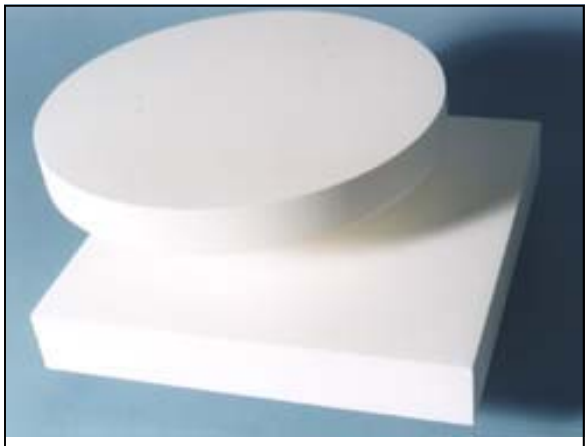
Zircar Zirconia, Inc.
"Manufacturer of the original ZIRCAR products" ©

ZIRCONIA BOARDS, DISCS & CYLINDERS
TYPE FBD



FBD Boards & Discs are Available in Three Standard Thicknesses.

FEATURES

- **Rigid and Machinable**
- **Our Most Dense, Highest Strength, Fibrous Zirconia Material**
- **High Purity Zirconia Bonded**
- **Extreme High Temperature Stability**
- **Fibers Stabilized with ~10 wt% Yttria**
- **Low Thermal Conductivity**
- **Can be Cemented with Zircar Zirconia Cement Type ZR-CEM**
- **Can be Surface Hardened with Zircar Zirconia Rigidizer Type ZR-RIG**
- **Pre-fired and Organic Free**

Type **FBD Boards, Discs and Cylinders** are high strength, uniform, rigid, refractory structures composed of zirconia fibers stabilized with yttria. Type **FBD** is Zircar Zirconia's strongest and most stable zirconia material. Type **FBD** is ideally suited for thermal insulation and protection applications under conditions of ultra-high temperatures and in varied atmospheres. **FBD** has been high fired and is tightly bonded resulting in nearly dust free use. This tight bonding makes machining to tight tolerances possible.

FBD is dimensionally stable to 2000°C and can be used at higher temperatures in areas where some sintering can be tolerated. **FBD** has good hot strength up to 1700°C and can be used as a self supporting setter for loads equal to twice its own weight up to this temperature. It has exceptional resistance to oxidizing and reducing atmospheres at high temperatures. Zirconia does, however, lose a small amount of oxygen at very high temperatures in vacuum and inert or reducing atmospheres. Although this reaction results in a color change from white to gray, other properties remain essentially unchanged and insulation effectiveness is not impaired.

FBD has exceptional resistance to most corrosive environments. It undergoes little attack by molten alkali metal chlorides and carbonates at temperatures as high as 700°C and withstands aqueous solutions of alkali metal hydroxides at temperatures as high as 230°C. **FBD** will tolerate exposure to inorganic acids at their boiling point for short lengths of time. **FBD** contains no organic binders, produces no smoke or odor and undergoes no physically disruptive phase transitions when heated.

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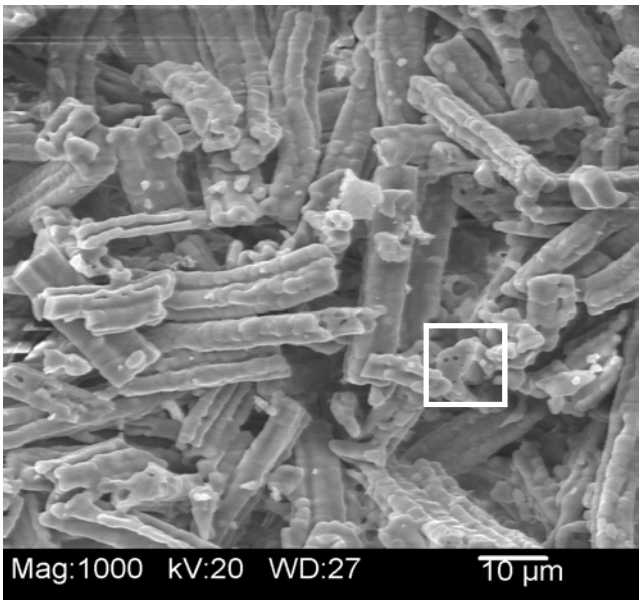
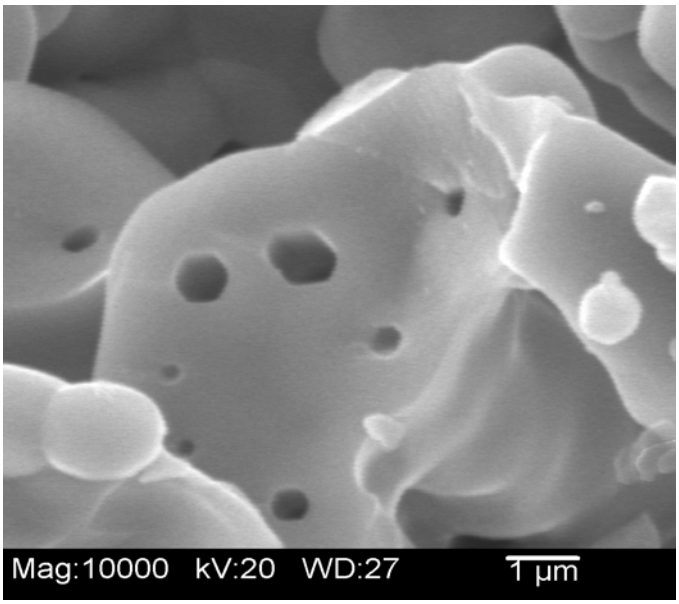
Shown below are SEM micrographs of **FBD.** The micrograph on the left is of the face of a board and illustrates the serrated structure that is characteristic of all of our zirconia fibers. It also shows how the tightly packed fibers are preferentially arranged parallel to the vacuum formed board face. This fiber orientation creates anisotropic behavior. Vacuum formed ceramic fiber boards exhibit lower compressive strength and thermal conductivity perpendicular to the fiber plane while shrinkage is greater. Standard **FBD** boards and discs have the fiber plane parallel to their faces. Standard **FBD** cylinders have the fibers aligned perpendicular to the radius of the cylinder. Custom cylinders and boards can be made with fiber orientation as required for your application.

