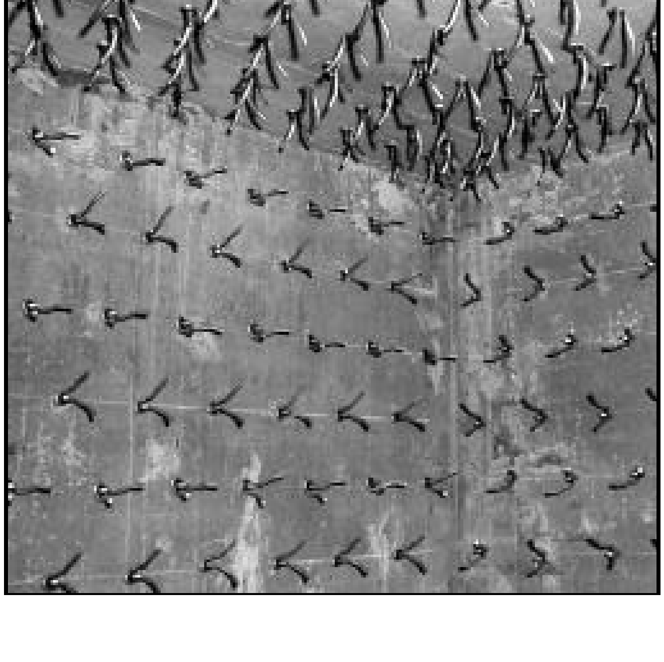
ANCHORING OF MONOLITHIC REFRACTORIES
DESIGN AND INSTALLATION MANUAL



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INTRODUCTION

Over the past 75 years, Thermal Ceramics has proven to be a world leader in solving heat intensive problems.

In addition to manufacturing ceramic fiber, brick and fired shape products, a wide range of refractory monolithic products are available. From lightweight, highly insulating materials to dense, high strength products, Thermal Ceramics has a refractory castable to meet the needs of the customer. All industries are serviced with these products, including ferrous, non-ferrous, chemical, utility and ceramic related markets.

The Thermal Ceramic operation in Augusta, Georgia has been certified to ISO 9002 standards for refractory monolithic production. At this facility, both raw materials and finished products are routinely tested to make sure they meet a demanding quality level.

An experienced staff of refractory specialists is on hand at Thermal Ceramics to assist you in product selection, system design, and installation techniques. This Design and Installation Manual is intended to give the designers, installers and users of Thermal Ceramics monolithic products a broad range of information guidelines on the particular topic. Any questions or comments regarding this manual should be addressed to your local Thermal Ceramics representative.

1. GENERAL

With the design of high performance furnaces and vessels containing complete linings of monolithics, anchoring the refractory to the vessel structure is an integral part of any successful installation. The anchors that can now be specified for a project are an immense improvement over early designs and provide an installer with a wide variety of choices depending on the prevailing service conditions. The following information gives a broad overview of this subject, but since all projects are different, the information presented is only a guide. For specific information, contact your Thermal Ceramics representative.

2. ANCHOR TYPES

2.1 Wire Anchors

Wire anchors can be fabricated in a multitude of different sizes and shapes as shown below. They can be specified in various grades of stainless steel depending on the atmosphere and temperature they are expected to face.

