wrap. On completion of winding, the mandrel is collapsed and retracted allowing the formed barrel or pipe to be removed. These finished forms are then used to fabricate custom parts with high integrity and minimal waste.

IR Heat :
Principles, Definitions and Laws

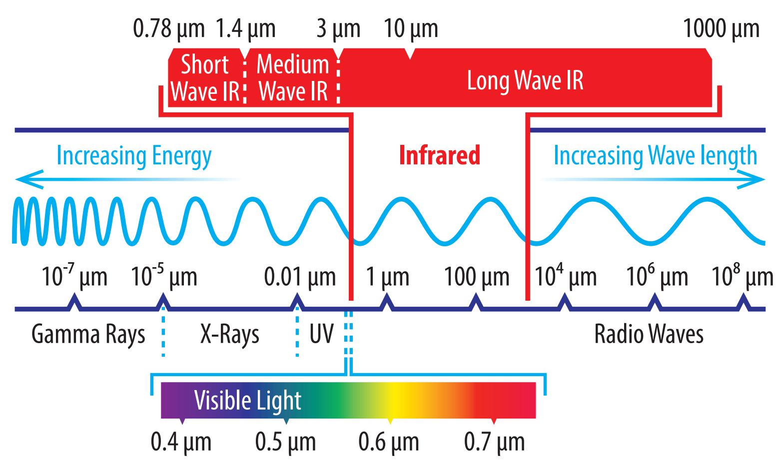
4.1 Terms and definitions

Infrared (IR) heating is an exact and measurable science: It has its own history and terminology and it is also framed and bound by several immutable scientific and physical laws.

This publication describes these main principles and laws and also outlines the main applications for IR heating technology as it practiced today.

At its most basic IR heat is produced through temperature differentials between objects: Any object at a temperature greater than 0 K (-273.15°C) radiates infrared energy. And when one object is hotter than another IR energy will flow from the hotter object to the colder one. The surface of the receiving object will play a key role in both the emission of the IR energy and in the absorption of the energy emitted.

Visible light lies in the range of 380 - 780 nanometres (nm) or 0.38 - 0.78 microns (µ). Infrared is just 'beyond red' from 780 nm or 0.78 - 1000 µ, 1000 µ = 1mm.



This Infrared heat can be best thought of as a form of energy or radiation; sharing several characteristics of solar radiation and sometimes popularly described as 'sunshine without light'.

In scientific terms IR heat is a form, or wave, of electromagnetic radiation. And for industrial purposes these IR waves are utilized in three main forms of delivery; short (0.78 - 1.4 µm) , medium (1.4 - 3 µm) and long wave (3 - 1000 µm).

The physics of IR energy are similar to light – another solar property. However, most of the IR spectrum lies beyond that which is visible to the human eye.

In qualitative terms, Infrared-based heating is beneficial to the human body and to animal life. Low-wattage based ceramic IR heaters have no air born pollutants such as smell, paint and dust.

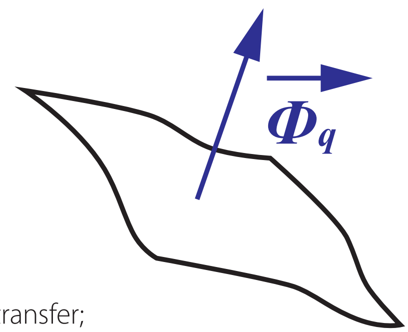
Some forms of IR heat can penetrate over 3cm beneath human skin. Healthcare industries are currently developing embedded ceramic IR heat systems in clothing in order to promote cell repair and therapeutic recovery.

4.2 The key principles of heating and heat transfer – non-IR based

Heat is a form of energy and is most typically measured in **Joules** (***J***).

Heating power is measured in **Watts** (***W***) and is defined as one joule per second.

Heat Flux (Φq)is then defined as heating power per unit area and is measured in units - either **W/m2** or **W/cm2.**



There are three principle methods of heat transfer;

conduction, convection and **radiation.**

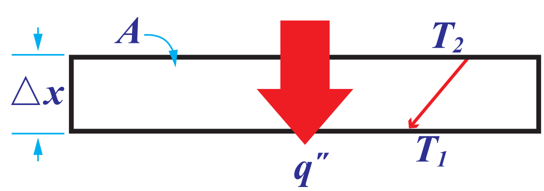
The first two of these require a medium such as gas, liquid or air.

Conductive heat transfer generally requires contact between two physical bodies/properties – metals, for example, having high thermal conductivity and gases having low.

Thermal conductivity (Watts/m.°C) Cross sectional area (m²)

$$q'' = -k \frac{A}{\triangle x} (T_2 - T_1)$$

Heat transfer rate (Watts) Thickness (m) Temperature difference (°C)



The symbol ***k*** is a measure of how well various substances transmit heat. The amount of heat that can be transferred depends also on temperature differentials, surface areas, material conductivities and thickness.

Convective heat transfer operates on the expansive movement of gases and liquids; such as the heating of air via household radiators, or fan-based systems in car engines.

Heat transfer coefficient (Watts/m².°C)   Fluid contact area (m²)

$$q'' = hA(T_2 - T_1)$$

Heat transfer rate (Watts)   Temperature difference (°C)

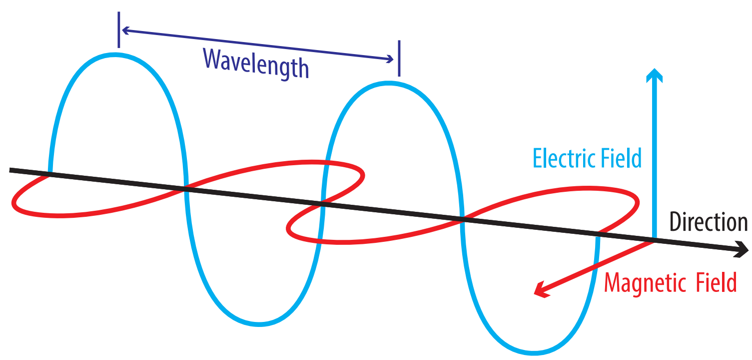
Convectional heat depends upon the management of surface area for its efficient operation and delivery which is why almost all convectional devices have fins for this purpose.

Infrared radiant heat is non-contact and requires no medium for heat transfer.

See the next page for the key principles of IR heating.

4.3 The key principles of IR heating and heat transfer

As already stated, Infrared radiation is an electromagnetic wave which does not require a medium for heat transfer.



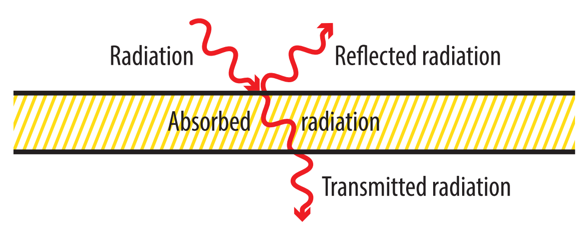
The radiation of shorter IR wavelengths is more energetic and contains more thermal energy.

Radiative heat transfer occurs when the emitted radiation strikes another body and is absorbed.

