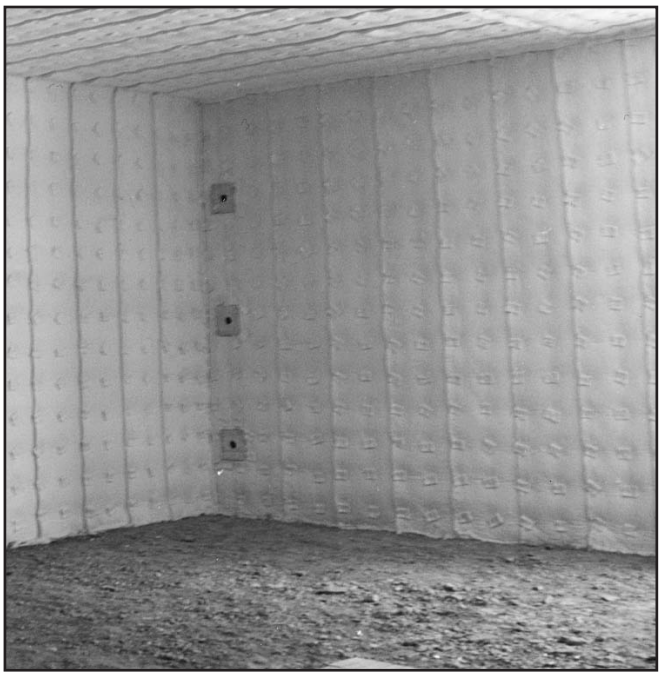
Thermal Ceramics

BLANKET AND WALLPAPER LININGS DESIGN AND INSTALLATION MANUAL



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INTRODUCTION

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

The refractory ceramic fiber manufactured by Thermal Ceramics is a highly versatile material. It can be spun or blown into bulk, air-laid into a blanket, folded into modules, formed into monolithic modules (Pyro-Bloc®), converted into boards and shapes, die-cut into gaskets, twisted into yarns, woven into rope and cloth, and blended into liquid binders for coatings and cements. With this wide range of products, Thermal Ceramics can provide exactly the right product, or engineered system to fit your requirements. Thermal Ceramics has an experienced staff of refractory specialists to assist you in product selection, system design, and installation techniques.

Thermal Ceramics has enjoyed great success with its ceramic fiber products due to their cost-effectiveness and excellent insulating properties. They are lightweight and have low thermal conductivities, excellent resistance to thermal shock, outstanding electrical resistivity, and good acoustical properties.

This Design and Installation Manual is intended to give the designers, installers, and users of Thermal Ceramics ceramic fiber products a broad range of information on how to select the most appropriate fiber system for a particular application, necessary design criteria, and how to correctly install the selected system.

PLEASE NOTE: This manual has been designed to easily accommodate new or revised information. Holders of the manual are advised to keep their address current with the Advertising and Sales Promotion Department at Thermal Ceramics in Augusta, Georgia. Any questions or comments regarding this manual should be addressed to your local Thermal Ceramics representative.

BLANKET AND WALLPAPER LININGS

Our line of ceramic fiber blanket products features low thermal conductivity, excellent thermal shock resistance and low heat storage capacity. Available in a wide range of temperature and density compositions, Thermal Ceramics refractory ceramic fiber blankets contain no organic materials that could contaminate furnace atmospheres at elevated temperatures. Thermal Ceramic blanket products can be supplied from stock in a variety of densities, thicknesses and roll widths.

The following procedures are intended to provide instruction on how to install blanket/wallpaper linings successfully. It is important that certain installation considerations are taken into account during the design process. The procedures presented here will apply to the majority of cases, but do not attempt to address all the situations that might be encountered. The specific topics which will be discussed are:

- Anchoring Systems and Layout
- Tools and Equipment
- Installation Designs

1. GENERAL

1.1 Anchoring Systems

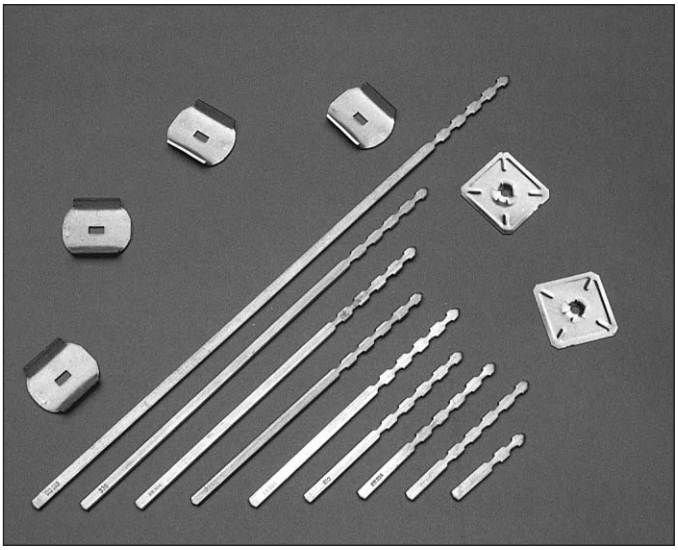


Figure 1 - Anchoring System

1.2 Tools and Equipment

The basic equipment required for the installation of a ceramic fiber blanket lining includes the following:

- 300 amp welding machine
- stud welding guns
- chalk line & soapstone
- tape measure
- 6" butcher knives
- 4' straight edge
- rubber bands ($^1/_4$" x 3")
- lighting
- scaffolding
- 3" side grinders
- plumb line

1.3 Anchor Layout

The anchor layout should be made on the inside of the casing, making sure that the anchor system is appropriately placed for the blanket lining. Typically, the anchor layout begins at the endwall of the unit. Special attention should be given to the corner anchors to ensure enough distance from the adjacent wall.