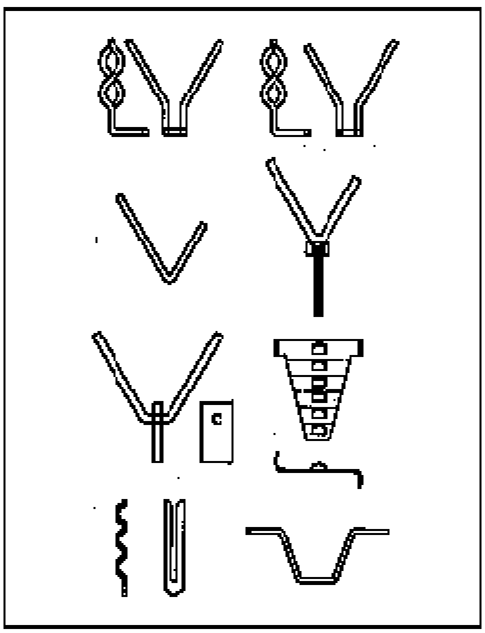

Figure 1 - Assorted Wire Anchors

Wire anchors are the most common anchoring devices used due to their low cost and easy installation. They are used in most applications where service (lining) temperatures do not exceed 2000°F. Various grades of stainless steels are used for wire anchors because carbon steel is not suitable for high temperatures. The choice of metal depends on the actual temperature the anchor will face as shown in Table 1.

The maximum temperature can be used only as a guide. As the lining temperature approaches the anchor's maximum temperature, the anchor will begin to suffer plastic deformation. This may cause problems especially where there are high loads to support. In this case, an anchor of higher service temperature should be specified or the anchors should be solution annealed.

Maximum Temperature of Metallic Components (°F)	Type of Steel Required
500	Carbon Steel
1500	304 SS
1500	316 SS
1600	309 SS
1700	310 SS
2000	Inconel 601

Table 1 - Maximum Use Temperature of Various Grades of Stainless Steel

In all cases, the anchor or holder should be designed to operate as cool as possible and should be installed in ways which allow heat dissipation by conduction and/or circulation. The temperature that the wire anchor is subjected to controls the rate of oxidation and is a main determinant in its life expectancy. Operating at excessive temperatures can create a carbide precipitation in the metal that will change the original properties of the parent metal, causing rapid oxidation and leading to premature failure.

The furnace atmosphere will also affect the maximum temperature that an anchor can handle. Reducing sulphurous or nitriding environments can severely affect the metallic anchor and care should be taken in the choice of metal alloy for such environments. For instance, the chemistry of 316 SS provides better resistance to sulphur attack than other stainless steel grades.

2.1.1 Wire Anchor Styles

The following are examples of the various styles of anchors that can be supplied for different purposes.

The most common wire anchors are "V" type or steerhorn anchors. They generally have legs with unequal lengths to reduce the chance of shear planes in the lining. Another variation is to twist the legs to give more holding surface area, especially for overhead use.

The anchor in Figure 3 is specially designed for units which will be subjected to mechanical movement during operation, e.g. rotary kilns. The nut is welded to the shell and the anchor only tack welded to the nut. As the lining and anchor are subjected to the stresses of movement, the tack weld will break, allowing the anchor to "float" in the nut, yet remain fixed to the shell.

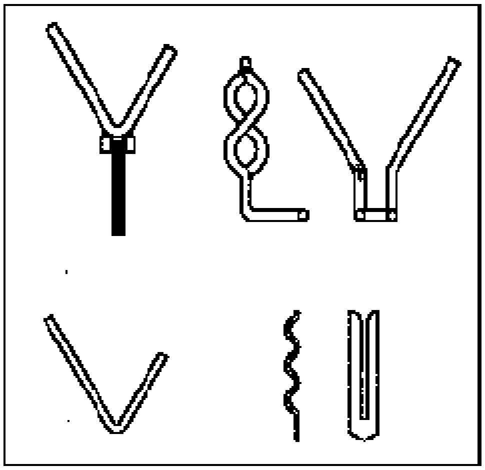

Figure 2 - Various Anchor Styles

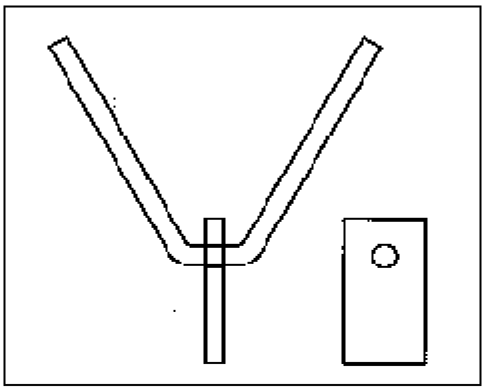

Figure 3 - Rotary kiln Anchor

The anchor shown in Figure 4 is sometimes used in multicomponent linings either gunned or cast. The lengths of the different sections can be altered to suit the different thicknesses of the linings.

