

Aremco offers a broad range of machinable and fully-dense ceramic materials for applications in which high temperature insulation, thermal shock resistance and high dielectric strength are required. Aremcolox™ and Super-Heat ceramics include compositions based on alumina, alumino-silicates, boron nitride, glass-ceramics, magnesium oxide and zirconium phosphate. Production capabilities include isostatic and dry pressing, low pressure injection molding, extrusion, slip-casting, and CNC machining.

## TYPICAL APPLICATIONS

- Aerospace**      *Gas nozzles, thermal insulators, space mirrors, and nose cones.*
- Automotive**    *Diesel port liners, manifold insulation, catalyst support systems, flow separator housings, regenerator cores, turbine nozzles.*
- Electrical**      *Connector housings, heater and resistor supports, stand-offs, instrument and appliance insulators, coil forms and bobbins.*
- Electronics**    *Wafer chucks, insulators, vacuum tube structures, microwave housings, arc barriers, x-ray equipment, and PVD applications.*
- Heat Treating**   *Brazing/carburizing fixtures, induction heating tubes, furnace and tooling insulation, kiln furniture, welding jigs, hot forming dies.*
- Metallurgical**   *Molten metal crucibles, nozzles, troughs, liners, transfer rollers, structural parts, filters, thermocouple sheaths, permanent molds.*
- Petrochemical**   *High temperature corrosion and wear resistant components.*
- Plastics**         *Hot die parts for thermoplastic forming equipment.*

## STANDARD FORMS

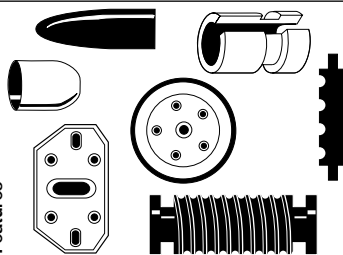
Ceramic Grades	Rods	Plates	Bars	Crucibles	Fasteners
502-0400 Glass-Ceramic	•	•			
502-0600 Glass-Ceramic	•	•			
502-0676 High Density MgO				•	
502-1100-UF Un-Fired Alumino-Silicate	•	•	•		
502-1100-FF Full-Fired Alumino-Silicate	•	•	•		
502-1400-BF Bisque-Fired Alumina	•	•			
502-1400-FF Full-Fired Alumina				•	•
502-1550-LD Zirconium Phosphate	•	•			
502-1550-MD Zirconium Phosphate	•	•			
502-1600-94 Boron Nitride, 94%	•	•	•		
502-1600-99 Boron Nitride, 99%	•	•	•		
502-1800 Boron Nitride/ Aluminum Nitride Composite	•	•	•		

Aremco can supply all grades of ceramic as finished parts. In addition, Aremco offers parts manufactured in other ceramic materials including cordierite, Macor®, mullite, silicon carbide, silicon nitride, steatite, and zirconia.

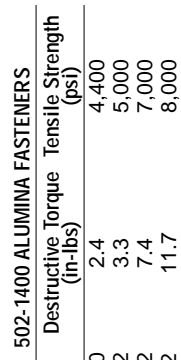


High strength alumina bolts, nuts and washers are electrically insulative, non-magnetic, and resistant to chemical corrosion and high temperature oxidation. Will not rust, seize or melt, even in molten steel.