The anchor layout is based upon the exposed or hot face layer of blanket without regard to any of the back-up layers of blanket. Ensure that all joints in successive layers of blanket are staggered or offset. Also, there should be a 3" maximum distance between the last row of studs and the end or edge of the blanket. In the majority of cases, the required stud length will be the same as the nominal thickness of the blanket lining. The layout should include a minimum hot face blanket width of 12".

The maximum length of the hot face blanket layer should not exceed $12^1/_2$'. This will prevent shrinkage tears from developing along the length of the blanket.

Stud patterns vary across the width of the blanket according to the type of installation desired. For instance, butt joint applications require a 9"-9"-$5^1/_2$" stud pattern; 4" overlap applications require a 10"-10"-10" stud pattern, while 12" overlap applications require a 6"-6"-6" stud pattern.

Anchor Alloy Selection - The following use limits are suggested by API and are based solely on furnace operating temperature. If sulphur and/or other contaminants are present, a change in the anchor alloy selection may be required.

Furnace Temperature	304SS	316SS	309SS	310SS	Inconel 601
1400°F	X	X			
1500°F			X		
1700°F				X	
2000°F					X

The 316SS alloy anchors have provided greater resistance to sulphur and should be considered in these situations.

For operating conditions above 2000°F, ceramic cone anchors or ceramic spike anchor systems can be considered. For more information on these designs, contact your Thermal Ceramics representative.

1.4 Butt Joint Construction

The pattern for the horizontal spacing with butt joint construction is 9"-9"-$5^1/_2$". This will be across the width direction of the blanket. The use of $5^1/_2$" instead of 6" with a 24" wide blanket ensures a slight compression of the joint. A template can be made up to assist with the layout. Repeat this pattern along the top and bottom of the wall as long as full width blankets can be used and strike the vertical chalk lines by connecting the corresponding marks.

When intersecting another wall, the spacing is adjusted to ensure that the first stud row from the adjacent wall will be 3" plus the lining thickness. Measure from the last full stud row to the corner and subtract 3" plus the lining thickness. Take one half of this distance to determine the location of the intermediate stud row. See Figure 2.

To obtain the vertical spacing between stud rows start in the same back wall corner. Measure down from the roof 3" plus the thickness of the lining and mark. The vertical spacing between each of the remaining rows is 14". The only exception to this will be the last two stud rows nearest the floor. These will be located in the same manner as described earlier for intersecting another wall. To

complete the vertical spacing, make the same measurements down the opposite corner and mark each. The horizontal lines can now be struck to complete the grid.

This same procedure should be used for all the walls in the furnace and then recheck all corners to ensure that the first stud row in each case is 3" plus the lining thickness.

In order to start the stud layout for roof or arch, the vertical lines on the end walls will be used for one set of measurements. These will provide the 9"-9"-5$^1/_2$" pattern required along the width of the blanket. The chalk line can be lined up with these marks and the lines running the length of the furnace struck. The stud spacing running along the length of the furnace will start from one endwall. The first stud row is located by measuring in 3" plus the thickness of the lining. Subsequent stud rows will be located every 12" if the furnace operating temperature is less than 1900°F, or every 9" if the furnace operating temperature is equal to or greater than 1900°F. At the opposite end of the roof, place than last stud row in 3" plus the thickness of the lining. Then center the second row between this and the last full row.

Stud Placement - When the layout for the furnace is completed, an anchor should be welded at each intersection of the chalk lines. Some of the anchor locations may require grinding to ensure a good weld if rust, paint, grease, etc. is present. The Kao-Lok anchor may be stik-welded or welded with a stud gun. If a stud gun welding system is used, test welds should be made periodically to ensure the equipment stays properly adjusted.

All welds should be visually inspected and approximately 5 to 10% should be randomly selected for testing. The most common test is a “bend” test which consists of bending the stud over approximately 30 degrees from the casing and then straightening it back to the perpendicular. A poor weld will fail during this test. Where the stud