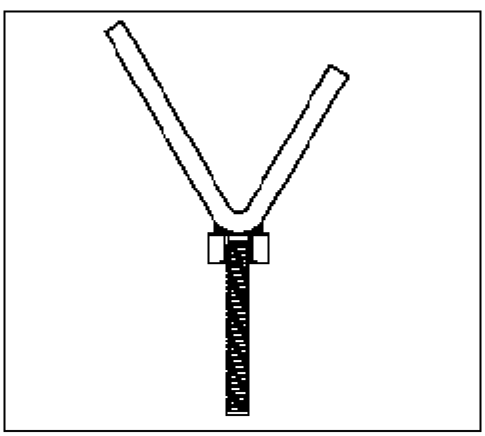

Figure 4 - Multicomponent Anchor

2.1.2 Anchor Length

The length of wire anchors should allow the tips of the anchor to be positioned a minimum of one inch behind the hot face. Generally, this should approximate to three quarters of the lining thickness. Allowance must also be made for the expansion of the wire anchor in the refractory mass. This can be achieved by placing plastic caps over the tips of the anchor or coating the complete anchor

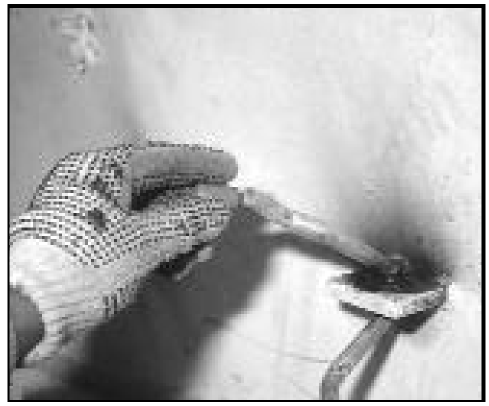

Figure 5 - Anchors with Plastic Caps

with a tar solution (Figure 5). They melt at elevated temperatures allowing the anchor to grow slightly without inducing a stress on the refractory.

2.1.3 Anchor Welding

Wire anchors need at least a ½ inch of weld fillet on both sides; tack welding of anchors to the shell is not sufficient. Some heavy rod anchors may require additional welding. Welding is critical to the performance of the lining. If the welds fail, the anchors will not hold the lining in place and a complete lining collapse could quite easily occur.

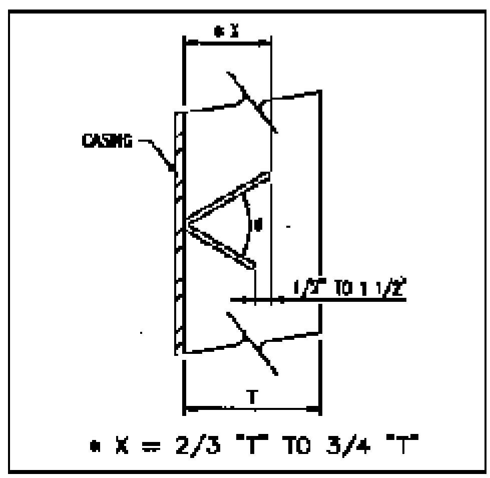

Figure 6 - Lining Thickness Guide

The installer should check approximately one in every 100 anchors by striking with a hammer. If a dull sound is heard or the anchor falls off, then check all anchors for potential failures and replace those that fail. If a ringing sound is heard, a good weld is indicated.