Reflectivity   Transmissivity

$$1 = \rho + \alpha + \tau$$

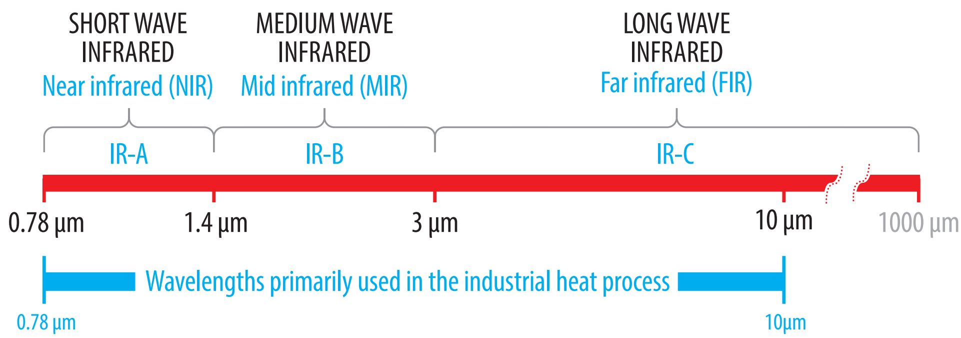
Absorptivity



For example, where radiation strikes an object that is 40% reflective (ρ) and 30% transparent (τ) the absorption factor (α) must be 30%.

All infrared emissions are either reflected, absorbed or transmitted. There is a simple and arithmetic relationship between these three factors which totals one – or 100%. This totality is termed a black body; an idealised physical entity that absorbs all electromagnetic radiation.

The IR radiation spectrum is generally characterised by three classes of wave form; each with their own physical characteristics (see table below).



"Efficiency is achieved by matching the wavelength of the infrared heater to the absorption characteristics of the material"

In theory, IR radiation can emit in all directions. IR heat emitters therefore need to designed and made in order to follow 'line of sight' or view factor principles. View factor (Vf) principles are calibrated from 0 to 1. The use of reflectors can optimise the direction and amount of radiation hitting the target body – the nearer to 1 the better.

Ceramicx Infrared Heaters are used from everything such as paint curing, shrink wrapping, thermo and vacuum forming of plastics to the heating of satellites in space and a variety of other applications in multiple industries both high and low tech. You can find examples of some of the most common applications below.

Plastics	Short wave	Medium wave	Long wave
PVC Paste Curing		■	■
ABS Forming		■	■
Polystyrene Forming		■	■
Polyethylene Forming		■	■
Polypropylene Forming		■	■
Car Bodies		■	
Prelacquering	■		
Powder Paint	■		
PVC Shrinking		■	■

Textiles	Short wave	Medium wave	Long wave
Latex Backing Carpet			■
PVC Backing Carpet			■

Food	Short wave	Medium wave	Long wave
Pasteurisation / Sterilisation	■		
Thermal Stabilisation	■		
Roasting		■	■

Paint	Short wave	Medium wave	Long wave
Paint Drying Steel Panels - Acrylic		■	■
Paint Drying Steel Panels - Alkyd		■	■
Paint Drying Steel Panels - Epoxy		■	■
Epoxy Lacquer	■	■	

Adhesives	Short wave	Medium wave	Long wave
Water Based	■	■	
End Polymerisation	■		
Paper Labels			■
Glue Coating on Paper			■

Printing	Short wave	Medium wave	Long wave
Screen Printed T-Shirts		■	■
Heat Setting Transfers			■
Plastic Instrument Dials			■
Aluminium Fascia Panels		■	

CCII 00034 Performance of an FTE 650W with and without a reflector,

Introduction

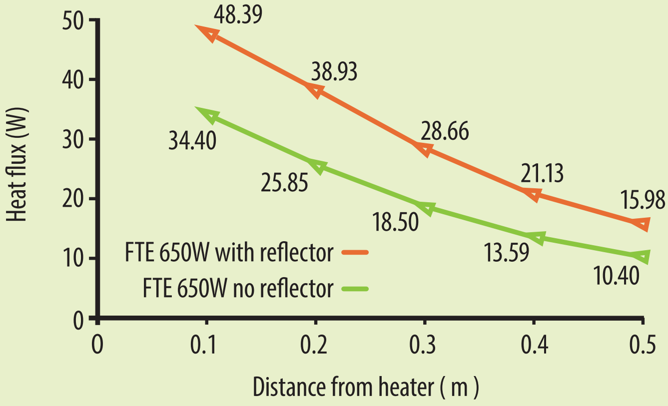
this report measures the effect of a reflector placed at the rear of the elements on the emitted infrared output.

Method

An FTE 650W element was placed in the Herschel and analysed using the 3D Infrared heat flux mapping routine. In this automated system, an infra-red sensor is robotically guided around a pre-determined coordinate grid system in front of the heater element under test.

Results

To start with, the standard FTE 650W with a standard aluminised steel RAS1 reflector was measured in the Herschel. At a distance of 100mm, the Herschel heat flux sensor measures 48.4% of the 650W input, next the reflector was removed from the rear and the test repeated. The measuredpercentage of radiation detected reduced from 48.4% to 34.4% as shown in the graph. This is a drop of around 29% of the radiated heat output with a reflector, the peak heat flux also reduced sharply from 0.69 W/cm2 to 0.37 W/cm2



Comparison graph showing the percentage of heat returned with and without a reflector at set points between 0.1 and 0.5 m from the face of the emmiter .

Note due to the method of orienting the sensor, the percentage of radiation detected from the heaters as quoted here is actually lower than their true efficiency. However, as a back to back comparison, the tests are valid.

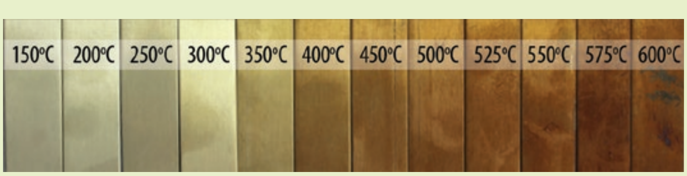
CCII 0013 Aluminised and Stainless Steel Discolouration

Introduction

This report presents two investigations measuring discolouration on the steels used for making reflectors and quartz cassettes, aluminised steel and stainless steel. It shows results of furnace tests on stainless steel samples and also includes supporting material from a previous investigation into aluminium clad steel.

Results and Discussion

Aluminised and stainless steel can suffer from discolouration and subsequent increase in emissivity with a decrease in reflective properties. In a stainless steel quartz heater, this discolouration can begin early in the product lifetime. In this trial, twelve samples of stainless steel were placed in an electric thermostatically controlled kiln and allowed to soak for 30 minutes at temperatures ranging from 150°C to 600°C. Images of the samples after heating are shown here.



Below temperatures of 350°C the stainless steels samples retain their shiny and mostly silvery hue. Some light browning is apparent as temperatures increase to 350°C after which the surface begins to darken noticeably.

Comparion of aluminised steels and galvalum/aluzinc coated steels.

This study was performed to clarify the heat resistance of an aluminised steel to high operating temperatures, and the subsequent blackening or de-lamination of the body. In order to assess Galvalum/Aluzinc material, samples were taken from US and Global suppliers and tested against the Aluminised steel currently used by Ceramicx.