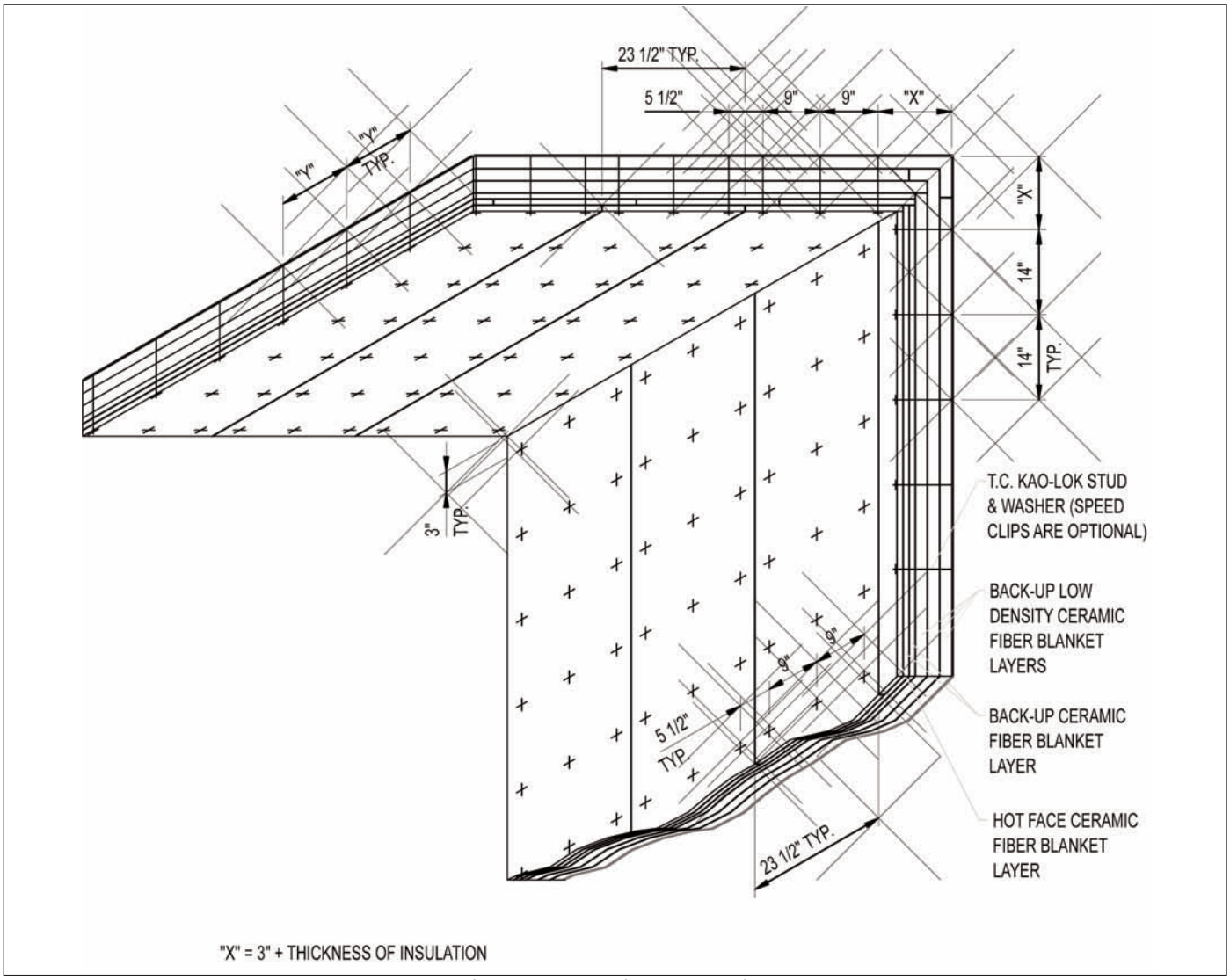


Figure 2 - Butt Joint Construction

weld failed, the casing should be ground smooth to remove all traces of the initial weld and a new stud welded.

The equipment needed includes a stud gun, a control unit and an adequate DC welding current supply. The stud is loaded into the properly sized chuck, the ceramic ferrule is placed in position over the end of the stud and the gun is properly positioned for welding. The gun, control unit and welding machine are connected as shown in Figure 10 or 11 for welding.

The anchor layout for the furnace walls should start from

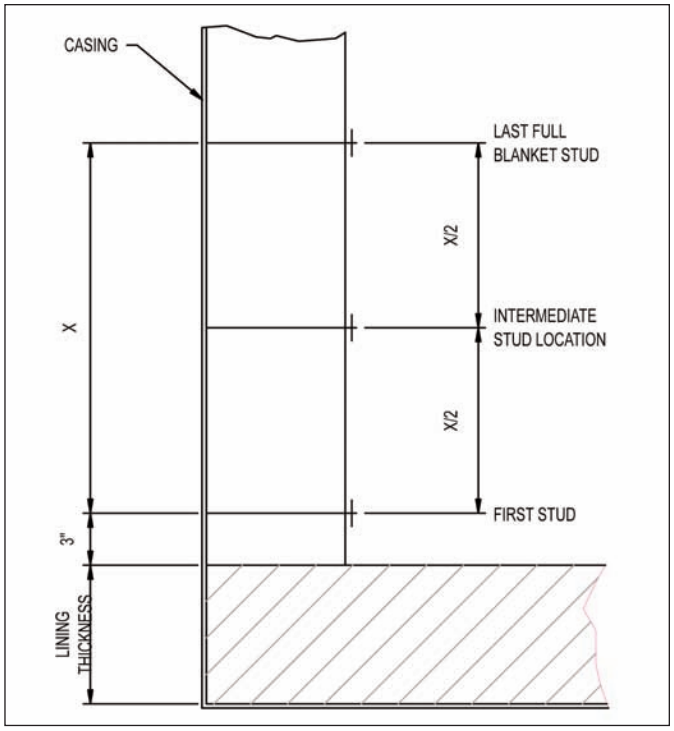


Figure 3 - Vertical Stud Layout

the top of one back or endwall corner. To begin the layout for the horizontal spacing between stud rows, measure in 3" from the corner plus the lining thickness and mark. Using a plumb line, strike a vertical line from the above measurement down the sidewall. This line provides a starting point for the other vertical lines.

1.5 4" Overlap Construction

The 4" overlap design is frequently used in furnaces operating above 1900°F. The stud pattern is laid out with regard for the hot face blanket layer only. The stud pattern along the width of the blanket is different from the other designs. In the 4" overlap construction, this pattern should be 10"-10"-10".

Unlike the layout for butt joint construction, it is easier with overlap designs to begin the layout at the vertical center line of a wall. Mark a vertical chalk line 5" on either side of the wall center line. Strike the other vertical chalk lines every 10 " back toward each corner. When this wall intersects with other walls, follow the same procedure as described for butt joint construction. To locate the vertical spacing between stud rows on the walls, start at the top of one backwall corner. Measure down from the roof 3" plus the thickness of the lining and mark. Continue to measure down the wall and mark every 14" if the furnace operating temperature is less than 1900°F, every 12" if the furnace operating temperature is equal to or greater than 1900°F. The last two stud rows, where the wall meets the floor, are located in the same manner as described previously for intersections of this nature. Repeat these measurements at the opposite end of the wall and strike the chalk lines by aligning the respective marks.

The procedure is repeated in an identical manner on the roof.