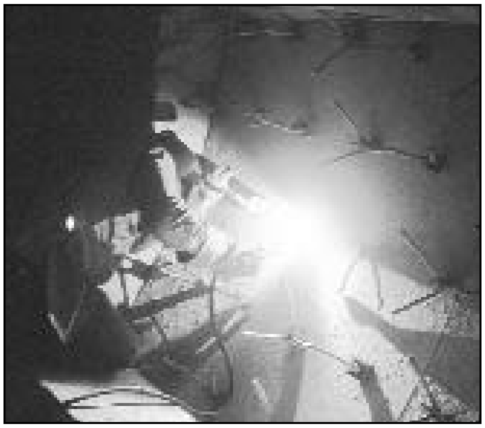

Figure 7 - Stick Welding Anchors

2.2 Ceramic Anchors

For dense monolithic linings with thick cross-sections (greater than 9-10 inches), pre-fired refractory anchors is the preferred method of anchoring the structure. Ceramic anchors have several advantages over other types of anchoring systems. They have more holding power than metal anchors due to their design and greater surface area. They also extend through to the hot face providing extra retention of the lining. Also, being ceramic, they can withstand much greater temperatures and tougher atmospheric conditions than standard wire or metal anchors.

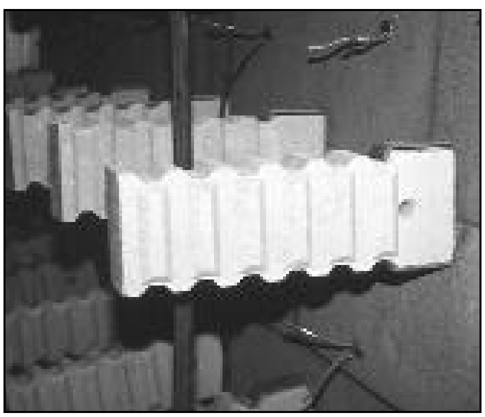

Figure 8 - Ceramic Anchors

Thermal Ceramics makes various lengths of anchor tile including T-9 (9 inch long) and T-13½ (13½ inch long) from the Firebrick 80® composition. The brick shape, with its grooves and rises, provides excellent retention power over the monolithic lining. The head of this anchor is designed to accept slip-over castings (commonly known as C-Clips). The brick is excellent in roof applications and can also be used in wall construction with the C-Clip. A certain amount of movement can occur between the refractory anchor and the C-Clip to accommodate expansion and contraction of the lining. This can be done by