The first 3 samples above show how the materials behaved at 500°C. The Aluzinc sample (a) deteriorated totally. The Galvalum sample (b) is beginning to show enlarged grain growth at this temperature. The Ceramicx aluminised steel (c) remains clear and unaffected by the temperature. The next 2 samples show how the Galvalum material (d) deteriorated after reaching 550 °C (1 hour soak) in the test kiln. By contrast the Ceramicx aluminised steel (d) is still in good condition.

Summary

Stainless steel progressively changes colour with temperature due to oxides forming on its surface. Darkening and colour change becomes significant above 350°C. The Aluminised steel as currently used by Ceramicx resists degradation up to a temperature of 630°C Galvalum and Aluzinc type coatings degrade at much lower temperatures and consequently are not used by Ceramicx.

The choice between stainless steel or aluminised steel is often down to operating environment, especially if corrosion is a concern. Contact Ceramicx where we will be happy to advise.

4.4 The fundamental laws of IR heating

As IR heating has evolved, so has the fundamental science that underpins the workings of its heat transfer.

Three main laws apply:

Stefan-Boltzmann law gives the total power radiated at a specific temperature from an IR source.

Planck's law gives the spectral distribution of radiation from a black body source – one that emits 100% radiation at a specific temperature.

Wien's law is a follow on from Planck's law and predicts the wavelength at which the spectral distribution of the radiation emitted by a black body is at a maximum point.

The Steffan Boltzmann law relates primarily to infrared emissivity – calculating the power radiation from an IR source based upon the object's surface area, temperature together with a black body factor. A perfect black body has a factor of 1; other materials (please see table below) vary in that factor; Aluminium foil, for example is set at 0.04 and concrete at 0.85.

$$P = \varepsilon \sigma A T^4$$

Power (Watts)
Surface area of emitter(m^2)
Absolute temperature (K)
Emissivity ($\varepsilon = 1$ for a perfect black body)
Stefan-Boltzmann constant 5.67 x 10^{-8} Watts/m^2.K^4

Back body (matt)	1.00	Aluminium foil	0.04
Brass plate dull	0.22	Brass plate polished	0.03

Stefan-Boltzmann law – emissivity explained

Within the definition of Kirchhoff's law, for an arbitrary body emitting and absorbing thermal radiation in thermodynamic equilibrium, the emissivity is equal to the absorptivity. This means that emissivity is useful to determine how much a surface will absorb as well as emit.

Planck's Law describes the electromagnetic radiation emitted by a black body in thermal equilibrium at a definite temperature. It is named after Max Planck a German physicist who proposed it in 1900."

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5} \frac{1}{exp\left[\left(\frac{hc}{\lambda k_B T}\right)-1\right]}$$

spectral emissive power
the speed of light in the medium
absolute temperature
Plank's constant
Boltzmann's constant

CCII 00065 Explanatory notes on Planck's Law

Planck's Law tells us that as the temperature of any emitting surface increases, more and more energy will be released as Infrared energy. The higher the object temperature, the greater the amount of infrared energy will be produced. As well as becoming more intense (Power) the emitted frequencies become wider and the peak wavelength becomes shorter.

At very high temperatures not just infrared, but some shorter wavelength visible light will also be produced. This is first witnessed as a dull red glow, then to orange, yellow and finally white. Figure 1 shows typical Planck curves for a range of temperatures that have been plotted from 1050°C to 50°C.

Planck distribution, emissive power and wavelength with temperature

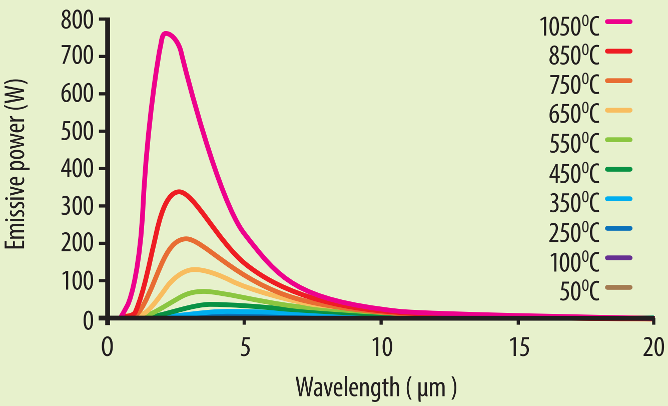


Figure 1 : Infrared distribution for various emitter temperatures from 1050°C to 50°C.

The red curve corresponding to 1050°C exhibits the strongest output. It shows the highest power output and its peak is at around 2.5 microns. This is followed by the curve at 850°C where the peak energy is less than half of that produced at 1150°C. As the temperature decreases, the energy levels also drop, and the peak energy wavelength shifts to the longer wavelengths. The lowest temperatures from the 250°C, 100°C and 50°C curves cannot be seen in the graph.

When the graph is enlarged to see the lower temperature curves, this shift to the longer wavelengths is more apparent. However the power intensity drops significantly.

Planck distribution, emissive power and wavelength with temperature

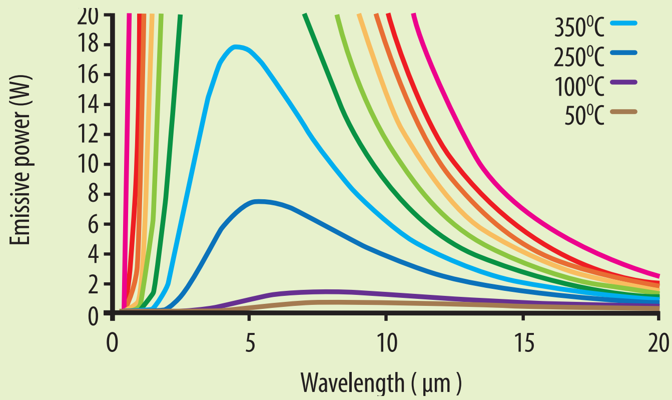


Figure 2: Close up of Infrared distribution for various emitter temperatures from 350°C to 50°C

This is shown in Figure 2. At 250°C the blue curve can be seen to have an approximate peak around 6 microns, whereas at 100°C the peak wavelength is around 7.5 microns. Note also that the extent of wavelength is more evenly distributed and doesn't exhibit the concentrated narrow peak seen at higher temperatures.

Planck distribution, emissive power and wavelength with temperature

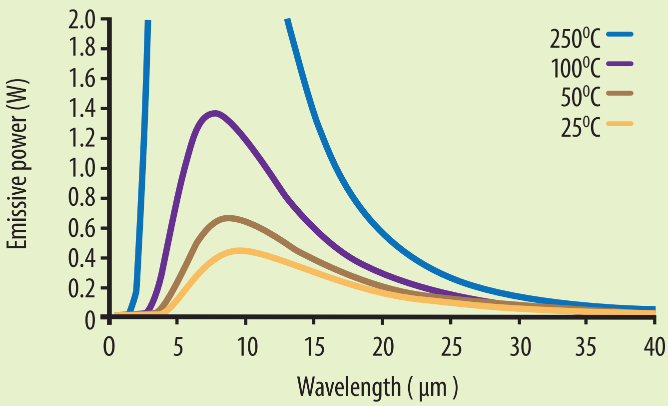


Figure 2: Close up of Infrared distribution for various emitter temperatures from 100°C to 25°C

If we enlarge the same graph again and focus only on the lower temperatures as shown in Figure 3 we see that temperatures of 50°C and 25°C have peak wavelengths of around 9 and10 microns respectively.