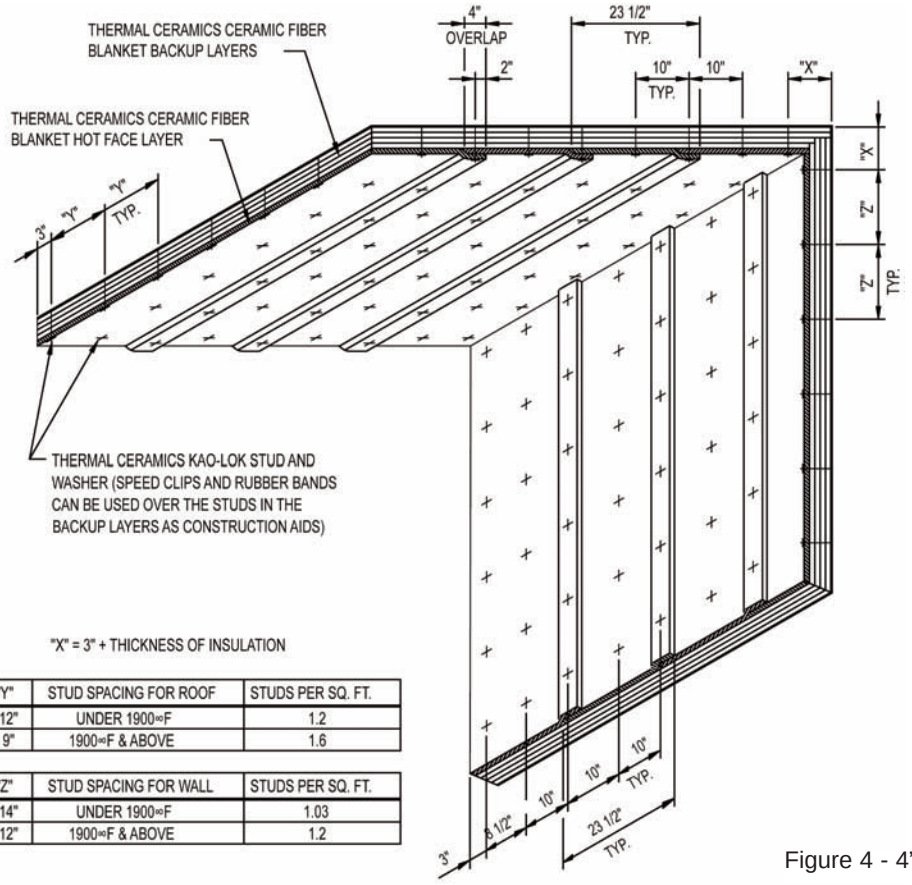
1.6 12" Overlap Construction

Another method of installing blanket/wallpaper linings is to use the 12" overlap technique. The stud layout is carried out in the same manner as previously described for the 4" overlap. The only difference is the horizontal stud spacing. When designing for a 12" overlap use a horizontal stud spacing of 6" between each row.

	Butt Joint Construction <1900°F < 1900°F		4" Overlap Construction <1900°F < 1900°F		12" Overlap Construction <1900°F < 1900°F	
walls	1.3	1.3	1.1	1.1	1.8	1.8
roof	1.5	2.0	1.2	1.4	2.0	2.7

An anchor overage of 10% in the appropriate stainless steel is recommended for most installations

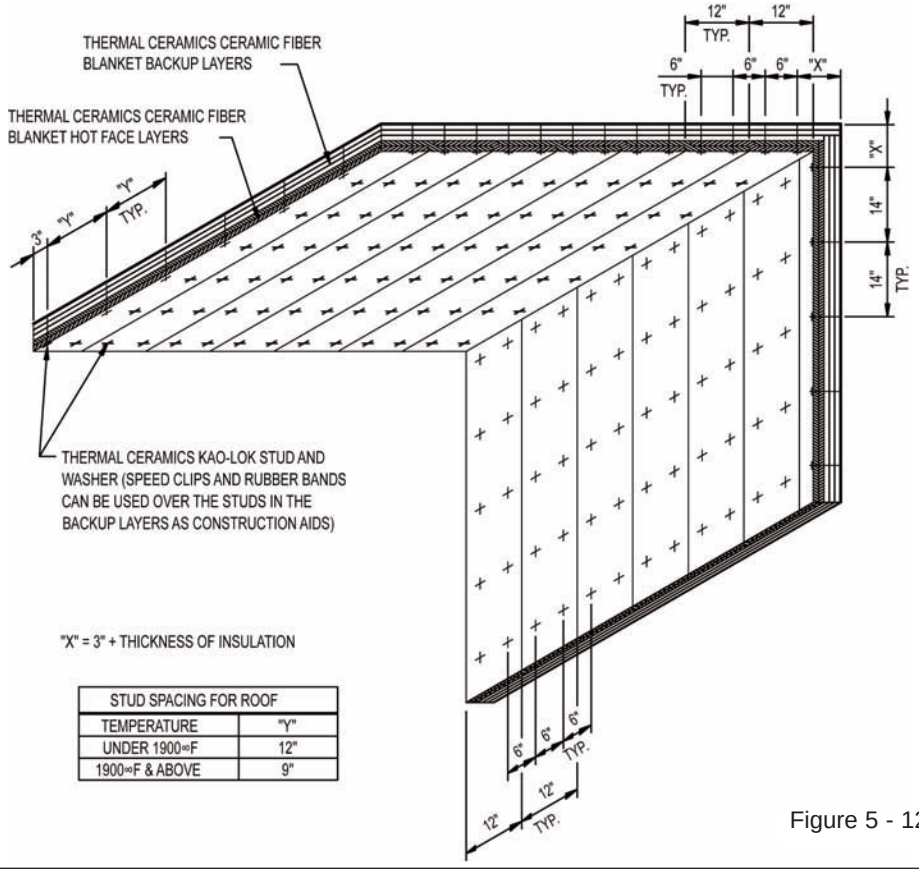
Table 1 - Estimate of studs/anchors required per square foot for flat, unobstructed surface