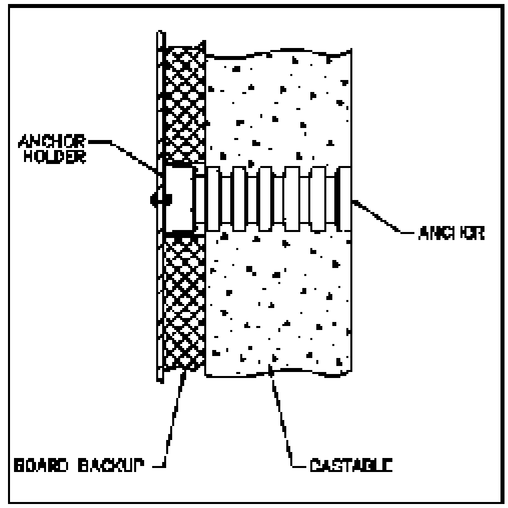

Figure 9 - Diagram of Brick and C-Clip

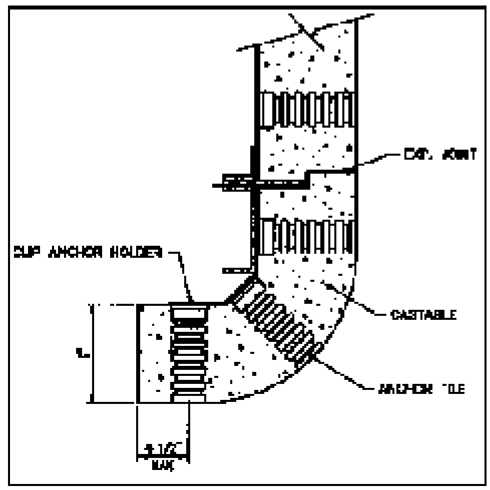

Figure 10 - Castable Bullnose

using a threaded stud standoff and PVC spacers. The C-Clip can be hung from steelwork in the roof, or cantilevered out from the vessel wall. They are available in various lengths and steel grades (generally 310SS) to suit different applications.

Besides C-Clips, ice tong type support anchors can be used for holding the brick in roof construction.

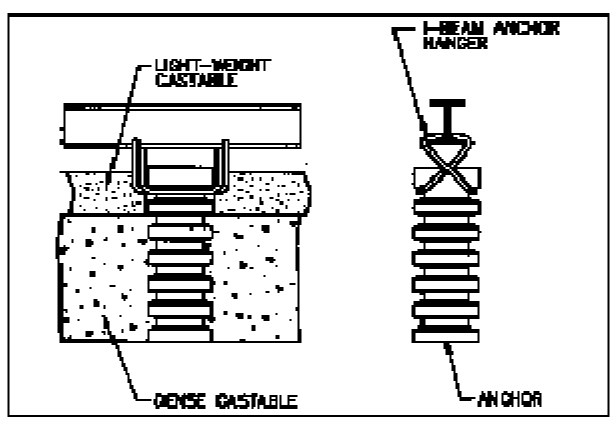

Figure 11 - Diagram of Brick and Ice Tongs

3. ANCHOR LENGTH AND SPACING

3.1 Wire and Metal Anchors

The distance between anchors needs careful consideration. Edges, roofs, bullnoses, and areas where vibration, mechanical movement or gravity impose loads on the lining need more anchoring than a straight wall or floor. Standard spacing for various areas is suggested in Table 3. Anchors are usually welded in a square pattern (as near as possible in some cases), but alternative patterns such as diamond are also suitable in many installations. The tines are rotated 90° from neighboring anchors.

Anchor Spacing	Anchors/ft^2
6 inch	4
8	2.25
10	1.44
12	1
14	0.75
18	0.45

Table 2 - Anchor Density

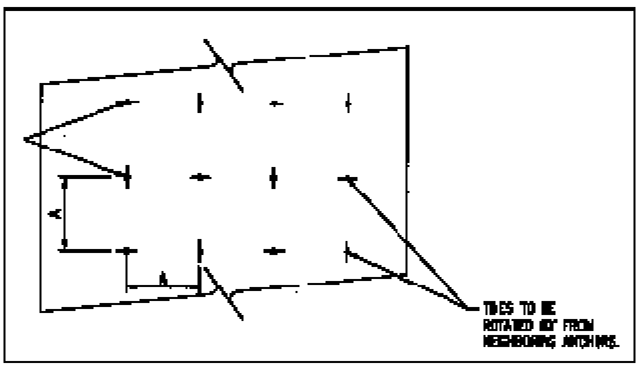

Figure 12 - Square Pattern

Where X = anchor spacing

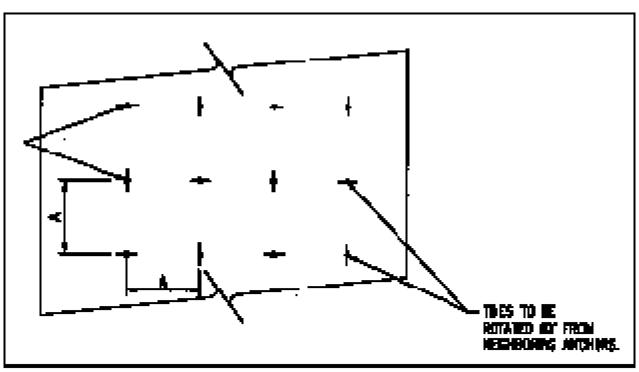

Figure 13 - Diamond Pattern

3.2 Ceramic Anchors

The total length of the refractory anchoring including brick and anchor support equals the lining thickness.