Summary

Planck's Law describes the electromagnetic radiation emitted by a black body in thermal equilibrium at a definite temperature. When plotted for various heater (emitter) temperatures, the law predicts

1. The range of frequencies across which infrared heating energy will be produced

2. The emissive power for a given wavelength

When selecting an infrared emitter for a particular heating task, the target material absorption characteristics are of high importance. Ideally,the emitted infrared frequencies and the target material absorption frequencies should match to allow the most efficient heat transfer. However as can be seen from the previous graphs, at longer wavelengths, the amount of energy transferred will be lower due to the lower emitter temperatures, therefore heating times will usually take longer.

The shorter the wavelength, the higher the emitter temperature and the available infrared power increases rapidly.

Wien's law is a follow on from Planck's law and predicts the wavelength at which the spectral distribution of the radiation emitted by a black body is at a maximum point.

$$\lambda_{max} = \frac{b}{T}$$

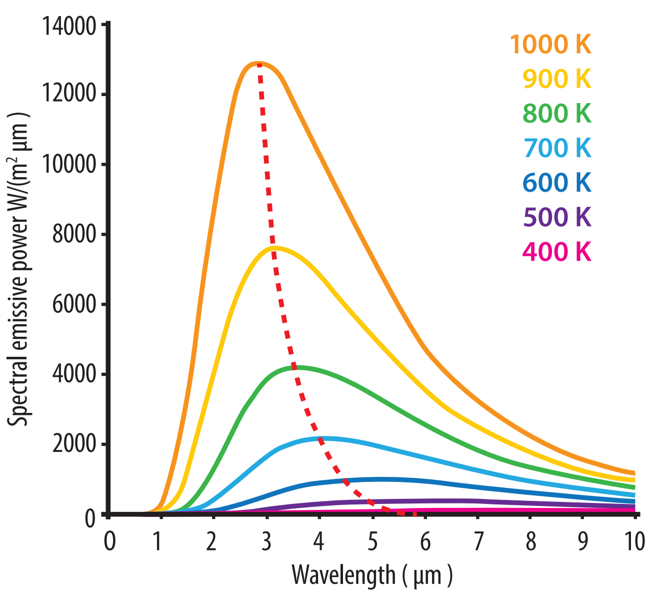
Wiens displacement constant 2898 µm. K

peak wavelength in µm

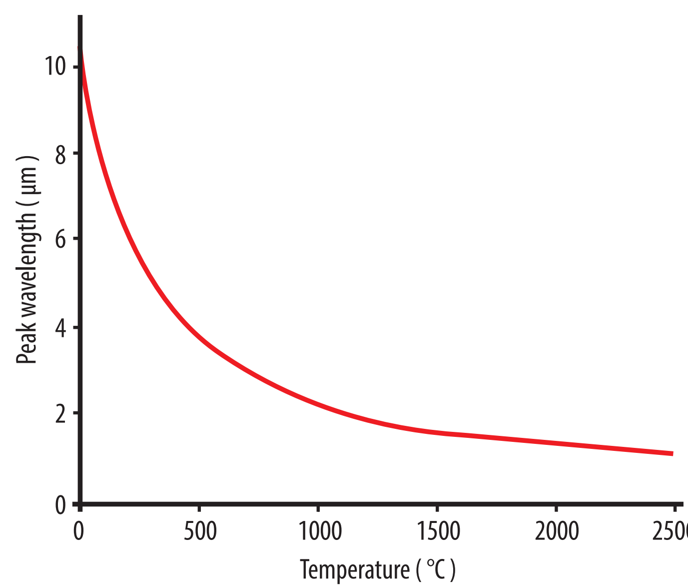
temperature in Kelvin

Notice the dotted red line formed when we connect the maximum points of each temperature curve on Planck's distribution and connect them.

Black body spectrum



Source temperature versus peak emission wavelength

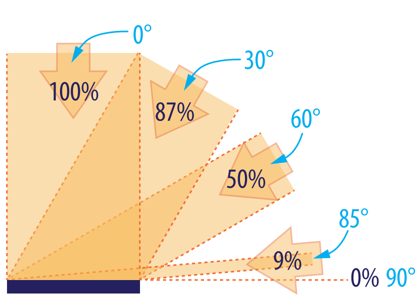


Two other scientific laws inform the practical application of IR radiant heat; the **Inverse Square Law** and **Lambert's Cosine Law**.

The former defines the relationship between radiant energy between a IR source and its object – that the intensity per unit area varies in inverse proportion to the square of that distance. However, and in practice, the inverse square law is less effective when concerned with large parallel surfaces, such as heated platens and oven systems.

Lambert's Cosine Law allows for the calculation of IR intensity when the radiation is not applied directly to the target body but is set at an angle. The law applies mainly to small sources radiating over a relatively large distance.

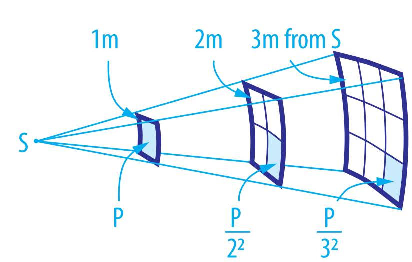
Lambert's cosine law



$$E_\theta = E \cos \theta$$

Angle of incidence

Inverse square law



$$E \propto \frac{1}{d^2}$$

Irradiance

Distance

5.1 Control overview

Ceramicx provide customised control solutions to suit specific heating applications. These solutions can vary in size from simple single zone open loop systems to large complex multi-zone installations with temperature feedback and closed loop control.

The objective in most process heating applications is to match the installed heating load to the process heat requirement in so far as possible. Usually, the power requirement is over estimated to ensure there is always adequate capacity to allow for process variations and in some cases to provide a fast thermal response. For this reason, control can be critical. The ability to control heat energy output as required allows the heating process to be optimised. With all radiant heat transfer applications there is a limit to the amount of energy which can be directed at the target over a specific period of time. Modern manufacturing requires short process times with minimal energy usage. Applying excess heat introduces the risk of surface scorch making it critical that the heater output can be tuned to provide both process speed and high quality results.

