Rio Tinto Alcan

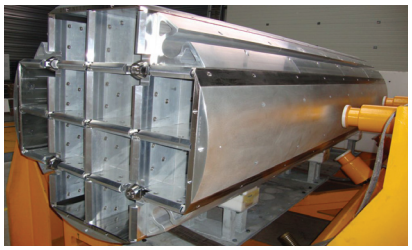
Dubuc Works
SAGUENAY, CANADA

BORALCAN™

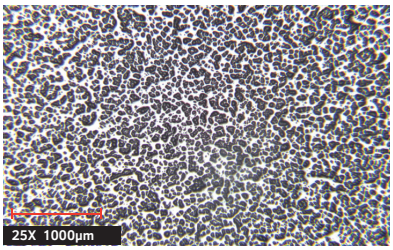
Alloying aluminium and high technology

BORALCAN™ is a Metal Matrix Composite: An aluminium alloy with nuclear grade B_4C addition for use as neutron absorbing material for

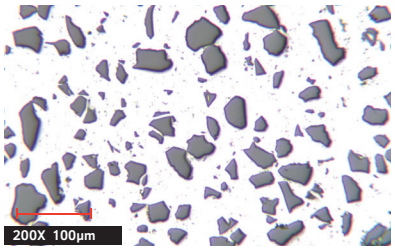
- Spent Fuel Dry Storage Basket in form of rolled strip or extruded shapes.
- Spent Fuel Wet pool Rack shielding in form of rolled strip.



TN 117 BASKET, DESIGNED BY TN INTERNATIONAL



BORALCAN™ 23 % ROLLED



BORALCAN™ 23 % ROLLED

Metal Matrix Composites (MMCs)

Aluminium matrix composites containing reinforcing ceramic particles such as SiC, B_4C and others have been historically used in a range of high performance applications such as transportation components, aircraft and aerospace structures, medical devices and neutron-shielding components. **BORALCAN**™ MMCs are attractive due to their special capability to capture neutrons along with their low density, superior stiffness and strength. Initially, widespread use of B_4C particle reinforced composite materials was limited due to their complex production routes.

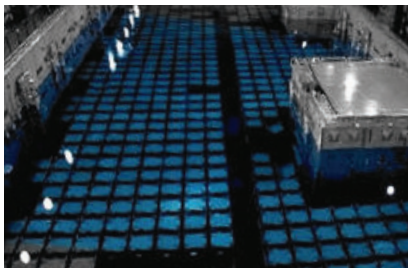
Based on many years of experience in the manufacture of aluminium-based MMC materials, Rio Tinto Alcan has developed a novel liquid mixing process and associated downstream fabrication technologies for the production of **BORALCAN**™ which can now be cast, extruded or rolled into almost any desired shape. A family of **BORALCAN**™ materials incorporating a range of Al matrix alloys and B_4C loadings is now available for use in a broad range of applications.

Common **BORALCAN**™ alloy matrix used are W1100N.xxB, W6351N.xxB which are based on AA 1100 and AA 6351 composition limits.

MMC with B_4C addition is the preferred approach to introduce the ^{10}Boron isotopes used to absorb neutrons.

Boron can typically be incorporated into aluminium as B_4C, TiB_2 or simply metallic Boron. These last two options offer very limited loading due to their low solubility in the aluminium matrix. Naturally occurring boron contains ~20% ^{10}B and ~80% ^{11}B and B_4C is an attractive method of delivery due to:

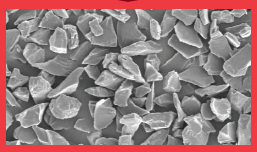
- Its high boron concentration in the particle (78 wt.%);
- Neutron absorption capability from bright loading of B_4C in the aluminium matrix;
- Lightweight (density 2.52 g/cm^3) and is commercially available in large quantities.



WET POOL RACK

BORALCAN™ production process route

Primary Metal +
Alloying Elements
B_4C Powder Treatment



Reactor
(Liquid Mixing)

Casting

Extrusion

Rolling

Via our partners, conversion to finished product by rolling or extrusion

BORALCAN™ product characteristics

LARGE BATCH SIZE: Excellent uniformity of B_4C distribution.

STIFFER: Young Modulus, higher than standard alloys (105 vs 69 GPa) due to cohesion between the particles and the aluminium alloy matrix.

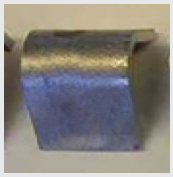
WELDABLE: Using friction stir welding

DRYABLE: 100% dense, no porosity, uniform structure across the whole thickness.

BENDABLE: Best bending characteristics are achieved with alloy W1100N.xxB in O temper condition:

Due to the nature of the material, **BORALCAN**™ exhibits the superior bending capabilities to alternate MMC products. B_4C content, sheet thickness and bend radius are the key parameters impacting the bend performance.

6.1 mm - 130°



4.8 mm - 130°

90° bending - 2.75 mm sheet

Material	MINIMUM BEND RADIUS mm		MINIMUM R/T	
	Rolling direction	Perpendicular to rolling direction	Rolling direction	Perpendicular to rolling direction
1100-17B	5.3	4.5	1.9	1.6
1100-30B	>6.6	5.3	>2.4	2.1

CORROSION RESISTANCE:
Very good, similar to AA 1200

MEASURED WITH ACCELERATED CORROSION TEST

- BWR and PWR pool environment
- In contact with 304L, Inconel 718, Zircaloy
- 16% and 25% B_4C, bent sheet
- Up to 8000 hrs at 195°F, equivalent to 17 years at 80°F

MAIN CONCLUSIONS:

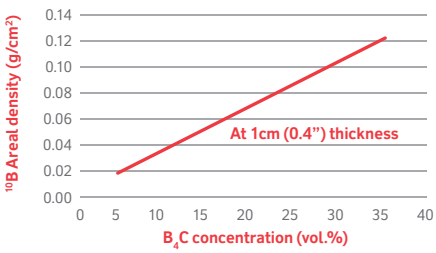
- Typical corrosion rate: ~0.01-0.04 mills/year
- Identical corrosion rate for **BORALCAN**™ 16% and 25% B_4C
- No differences between BWR and PWR environment
- No difference when exposed to galvanic conditions
- No local or pitting corrosion observed

BORALCAN™ process development

B_4C POWDER

- Nuclear grade boron carbide with tight control of the particle sizes
- Nuclear grade boron carbide certified for ^{10}B

Areal density vs B_4C concentration



LIQUID MIXING PROCESS

MAIN FEATURES:

- Efficient process for large-scale production
- Rio Tinto Alcan has patented the process ensuring a homogenous distribution of the B_4C powder incorporated into Al
- Strong interfacial bond between particulate and aluminium alloy matrix
- B_4C loading can vary over a wide range
  - 4.5% to 18% v/v B_4C for extruded products
  - 16% to 30% v/v B_4C for rolled products

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