4. SPECIAL ANCHORING SYSTEMS

4.1 Hexmesh Anchoring

Hexmesh systems are used when maximum abrasion resistance is required with moderate temperature linings. Generally, the mesh stands away from the shell on studs or bars allowing a layer of insulation behind the hot face. Where heat loss is not a problem, the mesh can be directly welded to the shell. Sometimes mesh is supplied with extended legs, allowing refractory to flow underneath and between the cells, causing bonding between cells which increases the strength of the complete surface. Final lining thickness should be flush with the surface of the hexmesh.

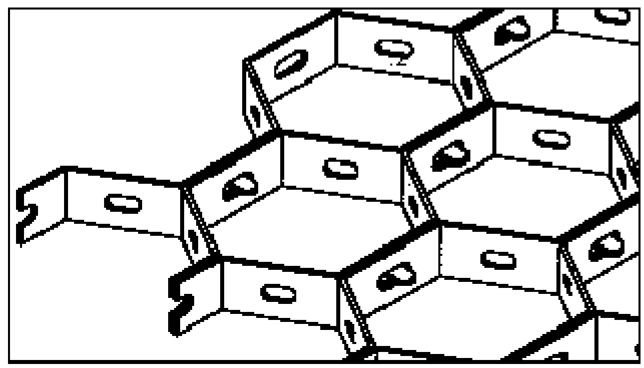

Figure 14 - Hexmesh Anchoring System

Hexmesh needs to be installed correctly for optimum performance. A continuous full penetration fillet weld should be used to attach the mesh to the shell. If the mesh is not tight against the steel shell, it can “chatter” from vibration or movement under operating conditions. This can cause the refractory to crack or dislodge from the cells.

4.2 S-Bar Anchoring

S-bars (or Stop bars) were originally developed as an alternative to hexmesh systems (Figure 15). The fundamental design requirements for S-bars are to supply an anchorage system of a design to hold ultra-thin refractory linings in place, and to reduce wear of refractory by abrasion of particles.

S-bars are directly welded to the vessel shell. Under operating conditions, refractory wears in the direction of the abrasive medium. This is usually the direction of gas flow. The S-bars are arranged so the head of the bar acts as a barrier to these particles, shielding the refractory downstream. The S-bars are always placed at right angles to the direction of air flow, and since they overlap each other, there is no easy path for the abrasive particles to take. They have proved successful in many applications where extreme abrasion resistance needs to be coupled with very thin linings.

Similar to hexmesh systems, S-bars can be designed on extended legs to allow an insulating layer beneath the dense hot face (which should be flush with the anchor surface).

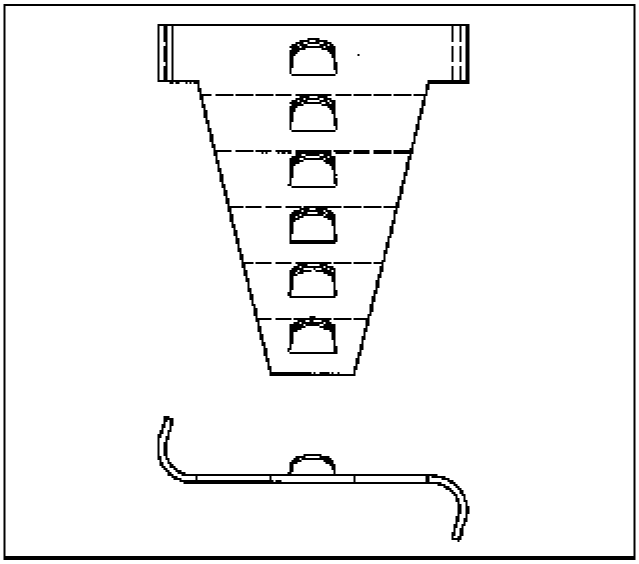

Figure 15 - S-Bar Anchoring System

5. CONCLUSION

Due to the almost infinite number of different needs for refractory and refractory anchors, the preceding pages are presented only as a general guide to the selection and installation of refractory anchors. For specific applications and information, contact your Thermal Ceramics representative.