"Y"	STUD SPACING FOR ROOF	STUDS PER SQ. FT.
12"	UNDER 1900∞F	1.2
9"	1900∞F & ABOVE	1.6

"Z"	STUD SPACING FOR WALL	STUDS PER SQ. FT.
14"	UNDER 1900∞F	1.03
12"	1900∞F & ABOVE	1.2

Figure 4 - 4" Overlap Construction



STUD SPACING FOR ROOF	
TEMPERATURE	"Y"
UNDER 1900∞F	12"
1900∞F & ABOVE	9"

Figure 5 - 12" Overlap Construction

2. INSTALLATION

2.1 General

The minimum number of blanket layers which will achieve the desired effect should be used to reduce installation cost. In most installations, it is convenient to roll out the blanket vertically, but horizontal applications can also be used. The direction of the gas flow should be taken into account when setting the orientation of the joints.

Ceramic fiber has relatively low resistance to erosion from high velocity gas with abrasive particles and mechanical or physical abuse. In these layered designs, it is recommended that the hot face blanket be 1" thick and 8 lb/ft^3 density. Depending upon the severity of these conditions, the durability of the lining can be increased by applying a coating of rigidizer (temperature limit of 1800°F) to the hot face of the blanket.

The hot face layers should be designed with proper allowance for shrinkage. For more information on shrinkage of ceramic fiber, refer to the publication “Technical Aspects of Ceramic Fiber” (M140).

A 6" thick lining is one of the most commonly used in industry and will be used for the following example.

Our lining example shall consist of:

2", 4# ceramic fiber blanket
2", 4# ceramic fiber blanket
1", 6# ceramic fiber blanket
1", 8# ceramic fiber blanket
(Hot Face Layer)

It is important to note that minimal cutting of the hot face blanket is desirable and that blanket joints should be offset or staggered from underlying layers. As a result, in this example, the initial blanket installed on the first and third layers should be cut approximately in half to form a 12" strip.

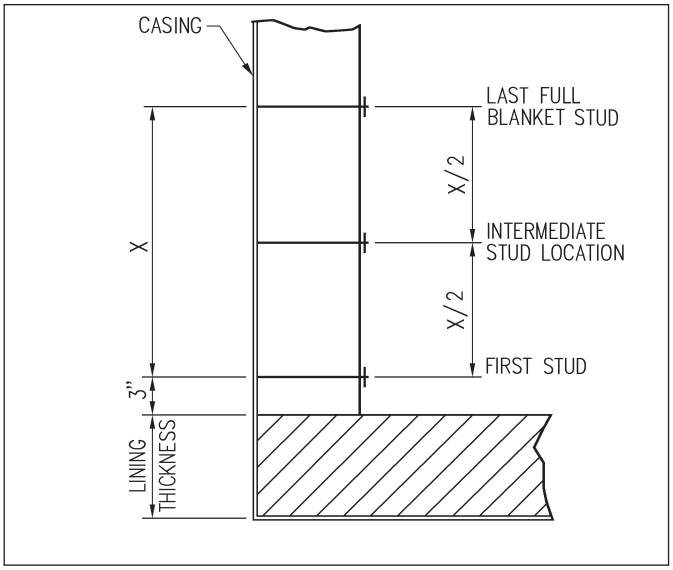


Figure 6 - Corner Details

Using a minimum of three people, start with the first layer of 2", 4# blanket in the back corner of the furnace. One person should hold the roll of blanket while the other two pull out approximately 6 feet of material. For this example, let the edge of the blanket hang down the sidewall approximately 4' from the roof and then push the blanket over the Kao-Lok studs. At the corner, be sure to mold the blanket into the corner before pushing onto the studs.

To install the blanket on the roof, the person with the roll of blanket should place it over his head and walk backwards slowly, letting the blanket feed off the roll in a straight line, while keeping the roll against the tips of the studs. The other two workers should push the blanket over the Kao-Lok studs and stretch rubber bands between the studs to temporarily prevent the blanket from falling. The blanket should be pushed carefully into place without stretching or tearing.

Install enough of the first layer of blanket to allow the second layer to be started, while staggering the joints formed along the length edge of the blanket. The full 24" wide blanket used on the second layer will automatically cover the joint on the first blanket layer by 12". When placing the blanket, always butt adjoining blankets together tightly.

The end of the second blanket layer should be started at the point on the sidewall approximately 3' down from the roof. In this way, there will be a 12" offset at the end of the blanket between successive layers. Each blanket layer should be staggered in this way.

After a sufficient area has been covered with the second blanket layer, the third layer can be started following the same techniques to ensure all the joints are staggered. On thick wallpaper roof applications, a Kao-Lok speed clip can be installed prior to the hot face layer of blanket to help carry the weight of the lining.

At this point, the hot face blanket layer can be installed. In most situations it is advisable to install the roof hot face layer first, followed by the side and endwall hot face layers. Compress the blanket, insert and rotate a Kao-Lok washer onto each Kao-Lok stud to secure the blanket in place.

2.2 Flue Openings

Flue openings in wallpaper linings can best be accommodated by cutting four extra pieces of hot face blanket

material as shown in Figure 7. In this way, the opening can be effectively lined without allowing a straight-through joint. This overlapping of as many layers as possible ensures the best possible seal of the blanket joints.