The micrograph on the right is an enlargement of the fiber that is highlighted by the white box in the micrograph on the left. This photo illustrates the highly sintered exterior and porous interior structure of the individual fibers. Because **FBD** is processed at a very high temperature the individual fiber grains grow to be almost as large as the fiber diameter and meld into a very smooth, highly sintered micro structure. The resulting FBD product is an unique fibrous ceramic material because of its high strength and 'dust free' nature

The very porous nature of Type **FBD,** including the porosity of the fibers themselves, is also evident in the micrographs. This combination of open and closed porosity is unique to Zircar zirconia fiber materials.





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CHEMICAL COMPOSITION

Zircar Zirconia's Type **FBD** is nominally 90 wt% ZrO_2 + HfO_2 and 10 wt% Y_2O_3. 1 - 2 wt% hafnia (HfO_2,) occurs naturally with zirconia (ZrO_2,) and does not affect performance. Only the highest purity starting materials are used to make Type **FBD** minimizing trace oxides.

Trace Oxide	Typical Wt%
SiO_2	0.12
TiO_2	0.14
CaO	0.09
MgO	0.03
Fe_2O_3	0.04

Trace Oxide	Typical Wt%
Al_2O_3	0.01
Na_2O	0.01
SnO_2	0.001
Cr_2O_3	0.0005
Ag_2O	0.0005

MACHINING INFORMATION

Zirconia Type **FBD** has the consistency of hard chalk and should be dry machined with solid carbide or carbide tipped tooling. Cutting wet is not recommended. For manual cutting, place the **FBD** part on a smooth clean surface and hold it in place with hand pressure. When close tolerances are not required and the amount of cutting is limited, holes can be drilled with a standard masonry bit or carbide grit hole saw powered by a hand held drill and boards can be cut with a carbide grit blade on a hack saw. If closer tolerances are needed, holes can be drilled using carbide drills powered by a drill press and boards can be cut with a composite or carbide tipped blade on a radial arm saw. Table saws are not recommended without a carrier board since the motion of the material over the saw bed will tend to abrade away the material. For very close tolerances and large amounts of cutting, CNC machining with solid carbide or carbide tipped tooling is recommended. High tool rotation rates and slow feed speeds are generally best. **FBD** boards can be held in place for CNC machining with a vacuum hold down set up. Hot glue can also be used to fixture **FBD** and if applied sparingly will pull away from the machined part without breaking away material. Hot glue is best applied in small amounts and with the addition of some excess glue on the setter board which can act as a tab. The tab on the setter board can be grabbed with a pliers and pulled to be made free of the setter and the **FBD** part.

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PROPERTIES & CHARACTERISTICS

Bulk Density, g/cc (pcf)	1.4 (90)
Porosity, %	70
Melting Point, °C (°F)	2590 (4694)
Flexural Strength, (Parallel to Thickness) MPa (psi)	8.27 (1200)
Compressive Strength, (Parallel to Thickness), MPa (psi) @ 10% Compression	5.52 (800)
Outgassing in Vacuum	Nil
Dilatometric Softening Temperature, °C (°F) at 10psi	1400 (2552)
Thermal Expansion Coefficient RT - 1400°C (2552°F) (Perpendicular to Thickness)	10.7 x 10^{-6}/C (6 x10^{-6}/F)
Linear Shrinkage (Perpendicular to Thickness), %	
1 hour at 1650°C (3002°F)	0.0
24 hours at 1650°C (3002°F)	0.9
1/2 hour at 2000°C (3632°F)	2
Thermal Conductivity, (Parallel to Thickness)	
W/mK (BTU/hr ft^2 °F/inch) at 400°C (752°F)	0.24 (1.7)
W/mK (BTU/hr ft^2 °F/inch) at 800°C (1472°F)	0.26 (1.9)
W/mK (BTU/hr ft^2 °F/inch) at 1100°C (2012°F)	0.31 (2.1)
W/mK (BTU/hr ft^2 °F/inch) at 1400°C (2552°F)	0.33 (2.3)
W/mK (BTU/hr ft^2 °F/inch) at 1650°C (3002°F)	0.35 (2.5)