# AREMCOLOX™ 502 SERIES CERAMICS – PRODUCT SPECIFICATIONS

PRODUCT	502-1100		502-1400		502-1550		502-1600®		502-1800					
	Unfired	Full-Fired®	Bisque-fired	Full-Fired®	Low Density	Med. Density <sup>①</sup>	94%	99%						
<b>Features</b> 	High dielectric and mechanical strength. For high voltage insulators, coil housings, thermal barriers. Readily machined, no firing required. Plates from 1/8" to 1" thick; rods 1/4" diameter.	High dielectric and mechanical strength. For high voltage insulators, lamp housings, thermal switches, and radiation parts. Readily machined, no firing required. Plates from 1/8" to 1" thick; rods 1/4" diameter.	Full-fired, fine grain, high purity MgO ceramic. Inert to molten metals, slags, superconductors. Broad line of standard crucibles. Custom parts made to print.	Good thermal and dielectric properties and can be fired to increase temperature resistance and mechanical strength. Easily machined to close tolerances. Plates, rods and bars available to 12".	Good mechanical strength and electrical and thermal resistance. For producing insulators, standoffs, feed-thrus, furnace carriers and brazing fixtures. Fabricate and fire yourself or send prints to Aremco.	Good corrosion, electrical and thermal shock resistance. Plates from 1/4" to 3/4" thick; rods from 1/4" to 3" diameter. Easily machined using conventional tools, no firing required.	Parts fabricated to print. Excellent physical properties and corrosion resistance. For pump liners, nozzles, guides. Standard crucibles and bolts, nuts and washers from 4-40 to 1/4-20.	Ultra high thermal shock resistance and low thermal conductivity. For brazing fixtures, induction heating liners, rocket nozzles, and high temp gauges, tooling and structures. Plates from 1/4" to 1" thick. Rods from 1/2" to 2" diameter.	Ultra high thermal shock resistance and low thermal conductivity. For molds, optical stands, microwave housings, and engine parts. Parts made to print. Plates from 1/4" to 1" thick, rods from 1/4" to 3" diameter, bars from 1/4" x 1/4" to 2" x 2".	Hot-pressed boron nitride - aluminum nitride composite. High thermal conductivity. Non-reactive in molten salts, aluminum and other metals. Plates from 1/4" to 1" thick, rods from 1/4" to 3" diameter, bars from 1/4" x 1/4" to 2" x 2".	Hot-pressed boron nitride - aluminum nitride composite. High thermal conductivity. Non-reactive in molten salts, aluminum and other metals. Plates from 1/4" to 1" thick, rods from 1/4" to 3" diameter, bars from 1/4" x 1/4" to 2" x 2".	Hot-pressed boron nitride - aluminum nitride composite. High thermal conductivity. Non-reactive in molten salts, aluminum and other metals. Plates from 1/4" to 1" thick, rods from 1/4" to 3" diameter, bars from 1/4" x 1/4" to 2" x 2".	Hot-pressed boron nitride - aluminum nitride composite. High thermal conductivity. Non-reactive in molten salts, aluminum and other metals. Plates from 1/4" to 1" thick, rods from 1/4" to 3" diameter, bars from 1/4" x 1/4" to 2" x 2".	Hot-pressed boron nitride - aluminum nitride composite. High thermal conductivity. Non-reactive in molten salts, aluminum and other metals. Plates from 1/4" to 1" thick, rods from 1/4" to 3" diameter, bars from 1/4" x 1/4" to 2" x 2".
<b>Composition</b>	Glass Ceramic	Glass Ceramic	Magnesium Oxide	Alumino-Silicate	Alumina	Zirconium Phosphate	Boron Nitride 94%	Boron Nitride 99%	BN-AIN Composite					
<b>Max Operating Temp., °F (°C)</b>	700 (371)	1100 (593)	3270 (1800)	2100 (1150)	3000 (1649)	2800 (1538)	2100 (1150)	5430 (3000)	2200 (1200) Vacuum 1200 (700 Air)					
<b>Hardness, Moh's Scale</b>	5.5	5.0	5.5	6.0	9.0	6.0	—	—	—					
<b>Specific Gravity, gms/cc</b>	3.0	2.8	3.45	2.3	3.9	2.53	1.9	1.7	2.43					
<b>Density, lbs/in<sup>3</sup></b>	0.11	0.10	0.12	0.083	0.134	0.092	0.069	0.061	0.088					
<b>Porosity, %</b>	Nil	Nil	4.5	2.3	Nil	28-30	11.0	22.0	9.0					
<b>Thermal Expansion, in/in/F x 10<sup>6</sup>(°C)</b>	6.0 (10.8)	5.2 (9.5)	7.7 (13.9)	2.9 (5.2)	3.5 (6.3)	0.5 (-9)	2.2 (4.0)	.2 (3)	3.1 (5.6)					
<b>Compressive Strength, psi</b>	40,000	32,000	120,000	25,000	340,000	25,000	10,000	4,800	—					
<b>Flexural Strength, psi</b>	15,000	14,000	35,000	10,000	46,000	5,500	7,500	2,800	18,200					
<b>Dielectric Strength, volts/mil</b>	400	380	150	100	225	80	1,340	865	1090					
<b>Loss Factor at 1 MHz</b>	.009	.012	—	.053	.0018	0.003	<.0002	<.0002	—					
<b>Dielectric Constant at 1 MHz</b>	6.9	6.8	9.6	5.3	9.3	7.0	4.1	3.8	6.4					
<b>Thermal Conductivity BTU • in/hr • ft<sup>2</sup> • °F (W/m • °K)</b>	2.88 (.41)	4.08 (.59)	15.0 (2.2)	9.0 (1.3)	220 (31.7)	5.3 (.8)	381.7 (55.0)	152.7 (22.0)	277.6 (40.0)					