2.3 Corners

In Figure 8 an alternative method for handling corners is illustrated. The additional strip of hot face blanket material provides an additional overlap resulting in a well sealed joint.

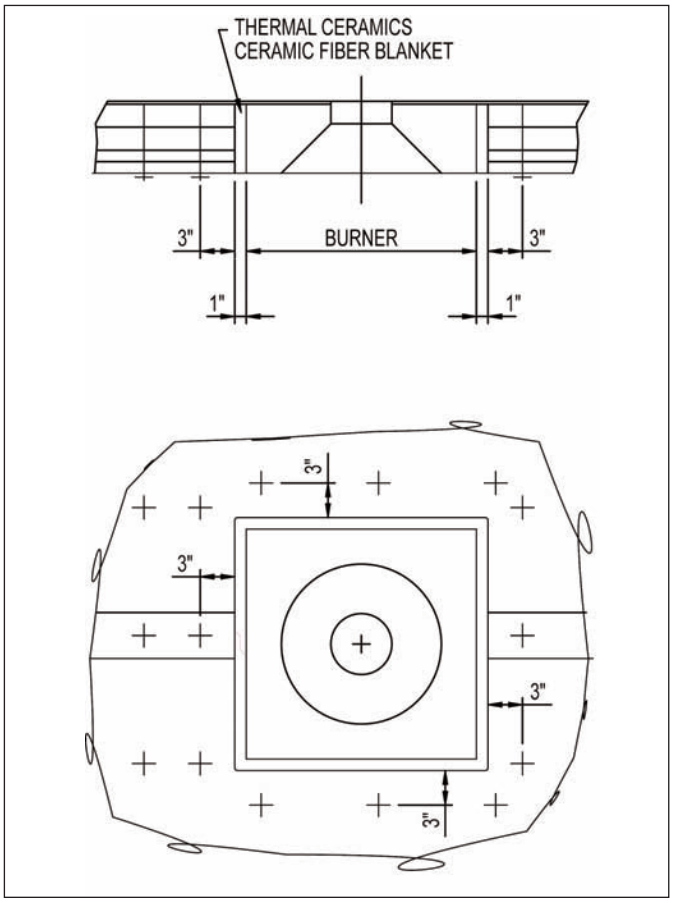


Figure 7 - Blanket Lining for Flues

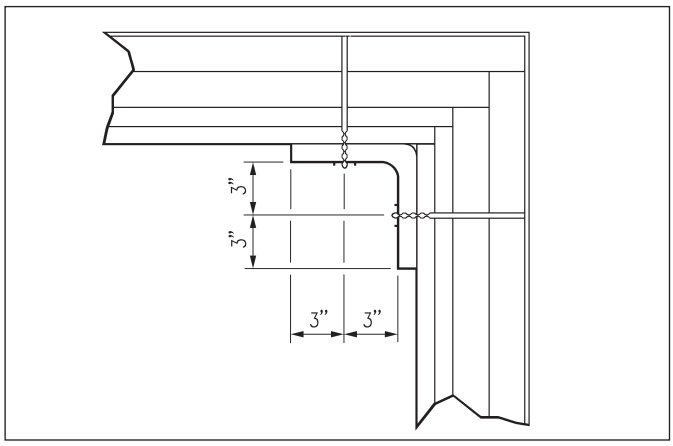


Figure 8 - Alternate Corner Detail

2.4 Burners

In those areas where burners are involved, special attention must be paid to the fiber arrangement around the burner opening. The recommended arrangement, which is shown in Figure 9, consists of a 1" thick, 8# hot face ceramic fiber blanket material that is used to wrap the burner block prior to the installation of the blanket on the wall. As the blanket is installed on the wall, each layer should be butted tightly into this blanket wrap.