Heating control solutions can be categorised as follows

- Individual zone controllers
- Centralized PLC based control
- Open/closed loop

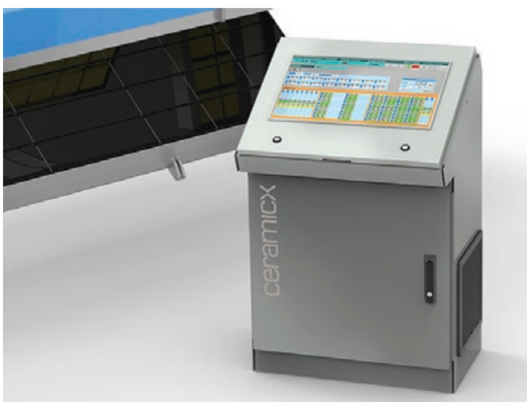
Individual zone controllers

Individual zone controllers are generally suited to smaller less complex systems with a typical zone count of 15 or less. It involves using individual PID temperature controllers for each temperature control zone required. Each controller is individually configured and used to provide a control signal to a solid state relay or similar power switching device. Solid state relays (commonly known as SSR's) are solid state switching devices which normally use back to back thyristors/SCR's or triacs for switching AC loads. Ceramicx normally employ zero cross SSR's which means the device will only switch on and off at the zero point in the sine wave of the AC supply which minimises the initial surge current and helps prevent electromagnetic interference (EMI). Another advantage of SSR's over conventional mechanical relays is that they can perform millions of switching operations with excellent reliability when specified and utilised correctly.

Centralised PLC based control

One of the disadvantages with individual zone controllers is that each controller has to be individually configured. Although each controller is configured before leaving the factory, parameters such as set point (the desired temperature value) or % power (required zone output on a % time basis) will need to be set by the customer. For a low zone count this is not an issue but for larger systems (potentially containing hundreds of zones) this is not a practical solution where process conditions and/or requirements are frequently subject to change. In this case, PLC's (programmable logic controllers) provide the best solution. Ceramicx use Siemens S7 series controllers as the standard control platform for larger multi-zone projects (AB on request). A single human machine interface (HMI) allows the operator to fully interact with the PLC which can be programmed to read all process

values (temperatures), set process values, configure alarm thresholds and operator access levels. The PLC can be used to directly switch SSR's similar to individual zone controllers and also facilitates the integration of multi-channel power switching hardware. These systems use the same switching technology as SSR's except installed in cards with multiple outputs which can in turn be mounted in racks. The total package can be networked to the PLC and offers a considerable space saving inside the electrical enclosure, a reduction in wiring time, increased functionality and load diagnostics. Systems incorporating PLC's can also be programmed to exchange digital IO with existing equipment or network directly to plant SCADA software.



Open/closed loop

Individual zone controllers and PLC based systems can be programmed to operate in both open and closed loop mode. Open loop mode is the simplest form of control and involves basic power control of the heating load without temperature feedback. Ceramicx normally uses time proportional control where the heating load is burst fired i.e. turned fully on for a period followed by an off period. For example, a setting of 50% with a 2 second cycle time results in 1 second on and 1 second off. Closed loop control involves temperature control of either the heating system or the target object. Where closed loop control of the heating system is employed, a type K thermocouple is normally incorporated into the heating element. This provides temperature feedback to the controller which will then employ PID (proportional-integrative-derivative) control in order to operate the heater at the set value. Closed loop control of the process is also possible and normally implemented through the use of non-contact infrared thermometers (pyrometers) which can be used to directly measure product temperature.

Ceramicx design and build the control enclosure which includes the required control hardware for the control solution selected. Most low voltage supply networks can be catered for. Both heating and control systems are fully tested before leaving the factory to help ensure seamless integration when installed in the customer's factory. Where closed loop control from the heater system is employed, Ceramicx ensure the PID functionality is tuned to provide close tolerance temperature control. The provision of "quick connect" plugs/sockets on the heating and control system where possible allow for a short installation time with minimal requirement for skilled electrical personnel.

5.2 Temperature Measurement

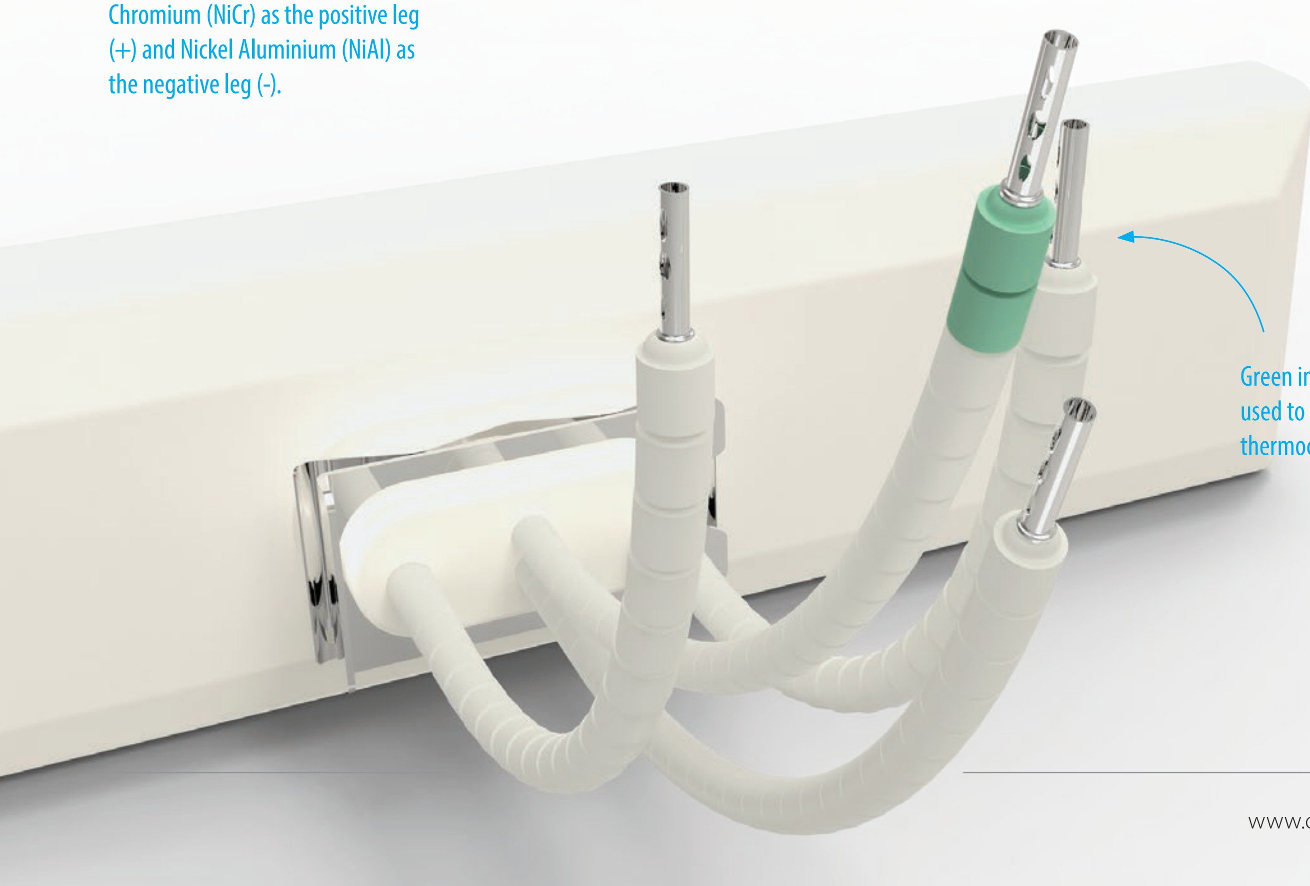
Ceramicx generally use two primary means of temperature measurement, contact measurement and non-contact measurement.