**ALUMINA AND MAGNESIUM OXIDE CRUCIBLES**  
 Aremcolex™ 502-676 and 502-1400 slip cast crucibles are available in stock shapes up to 6" diameter and 10" length. Wall thickness is 0.2" maximum and is typically specified between 0.09" and 0.15". Tolerances on outside dimensions are ±.125" or ±5%, whichever is less. Flanged lids are available for all stock shapes.



**Reference Notes:**

- Full-fired and medium density ceramics must be machined with diamond tools.
- Boron Nitride operates to a maximum of 850 °C in an oxidizing atmosphere and as high as 3000 °C in a reducing atmosphere. BN 94% contains a calcium borate binder which has a melting point near 1150 °C, the maximum use temperature in a vacuum/inert atmosphere. BN 99% binderless diffusion-bonded product is stable to 1600 °C in a 10<sup>-3</sup> vacuum. BN 99% may be stable up to 3000 °C as long as it is in the presence of an inert gas whose vapor pressure exceeds the vapor pressure of BN at that temperature. In the presence of hydrogen, BN 99% is stable in dry hydrogen only.

**502-1400 ALUMINA FASTENERS**

Size	Destructive Torque (in-lbs)	Tensile Strength (psi)
4-40	2.4	4,400
6-32	3.3	5,000
8-32	7.4	7,000
10-32	11.7	8,000
1/4-20	14.6	Not Available

The destructive torque is the force at which the bolt head shears off upon tightening.

Vapor Pressure (Torr)	Boron Nitride
Temp. (°C)	
200	3.1 x 10 <sup>-25</sup>
500	3.1 x 10 <sup>-17</sup>
800	6.8 x 10 <sup>-12</sup>
1200	9.9 x 10 <sup>-7</sup>
1600	8.1 x 10 <sup>-3</sup>
2000	11.5

**Send engineering drawings to Aremco for quotation on fabricated parts.**

## APPLICATION PROCEDURES

### Equipment

Conventional machine shop equipment can be used with excellent results. Note that an abrasive slurry or ceramic dust will be generated during the machining process. Make sure to use dust collection equipment as required and to clean the equipment thoroughly after use.

### Tooling

Aremcolox™ 502-1100 Unfired, 502-1400 Bisque-Fired, 502-1600 and 502-1800 may be machined using standard high speed hardened steel tools for short runs and carbide tipped or solid carbide tools for longer production runs. Follow the tooling recommendations on the adjacent chart for machining 502-400, 502-600, Macor® and Low Density 502-1550. Aremcolox™ 502-1100 Full-Fired, 502-1400 Full-Fired and 502-1550 Medium and High Density may only be machined using diamond tooling.

### Fixturing

Hold the ceramic carefully so as to prevent chipping or cracking. Place a soft paper sheet in between the gripping jaws and ceramic as required. Support ceramic plates for drilling or milling operations by using a soft backup block and temporary adhesive such as Aremco's Crystalbond™ 509. (Refer to Technical Bulletin A9.) Support cylinders using an internal metal sleeve. Do not use pointed screws to hold workpiece since ceramics are brittle.