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Application Information

- **FBD** is used as self-supporting insulation in industrial furnaces operating up to 1700° Celsius and as supported and back-up insulation in systems operating at much higher temperatures.
- **FBD** is used as protection sleeving in zirconia Oxygen / Carbon sensors.
- **FBD** insulation has been successfully used in Nuclear Meltdown Experiments
- Zircar Zirconia Cement type **ZR-CEM** can be used to bond **FBD** boards and shapes together to build up complex fixtures. Custom shapes can be easily machined.

Availability and Ordering Information

Zircar Zirconia Insulation Type **FBD** is available in standard sized Boards, Discs, and Cylinders which are listed below and on the following page with their ordering item number. Please contact our Sales Department for Pricing and Availability.

- **To order** one of our standard sizes specify the Quantity you wish to order, Product Type, Item #, and Size.
  For example: 12 ea., FBD, Item # AD016, 10" x 10" x 1"
- Our forming process and machining capabilities allow for a wide variety of **custom parts** to be made. Please contact us with your special requirements and we'll be happy to provide you with a quotation.

Standard Sizes	Item No.
Board, 3" x 3" x 0.50" TK	AD001
Board, 3" x 3" x 0.75" TK	AD002
Board, 3" x 3" x 1.00" TK	AD003
Board, 6" x 6" x 0.50" TK	AD004
Board, 6" x 6" x 0.75" TK	AD005
Board, 6" x 6" x 1.00" TK	AD006

Standard Sizes	Item No.
Board, 10" x 10" x 0.50" TK	AD017
Board, 10" x 10" x 0.75" TK	AD018
Board, 10" x 10" x 1.00" TK	AD016
Disc, 6" DIA x 0.50" TK	AD301
Disc, 6" DIA x 0.75" TK	AD302
Disc, 6" DIA x 1.00" TK	AD303

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STANDARD CYLINDER ORDERING ITEM NUMBERS

ID" x OD"	Length		
	2"	4"	6"
0.5 X 0.75	AD5001	AD5002	AD5003
0.5 X 1.0	AD5004	AD5005	AD5006
0.5 X 1.5	AD5007	AD5008	AD5009
0.75 X 1.0	AD500A	AD500B	AD500C
0.75 X 1.25	AD500D	AD500E	AD500F
0.75 X 1.75	AD500G	AD500H	AD500J
1.0 X 1.25	AD500K	AD500L	AD500M
1.0 X 1.5	AD500N	AD500P	AD500Q
1.0 X 2.0	AD500R	AD500S	AD500T
1.0 x 3.0	AD500V	AD501	AD5010
1.5 X 1.75	AD5011	AD5012	AD5013
1.5 X 2.0	AD5014	AD5015	AD5016
1.5 X 2.5	AD5017	AD5018	AD5019
1.5 X 3.5	AD501A	AD501B	AD501C
2.0 X 2.25	AD501D	AD501E	AD501F
2.0 X 2.5	AD501G	AD501H	AD501J
2.0 X 3.0	AD501K	AD501L	AD501M

ID" x OD"	Length		
	2"	4"	6"
2.0 X 4.0	AD501N	AD502	AD5020
3.0 X 3.25	AD5021	AD5022	AD5023
3.0 X 3.5	AD5024	AD5025	AD5026
3.0 X 4.0	AD5027	AD5028	AD5029
3.0 X 5.0	AD502A	AD503	AD5030
4.0 X 4.25	AD5031	AD5032	AD5033
4.0 X 4.5	AD5034	AD5035	AD5036
4.0 X 5.0	AD5037	AD5038	AD5039
4.0 X 6.0	AD503A	AD504	AD5040
5.0 X 5.25	AD5041	AD5042	AD5043
5.0 X 5.5	AD5044	AD5045	AD5046
5.0 X 6.0	AD5047	AD5048	AD5049
5.0 X 7.0	AD504A	AD504B	AD504C
6.0 X 6.25	AD504D	AD504E	AD504F
6.0 X 6.5	AD504G	AD504H	AD504J
6.0 X 7.0	AD504K	AD504L	AD504M
6.0 X 8.0	AD504N	AD504P	AD504Q

STANDARD SIZE TOLERANCES

Boards and Discs: +/- 1/16" on Length, Width, Diameter and Thickness
Cylinders: +/- 1/16" on ID, OD and Length

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