		ANCHOR TYPES	
		Wire & Rod	**Ceramic**
Location	**Lining Thickness (in)**	**Suggested Anchor Centers (in)**	**Suggested Anchor Centers (in)**
Wall and Slopes	2-4	6	-
	4-8	9	-
	8-12	12	18
	12-16	-	18
	>16	-	24
Roofs and Bullnose	4-8	7	12
	>8	10	12
Floors	2-4	12	-
	4-9	18	-
	>9	20	-

Table 3 - Suggested Anchor Spacing

Notice:

Some of the products described in this literature contain Refractory Ceramic Fiber (RCF) and/or crystalline silica (cristobalite or quartz). Based on experimental animal data, the International Agency for Research on Cancer (IARC) has classified RCF, along with fibrous glasswool and mineral wool, as a possible human carcinogen (Group2B) and respirable crystalline silica as a probable human carcinogen (Group 2A).

To reduce the potential risk of health effects, Thermal Ceramics recommends engineering controls and safe work practices be followed by product users. Contact the Thermal Ceramics Product Stewardship Group (1-800-722-5681) to request detailed information contained in its MSDSs and product literature and videos.

For further information, contact your nearest Thermal Ceramics technical sales office. You may also fax us toll-free at 1-800-KAOWOOL, or write to Thermal Ceramics, P. O. Box 923, Dept. 140, Augusta, GA 30903.

Global Headquarters
Thermal Ceramics Global
L'Européen - Bât. C
2, rue Joseph Monier
92859 Rueil-Malmaison Cedex, France
T: +33 (0)1 47 16 22 23
F: +33 (0)1 47 16 22 40
E-mail: info@tc-global.com

Global Marketing Offices
Thermal Ceramics Americas
2102 Old Savannah Road
Augusta • Georgia • 30906
T: +1 (706) 796 4200
F: +1 (706) 796 4398
E-Mail: tceramics@thermalceramics.com

Thermal Ceramics Asia Pacific
28 Jalan Kilang Barat
Kewalram House
Singapore • 159362
T: +65 6273 1351
F: +65 6273 0165
E-mail: thermalceramics@tcasia.com.sg

Thermal Ceramics Europe
Tebay Road • Bromborough • Wirral
CH62 3PH • England
T: +44 (0) 151 334 4030
F: +44 (0) 151 334 1684
E-mail: marketing@thermalceramics.co.uk

Sales and Marketing Office Locations

North America
Canada
T: +1 (905) 335 3414
F: +1 (905) 335 5145
Mexico
T: +52 (555) 576 6622
F: +52 (555) 576 3060
United States of America
Southeastern Region
T: +1 (800) 338 9284
F: +1 (706) 796 4324
Midwest Region
T: +1 (866) 785 2738
F: +1 (866) 785 2760
Eastern Region
T: +1 (866) 785 2763
F: +1 (866) 785 2764
Western Region
T: +1 (866) 785 2765
F: +1 (866) 785 2782

South America
Argentina
T: +54 (11) 4373 4439
F: +54 (11) 4372 3331
Brazil
T: +55 (11) 4178 1999
F: +55 (11) 4178 1675
Chile
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F: +56 (2) 854 1952
Colombia
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F: +57 (222) 82935/82803
Guatemala
T: +50 (2) 4733 295/6
F: +50 (2) 4730 601
Venezuela
T: +58 (241) 878 3164
F: +58 (241) 878 6712

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