

# Neutron Absorber Materials



Ceradyne, Inc. offers BORAL<sup>®</sup> Composite, BORTEC<sup>®</sup> MMC, BorAluminum<sup>®</sup>, BoroBond<sup>®</sup>, Enriched Boron, and Boron Carbide in a full range of thermal neutron absorber materials for criticality control in wet and dry storage applications and reactor control systems.

## **BORAL<sup>®</sup> Composite**

Well suited to many neutron absorption applications, the BORAL<sup>®</sup> Composite is used for spent fuel storage pools, dry storage canisters and fresh fuel transportation canisters in the United States, Europe and Asia. Since the late 1950's, BORAL<sup>®</sup> has been used in nuclear power plants, research reactors and spent fuel storage systems worldwide. It has the longest continuous service history of any neutron absorbing material, performing its intended function for very long periods in high gamma and neutron radiation fields, never failing to meet its neutron absorption function.

BORAL<sup>®</sup> Composite is produced in our Ceradyne Canada ISO and NQA-1 qualified plant in a wide range of surface dimensions, areal densities and thicknesses. It is manufactured in flat sheets that can be cut, punched, and water set into final dimensions. Physical properties allow it to be designed into fabricated structures that form a solid and effective barrier against thermal neutrons.



Ceradyne is the owner, manufacturer, designer, and exclusive seller of BORAL<sup>®</sup> Composite. Since our acquisition of the BORAL<sup>®</sup> business in June 2006, we have been committed to improving and delivering BORAL<sup>®</sup> Composite products that meet or exceed service requirements.

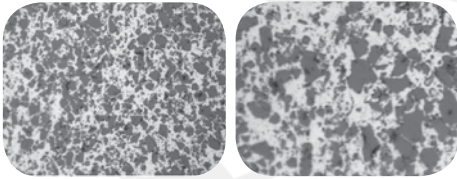
## **BORTEC<sup>®</sup> MMC**

In October 2007, Ceradyne acquired the exclusive rights to fabricate and sell BORTEC<sup>®</sup> MMC. We manufacture BORTEC<sup>®</sup> MMC in our Canadian ISO and NQA-1 facility into rolled sheets and in B<sub>4</sub>C contents up to 32% by weight using various aluminum alloys. The resulting composites have outstanding properties for structural or non-structural design applications, and are lightweight and adaptable for neutron capture in both wet and dry environments. BORTEC<sup>®</sup> MMC is used in high areal density neutron absorber applications and is known worldwide for its quality. It is available using 5000, 6000 and 1000 series aluminum alloys and has successfully passed a series of in-depth nuclear compatibility tests.

- Uniform microstructure
- Excellent mechanical properties using structural Al alloys
- Good thermal conductivity
- Virtually 100% dense
- High B<sub>4</sub>C loaded MMC



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Dense B, C population combined with uniform distribution ensures a very high neutron-absorbing capability for both dry and wet SNF storage.

AA1100-30% B<sub>4</sub>C BORTEC<sup>®</sup> MMC after Rolling

## BorAluminum<sup>®</sup>

BorAluminum<sup>®</sup> is an alloy material incorporating enriched Boron (<sup>10</sup>B) in standard aluminum alloys. It exhibits several superior properties, especially high thermal conductivity, and is in demand because of its unique combination of properties. Non-structural applications typically utilize 1100 Al + <sup>10</sup>B which permit very efficient thermal neutron capture. Applications with structural requirements most frequently are 6351 Al + <sup>10</sup>B which combine neutron absorption with strength of a standard alloy.

BorAluminum<sup>®</sup> is currently in use in several spent fuel storage and transportation applications. Ceradyne Boron Products can supply materials in a variety of rolled sheet or plate and extruded forms.

## Enriched Boron

Enriched Boron (<sup>10</sup>B) is produced by Ceradyne Boron Products to solve demanding neutron absorption requirements. We are the leading global supplier of boron isotopes having developed unparalleled expertise in the separation and analysis of boron isotopes (<sup>10</sup>B and <sup>11</sup>B) and in the measurement of impurities in

boron compounds. Ceradyne Boron Products has created advanced process technology to deliver the highest chemical purity boron products of tailored <sup>10</sup>B / <sup>11</sup>B atomic ratios which meet critical nuclear and electronic applications.

## BoroBond<sup>®</sup>

BoroBond<sup>®</sup> is a chemically bonded phosphate ceramic useful for criticality control, solidification and neutron shielding. It exhibits excellent strength properties and ease of manufacture due to ambient production conditions. Formulations and additives can be customized to provide application specific characteristics. The castability of BoroBond<sup>®</sup> increases its ease of use and flexibility. BoroBond<sup>®</sup> is available with either naturally occurring or enriched isotope ratios of boron.



## Boron Carbide

Boron carbide, both natural and enriched, is the most common material used to absorb and control thermal neutrons. Natural B<sub>4</sub>C is the neutron absorber material in our BORAL<sup>®</sup> and BORTEC<sup>®</sup> products. Boron Carbide is also sold for use in reactor control rods, instrument shielding and as an emergency reactor shutdown material, e.g., scram balls.



## Ceradyne Quality Program

The Ceradyne ISO 9001:2008 and NQA-1 Quality Program is fully qualified, audited, and approved by many worldwide customers. Ceradyne's unique advantage is that we control the entire value stream in the manufacture of these specialized materials. Whether using natural boron carbide from ESK Ceramics or enriched boron from Ceradyne Boron Products, we manufacture neutron absorber materials that meet or exceed stringent end user requirements. Under our NQA-1 and ISO programs, we provide best-in-class

service to our customers covering all steps of neutron absorber manufacturing and processing.

Ceradyne is the only vertically integrated manufacturer of neutron absorber materials that offers a diverse range of rolled BorAluminum<sup>®</sup>, BORTEC<sup>®</sup> MMC, and BORAL<sup>®</sup> Composite products for spent and fresh nuclear fuel containment. These products provide market-leading performance for thermal neutron absorption in both wet and dry spent nuclear fuel storage/transport and fresh fuel transport applications.



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Ceradyne Advanced Technical Ceramics

Ceradyne, Inc. (NASDAQ:CRDN) is a publicly traded corporation specializing in development and vertically integrated production of advanced ceramic materials at facilities based in North America, Europe and Asia. Ceradyne's advanced ceramics are sought for the most demanding applications in automotive, industrial wear, medical, electronic, neutron absorption and defense industries.