### Lubricant

Dry machining is recommended for 502-1100, 502-1600 and 502-1800 since these ceramics have a high open porosity and will absorb water readily. A water or low concentrate lubricant is recommended for 502-400, 502-600, 502-1400, and 502-1550. Where required, a continuous stream of lubricant should be directed at the work and tools to prevent chipping and tool wear.

### Cleaning

Clean parts after machining, and bake out at 200 °F for two hours and 250 °F for another two hours to remove residual lubricant. Clean fire as required up to 1000 °F to remove any discoloration due to lubricant.

### Firing (502-1100)

Aremco's Econo-Heat™ Series furnaces are ideal for firing 502-1100 ceramics. Refer to reverse side for detailed product specifications. Follow the procedure below.

- Bake out at 200 °F for two hours to remove moisture. Failure to eliminate moisture prior to ceramic reaching elevated temperatures will result in cracking or shattering.
- Increase temperature at a rate of 200 °F per hour maximum (slower for thicker sections) to 1100 °F. Soak at 1100 °F for six hours.
- Increase temperature at a rate of 200 °F per hour to 2050 °F. Soak at 2050 °F for 30 minutes for each 1/4" of cross-section (i.e. - soak a 1/2" thick part for one hour).
- Turn off furnace and allow to cool to below 150 °F before removing parts. Do not open furnace door until temperature is below 150 °F.

RECOMMENDED TOOLING	SPECIAL INSTRUCTIONS
<b>Turning</b> Tungsten carbide tipped or solid carbide tools.	Keep tool bits sharp and lubricate as required. Avoid tool point contact; orient tool at angle. Machine ceramic from the edge inward. Turn at 400 - 900 RPM; remove .020 - .050" per cut.
<b>Grinding</b> Silicon carbide resinoid or metal-bonded diamond wheels.	Use low concentrate lubricant (minimum 1% soluble oil) to increase wheel life.
<b>Cutting</b> Diamond or silicon-carbide cut-off wheel.	Flood work with lubricant and cut slowly.
<b>Drilling</b> Tungsten carbide tipped or solid carbide tools.	Drill at a maximum of 2500 RPM for 1/4" diameter tools and 1500 RPM for 1/2" tools. Penetration rate should not exceed 12" per minute. Drill 1/8" per pass and remove powder. Drill from both sides or support with backup block to prevent chipping or breakout.
<b>Threading</b> Carbide tool bits or diamond wheel tool-post grinder.	Sharpen tools frequently.
<b>Tapping</b> High speed hardened steel carbide taps for long runs.	Counter-sink each end to prevent chipping. Avoid tapping or if possible by drilling thru holes and fastening from each side using a bolt, nut and washer to load ceramic into compression.

### Firing (502-1400 Bisque)

This product has been pre-fired to 2475 °F. To achieve high density, hardness and strength, fire to 3075-3125 °F. A 15-18% shrinkage should be expected. Raise temperature 500 °F per hour to 2000 °F, 200 °F per hour to 3125 °F. Soak for 12 hours, then cool in furnace to room temperature.

### Special Machining Notes – Aremcolox™ 502-1100

- Typical tolerances for fired parts can be held to  $\pm 1\%$  or  $\pm .005"$  whichever is greater. For tighter tolerances it may be necessary to wet grind after firing.
- Machine all dimensions 1-2% undersize to allow for expansion during firing. All dimensions including centered and off-centered internal holes will increase by this percentage after machining.
- In order to fire the material properly, it is desirable that cross sections be held to 3/8" maximum. Hollow cut or drill thru holes in the unfired ceramic to maintain a 3/8" cross-section. When it is necessary to exceed 3/8", a slower rate of firing should be used. Cross-sections should not exceed 5/8". Drill longitudinal holes through round stock.

## SUPER-HEAT™ MgO CERAMICS

Aremco's Super-Heat™ Magnesium Oxide ceramic is a fully-fired, fine grain, high purity material used in applications as high as 4000 °F (2200° C). This ceramic exhibits better chemical and temperature resistance than alumina and is inert to metals, slags, and superconductor compounds. Super-Heat™ is fabricated typically into high density, thin-walled crucibles, as well as custom shapes such as tubes, rods and plates. Isopressed, thicker parts can be fabricated to print.