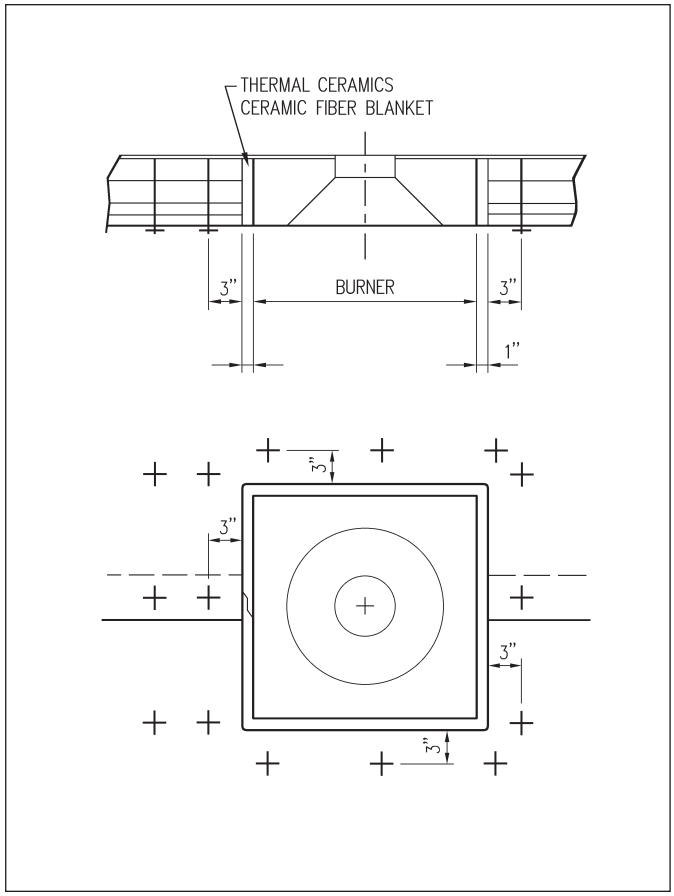


Figure 9 - Burner Wrap

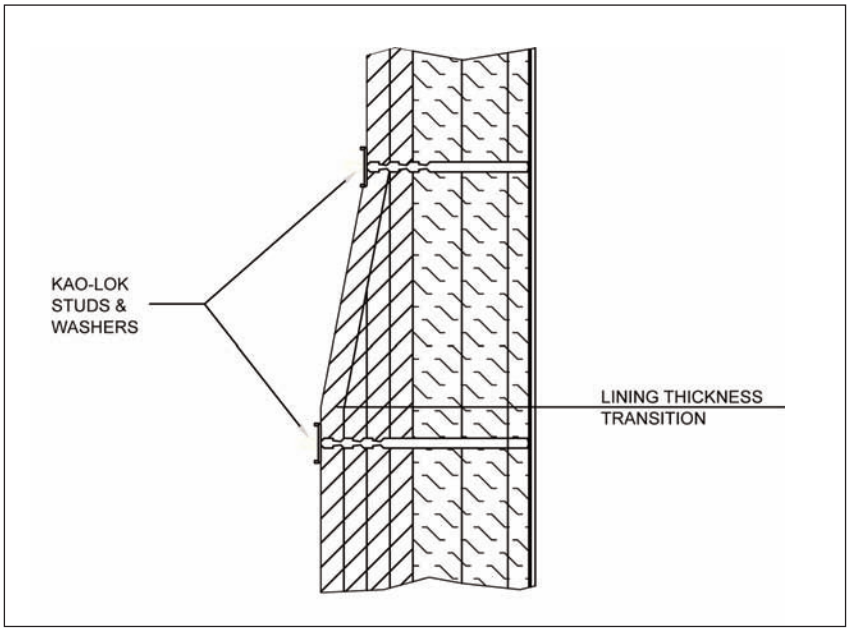


Figure 10 - Typical Lining Thickness Transition Detail

2.5 Miscellaneous

Other areas that will need careful attention are doors and tapered sections. Figures 10 and 11 are included for use as a guide when these areas are encountered.

For further information on Thermal Ceramics' blanket/wallpaper designed linings, please contact your local Thermal Ceramics Sales Representative or the Technical Sales and Service Department at (706) 796-4200.

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 (Group 2B) 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.

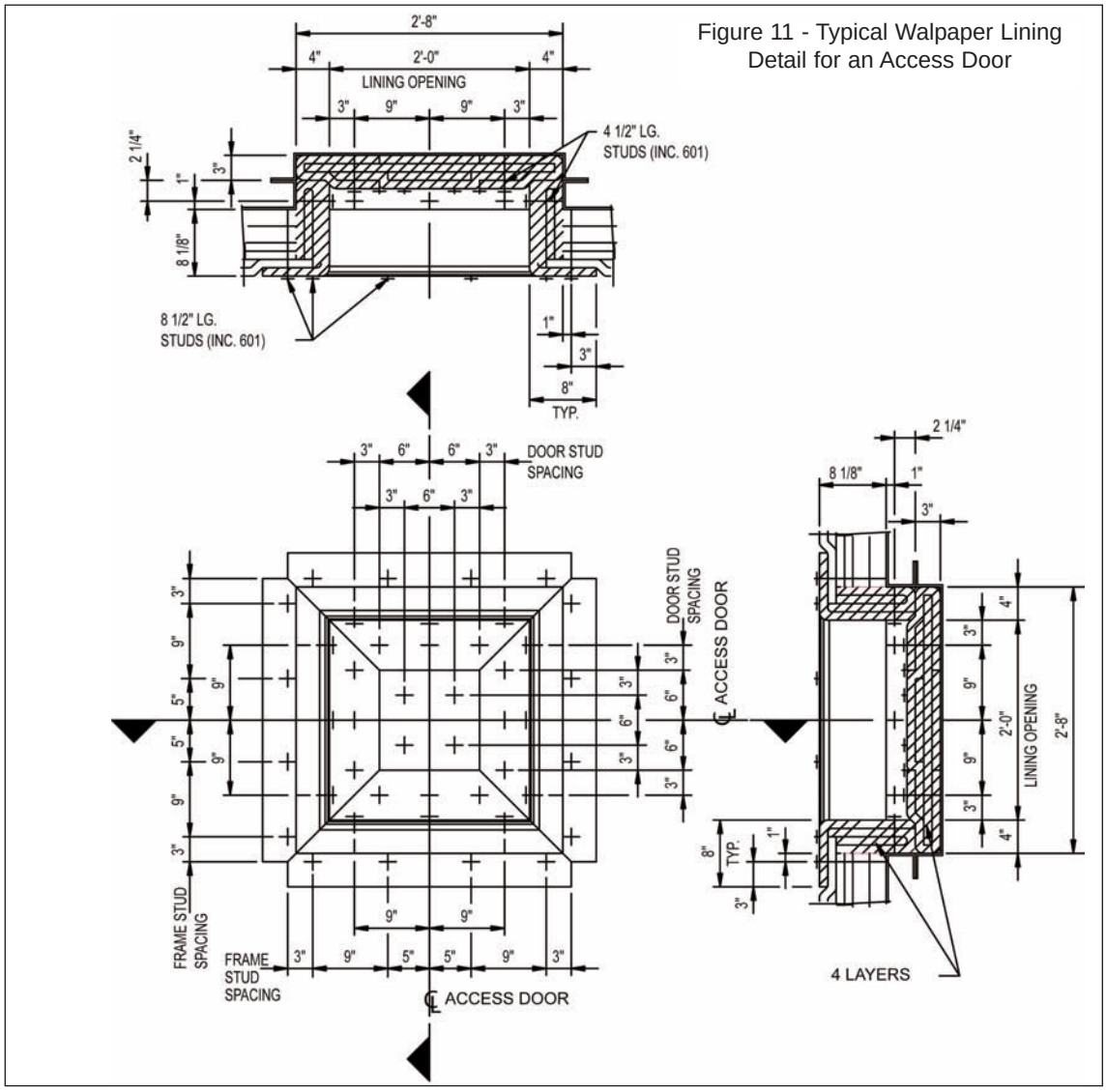


Figure 11 - Typical Walpaper Lining Detail for an Access Door

Amorphous: Having no definite crystalline structure or form.