Contact measurement using thermocouples

A thermocouple is a simple temperature sensor consisting of two dissimilar metals joined at one end to form a 'junction'. A voltage is generated in the thermocouple which is proportional to the temperature at the junction based on the Seebeck effect. The ends or legs of the thermocouple (+ and -) are then connected to a controller or measurement device capable of converting the low level mV signal generated by the thermocouple to a temperature value. Thermocouples are available with different combinations of metals depending on the temperature range required. Type K thermocouples can be used for continuous temperature measurement in the 0 to 1100°C range making them ideal for ceramic and quartz cassette emitters. Nickel Chromium (Chromel) is used as the positive leg and Nickel Aluminium (Alumel) as the negative leg. Since the type K is also widely used, the vast majority of PID temperature controllers available on the market can accept an input from a type K thermocouple.

Thermocouples installed in ceramic or quartz emitters give an indication of the operating temperature of the emitter itself at a point close to the resistance heating coil. The thermocouple measures temperature at the hot junction only and will therefore measure a higher temperature when placed closer to the coil. When connected to a suitable PID controller it allows closed loop control of the emitter temperature which in turn allows the radiant output to be optimised. Some applications require that the temperature of the target object or material to be heated is fed back to the controller for closed loop control. Thermocouples can also be used in this case but have the drawback that both the thermocouple itself and the extension cable attached to it can interfere with the process making such a solution difficult to implement in some applications. In these cases, non-contact temperature measurement is the preferred option.

Ceramicx use type K thermocouples as standard. Type K uses Nickel-Chromium (NiCr) as the positive leg (+) and Nickel Aluminium (NiAl) as the negative leg (-).



Green insulated beads are used to distinguish the type K thermocouples positive leg (+) .

The Ceramicx Cerix Thermocouple– responsiveness and accuracy

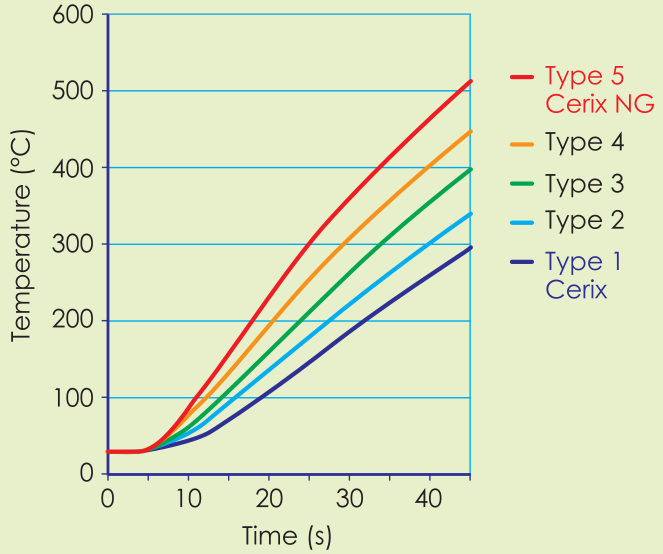
Wherever possible Ceramicx designs and introduces better IR heating products to the market place – raising performance and eliminating typical deficiencies. The area of IR energy measurement is no exception.

In creating the company's Next Generation (NG) Cerix thermocouple Ceramicx looked at a variety of possible innovations and designs.

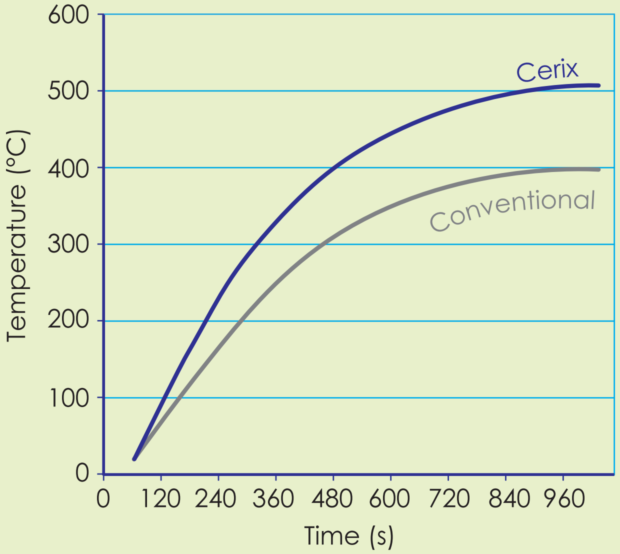
Ceramicx engineers reviewed and considered a number of factors in the design and manufacture of the Cerix NG, including placement in element; thermal and kiln firing effects; thermocouple signal outputs; issues of electrical noise; terminations and connections; thermocouples and heat flux outputs.

responds almost 4 times faster than a conventional triple wound and welded thermocouple. With the placement of the thermocouple in the rib, and with the improved design and response, the new Ceramicx thermocouple will perform to the highest levels in terms of accuracy, response speed and longevity.

The Cerix NG thermocouple readily integrates with all production and control systems.



Lab test comparing original type Cerix (blue) with other thermocouple designs including the current Cerix NG (red)



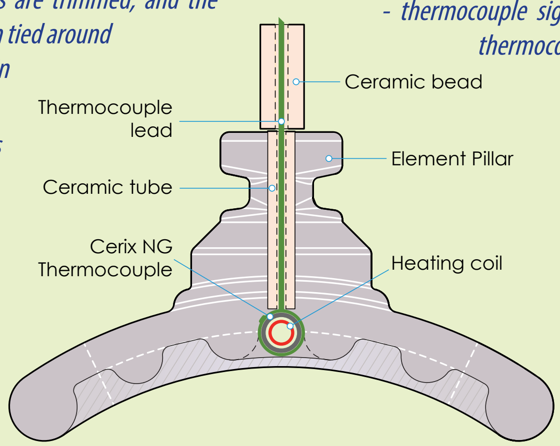
Original Cerix response verses conventional thermocouple

Ceramicx eventually worked with the successes of its previous thermocouple design, where two strands of triple wound thermocouple wire are spot-welded on top of each other to form the thermocouple junction. After the spot weld is made, two excess strands are trimmed, and the remaining single strands of each leg are then tied around a quartz glass tube to fix the thermocouple in relation to the heating coil.

In the final Cerix NG, the thermocouple leads make contact with the quartz tube via the twin tube and are then passed around the back of the tube where the welded junction is placed. The two remaining ends are then wrapped around and tied.

The result is a thermocouple that

A Ceramicx White Paper on this topic is available to Ceramicx website visitors. The paper includes topics such as: thermocouple design – placement in element; wire quality; degradation and lifetime service - thermocouple signal output - electrical noise and leakage - thermocouple and heat flux outputs.