### TYPICAL APPLICATIONS

#### Metal Alloy Processing...

such as nickel base superalloys and plutonium/uranium systems.

#### Superconductor Processing...

resistant to attack and non-contaminating 1–2–3 materials.

#### Piezoelectric Materials Processing...

resistant to lead based materials.

#### Beta-Alumina Processing...

resistant to sodium attack.

### TYPICAL PROPERTIES

Super-Heat™ High Density MgO consists of a fine grained microstructure with an open porosity of less than 1% and an average density of 3.45 gm/cc or 96% of theoretical. This composition includes a sintering aid of 3% yttrium oxide as a direct substitute for MgO.

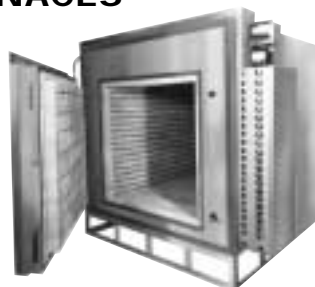
#### Analysis

MgO	99.38%	Al <sub>2</sub> O <sub>3</sub>	.03%
CaO	.36%	Fe <sub>2</sub> O <sub>3</sub>	.07%
SiO <sub>2</sub>	.14%	B <sub>2</sub> O <sub>3</sub>	.01%

Super-Heat™ parts are not resistant to thermal shock. Creep occurs above 2200 °F (1200 °C), so crucibles should be supported using MgO sand to prevent sagging. The maximum recommended ramp rate is 200 °C per hour.

## ECONO-HEAT™ FURNACES

Aremco offers a complete line of electric box furnaces for applications to 2350 °F. Custom features and sizes are also available upon request.



### FEATURES

All furnaces are built with 3" premium insulating firebrick and 1" fiber board to reduce skin temperature and permit rapid firing.

Elements are protected in dropped recessed side wall grooves to provide even heating, longer life, and easy replacement.

Outer shells are constructed using stainless steel to improve the casing resistance to high temperatures.

### Econo-Heat Furnace Specifications

MODEL NO.	SIZE (W" x D" x H")		STYLE		Controller Options	Apprx. Wt. (lbs.)
	ID	OD (Approx.)*	Front Load	Top Load		
2925	8.5 x 9 x 4.5	16.5 x 17 x 17.5	X		A	60
2926	6.25 x 6.5 x 6	14.25 x 14.5 x 19	X		A,B,C	60
2927	8.5 x 9 x 8.75	16.5 x 17 x 21.75	X		A,B,C	80
2928	13 x 13.5 x 8.75	21 x 21.5 x 21.75	X		A,B,C	110
2929	22 x 22 x 13.5	30 x 30 x 26.5	X		A,B,C	295
2930	15 x 18 x 15	29.5 x 29 x 29		X	A,B,C	280
2931	17 x 17 x 20	31 x 31 x 31		X	A,B,C	300
2932	21.5 x 21.5 x 24.5	31 x 36 x 35		X	A,B,C	410

\*Width of units using controller "C" is increased by 5"

### TEMPERATURE CONTROLLERS

#### Infinite Control Switch (A)

This is a basic switch for controlling temperatures up to 2300 °F. A separate pyrometer, thermocouple and mounting bracket are recommended with this option.

#### Single Set-Point Control (B)

This is an analog controller and pyrometer which holds the set-point temperature to an accuracy of ± 2%. Fahrenheit and centigrade readings are provided.

#### Programmable Controller (C)

This is a microprocessor-based ramping temperature controller. Features include a single input, dual output, auto-tuning control with 24-step program capability and easy fixed set point operation. PID or on/off operating algorithms are included. Optional RS-232C, RS-422A, RS-423A, and EIA-485 communications ports, and a strip chart recorder output are available. Operator-friendly features include automatic LED indicators to aid in monitoring and setup, as well as a calibration offset at the front panel. This controller automatically stores all information in a non-volatile memory.

Refer to Price List for complete order information.

Aremco Products makes no warranty express or implied concerning the use of this product.

The user assumes all risk of use or handling whether or not in accordance with directions or suggestions, or used singly or in combination with other products.