Back-up Insulating Material: The layer or layers of insulating material that are located between the hot face insulating layer and the outer casing.

Blanket: A flexible unbonded ceramic fibrous insulating material of reasonably determinate dimensions.

Board: A substantially rigid or semi-rigid flat sheet produced by vacuum forming.

Bulk Fiber: Ceramic fibers in the "as-produced" state.

Butt Joint: A ceramic fiber wallpaper construction joint where edges of adjacent blankets meet.

Cold Face Temperature: Term used to denote the outside casing temperature.

Continuous Use Limit: Long-term (continuous) temperature limit for a product installed as a lining. This temperature is based upon product shrinkage, specifically what is considered to be a "manageable" or "controllable" shrinkage. This term is not to be confused with temperature rating.

Cristobalite: A crystalline phase of silica which will begin to form above 1800°F.

Devitrification: The phase transformation from glass to crystalline structure.

Edge-grain: The orientation of a fiber system in which strips of ceramic fiber blanket or felt are oriented perpendicular to the plane of the furnace casing.

Felt (Pressed): A flexible sheet product formed from ceramic fibers and bonded with an organic binder.

Heat Loss: The term used to denote the amount of heat being lost through a lining construction over time, measured in BTU/sq ft/min, (watts/sq in).

Heat Storage: The thermal property of a material wherein heat accumulates in the mass (which in refractories is a function primarily of the material's specific heat, mass, and temperature rise measured in Btu/lb/°F *(Cal/g/°C)*.

Heat Transfer: The study of heat flow mechanisms - conduction, convection, and radiation.

High Alumina Fiber: A ceramic fiber containing more than 90% alumina, giving a high use limit. Mullite fiber is also used in high temperature applications.

High Purity (HP) Fiber: A ceramic fiber produced from synthetic alumina and silica.

Hot Face Insulating Material: The layer of lining insulating material that has at least one surface exposed to the full temperature of the furnace gases.

Kaolin Fiber: A ceramic fiber produced from calcined kaolin.

Laminar Flow: The flow of a gas in which the gas stream moves in straight lines parallel to the direction of the flow.

Layered Lining Wallpaper: Lining that is composed of several layers and thicknesses of refractory ceramic fiber.

Linear Shrinkage: The amount of shrinkage which occurs along the length of a material after it has been subjected to elevated temperatures and then cooled - measured in percent of original prefired length.

Lock Washers: Washers used in conjunction with Kao-Lok studs. They are slotted so that when pushed over the stud and then twisted 90° the washer is locked into place, other locking systems are available, such as cone anchors. Lock anchors come in ceramics or alloy metals to suit temperature requirements.

Maximum Temperature Rating: The temperature which is used by the industry as a loose classification of different grades of ceramic fiber. This is generally higher than the continuous use limit.

Module: A prefabricated unit which can be applied as a lining block to the inner face of a furnace structure.

Mortar/Cement: A ceramic-based adhesive for attaching ceramic fiber products to other surfaces.

Mullite: A crystalline phase of alumina-silica.

Overlap Construction: A construction technique used to accommodate shrinkage in ceramic fiber or to improve velocity resistance in which one edge of a blanket is lapped over an adjacent blanket edge by 4" to 12" and shares a common anchor stud and washer.

Paper: A roll product produced from ceramic fibers and organic binders on conventional paper-making machinery.

Parquet: A method of installing modular edge-grained forms of ceramic fiber so that the edge grain of one module is perpendicular to the edge grain of the adjacent modules.

Rigidizing: The practice of applying an inorganic hardening agent to the surface of ceramic fiber (by spray or brush) in order to improve its velocity resistance.

RCF: Refractory Ceramic Fiber.

Shingled Joint: A method of applying double layers of ceramic fiber blanket in such a way that half the width of each layer overlaps half the width of the adjacent layer.

Shot: A glassy material formed during fiberization.

Textile: Cloth, tape, sleeving, tubing, or other forms manufactured from ceramic fiber yarn.

Thermal Conductivity: The property of material to conduct heat - measured in Btu flow per hour through a square foot of area across one inch of thickness Btu•in/hr•ft•°F *(w/m •C°)*.

Thermal Resistivity: The property of a material to resist the flow of heat; the reciprocal of thermal conductivity.

Thermal Shock: A failure mechanism wherein sudden changes in temperature bring sufficient thermal mechanical stress in a material to cause cracking or spalling. As a general rule, the thermal shock resistance of a material is greater as the strength and thermal conductivity of a material increase and as the thermal expansion and modulus of elasticity decrease.

Turbulent Flow: Fluid flow in which the velocity of a given stream of gas changes constantly both in magnitude and direction.

Vacuum Forming: A method of producing molded shapes and flat board by converting fibers into a slurry and vacuuming them onto a screen former.

Veneer: Layer of ceramic fiber in either blanket or module form which is attached to the hot face of a brick, module or monolithic lining.

Wallpaper Construction: The term used to describe a ceramic fiber lining construction technique where the blanket is installed on a wall like a roll of wallpaper.

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
T: +56 (2) 854 1064
F: +56 (2) 854 1952
Colombia
T: +57 (222) 82935/82803
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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