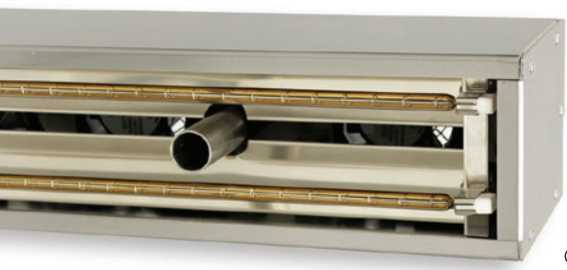


Non-contact temperature measurement is achieved using one of the following devices:

- Infrared thermometers (pyrometers)
- Thermal imaging cameras

For all non-contact temperature measurement surface emissivity must be known or approximated to receive accurate readings. The emissivity relates to how much energy a surface emits, and in turn how much radiant energy is received by the measuring device.

Special Fast IR with pyrometer. Quartz Tungsten tubes with integeral gold reflector 3,000W, 400V,



Infrared thermometers or pyrometers are non-contact temperature measurement devices which also measure emitted infrared radiation on a defined spot (spot size dependant on optical characteristics of the sensor). Unlike thermal imagers, pyrometers generate an analogue electrical signal (typically 4-20mA or 0-10V) which varies in proportion to the measured temperature again a knowledge of the material emissivity is required. Pyrometers can provide temperature feedback to compatible temperature controllers/monitors or to a PLC (Programmable Logic Controller) via an analogue input module. The pyrometer consists of a detector or sensor head and a controller which converts the measured signal. Because sensor heads can be much smaller than thermal imaging cameras and can have a much higher temperature rating (up to 250°C), pyrometers are frequently incorporated into Infrared heating applications for either temperature monitoring or control purposes.

Thermal image of FTE ceramic element under test on our semi automated valadation equipment

For non-contact temperature measurement the surface emissivity of the material must be known or approximated to receive accurate readings.

Material	Typical emissivity
Aluminium polished	0.02 - 0.10
Brass polished	0.01 - 0.05
Ceramic	0.95
Chrome	0.02 - 0.20
Concerete	0.95
Copper polished	0.30
Glass	0.85
Gold	0.01 - 0.10
Plastic solid	0.95
Rubber	0.95
Silver	0.02
Steel polished	0.1
Textiles	0.95
Water	0.93

Thermal imaging or thermographic cameras measure the infrared radiation emitted from an object and converts the measured data to a thermal image showing the temperature variation across the surface of the object in real time. These cameras are normally available with a software application which allows a detailed analysis of the measured data and can, with additional hardware, also be used to trigger events/alarms on test lines as part of a quality control process.

Thermal imaging camera showing data and thermal image of a long wave ceramic oven under test

6.2 Putting it all together

"A comparison of the use of convectional heating and infrared heating in out of autoclave curing of carbon fibre composites"

In conjunction with Comeragh Composites, Ceramicx conducted a study which systematically investigated the comparisons between a traditional convection oven and a novel infrared (IR) heating set-up when applied to the curing of an out of autoclave (OOA) carbon fibre / epoxy laminate.

Introduction

The need to move away from the widely documented drawbacks of the use of autoclaves for composite resin curing has seen an increased focus on OOA methods and materials, particularly within the aerospace sector in recent years. To date, the majority of OOA resin systems utilise some form of convection oven for curing and achieving the required material properties. IR curing has shown the ability to rapidly and accurately heat a wide range of materials, using the energy to directly heat a targeted part and limiting energy inefficiencies. Although IR curing will require some work initially to set-up the parameters of the process, it has been hypothesised that this is no different from accurate control of convectional curing.

Cure set-up

Two aerospace grade carbon fibre panels were cured for this study, one using IR heating and one with a convection oven. The set-up used to cure the IR samples utilised a combination of hollow ceramic elements and quartz halogen tubes to ensure optimal temperature equalisation through the carbon fibre sample. The quartz halogen tubes heated the top surface of the laminate, while the hollow ceramic elements heated from the bottom. The convective sample was cured in a small convection oven at Ulster University.

IR curing demonstrated an ability to accurately control the surface and internal temperatures of an OOA aerospace grade carbon fibre / epoxy laminate. It has been shown that curing using a convection oven is not a fit and forget method with programmed heating rates not being representative of the heating rate that the part experiences. IR's ability to respond rapidly to temperature variation ensures a greatly enhanced ability to match part temperature to intended temperature.

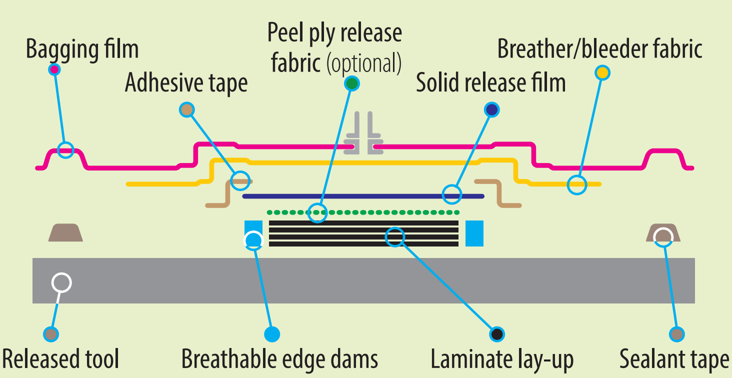
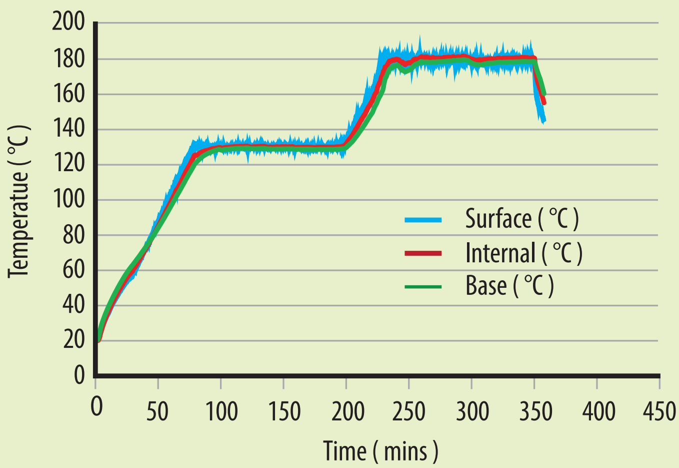


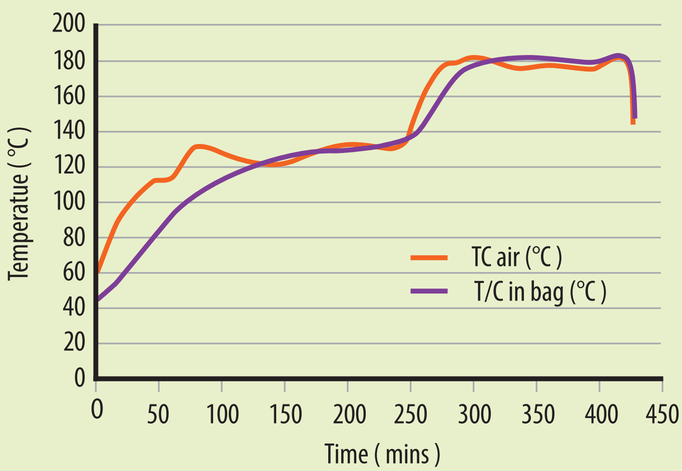
Figure 2.2 – The edge breathing set-up as recommended by Cytec

IR CURE

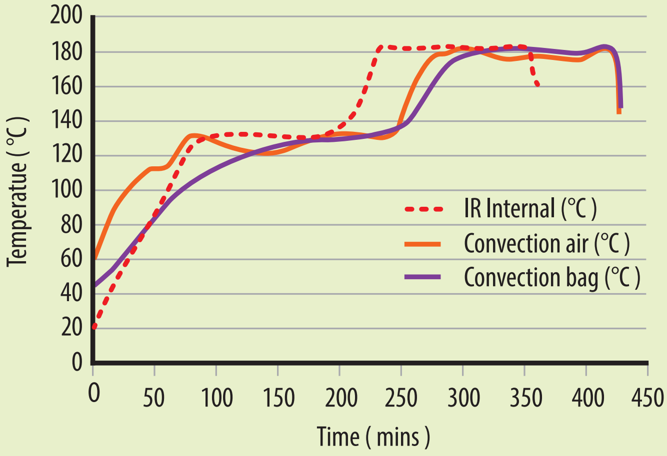


The temperatures recorded within the IR cured panel adhered very well to the intended cure schedule

CONVECTIVE CURE

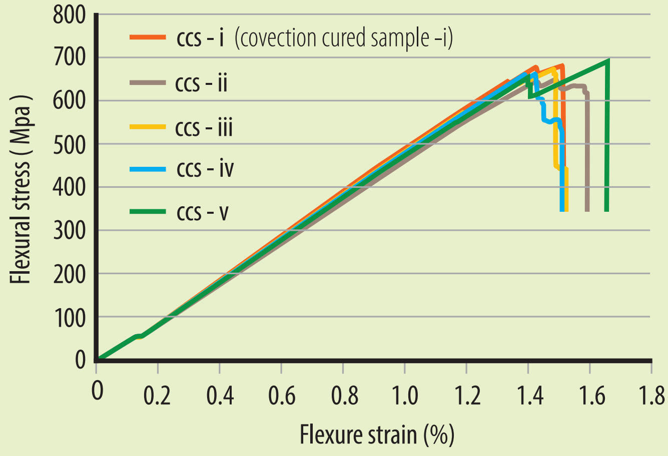


IR CURE V's CONVECTIVE CURE OVERLAY



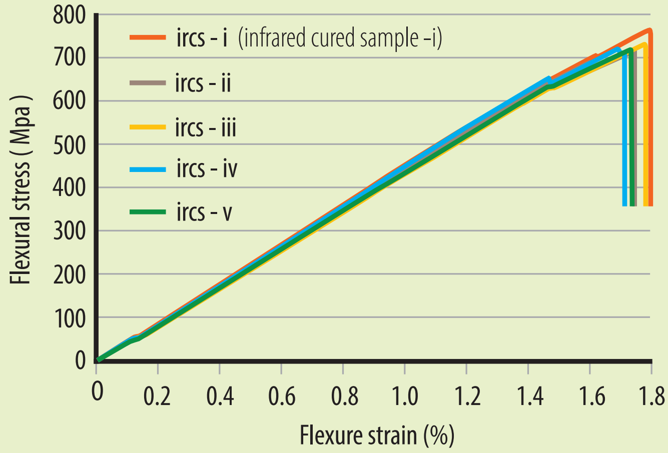
Approximate overlaying temperatures between the IR cure (Red) and Convection (Purple & Orange) shows that the convection cure lasted approximately 70 minutes longer than the IR

FLEXURAL TEST OF CONVECTION CURED SAMPLES



The Stress – Strain curve for Convective – cured samples tested under 3PB conditions

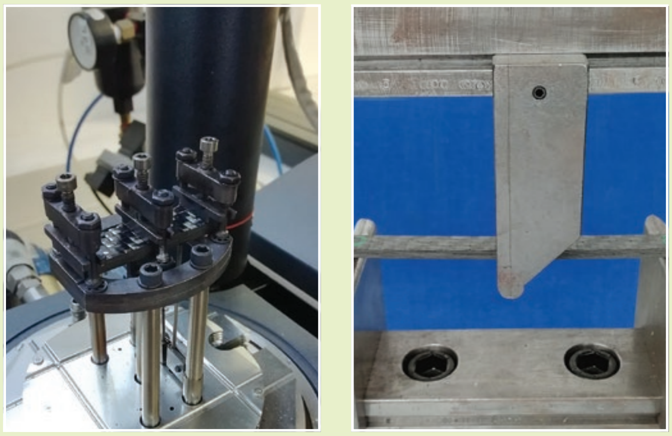
FLEXURAL TEST OF INFRARED CURED SAMPLES



The Stress – Strain curve for Infrared – cured samples tested under 3PB conditions.

Mechanical testing

The post cure composites were tested to compare the physical properties of each piece. As the epoxy resin undergoes cross-linking during curing, the scope would seek to analyse resin based properties as opposed to fibre based properties of the composite. Therefore, Dynamic Mechanical Analysis (DMA) and Flexural Testing were implemented.



(left) The TA Instruments Dynamic Mechanical Analysis (DMA) Q800 testing apparatus with a composite sample loaded in dual cantilever condition. (right) 3PB testing of composite specimen.

Following the tests, it was found that there was a small decrease in the glass transition temperature (Tg) of the IR samples compared to convective samples, and an increase in its flexural strength. These differences are likely due to poor temperature control in the convective sample, thus it can be confidently stated that IR can easily rival convective curing with regard to the physical properties of the composite produced.

Conclusion

Our aim with this analysis was to establish baseline comparisons between convective and IR curing methods of a carbon fibre / epoxy resin composite. What we found was that due to the directional properties of IR radiation, we can accurately control the temperature of the composite, resulting in a successful cure cycle, with advantages over the convective counterpart relating to the vibrational qualities that enhanced the process.

Ceramicx intend to continue our investigations into enhancing cured material properties now with select customers in this industry.

Talk to us today about your infrared heating needs.

ceramicx
INFRARED FOR INDUSTRY

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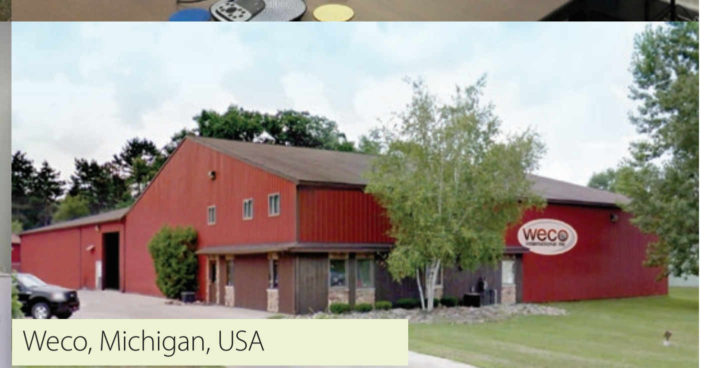

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