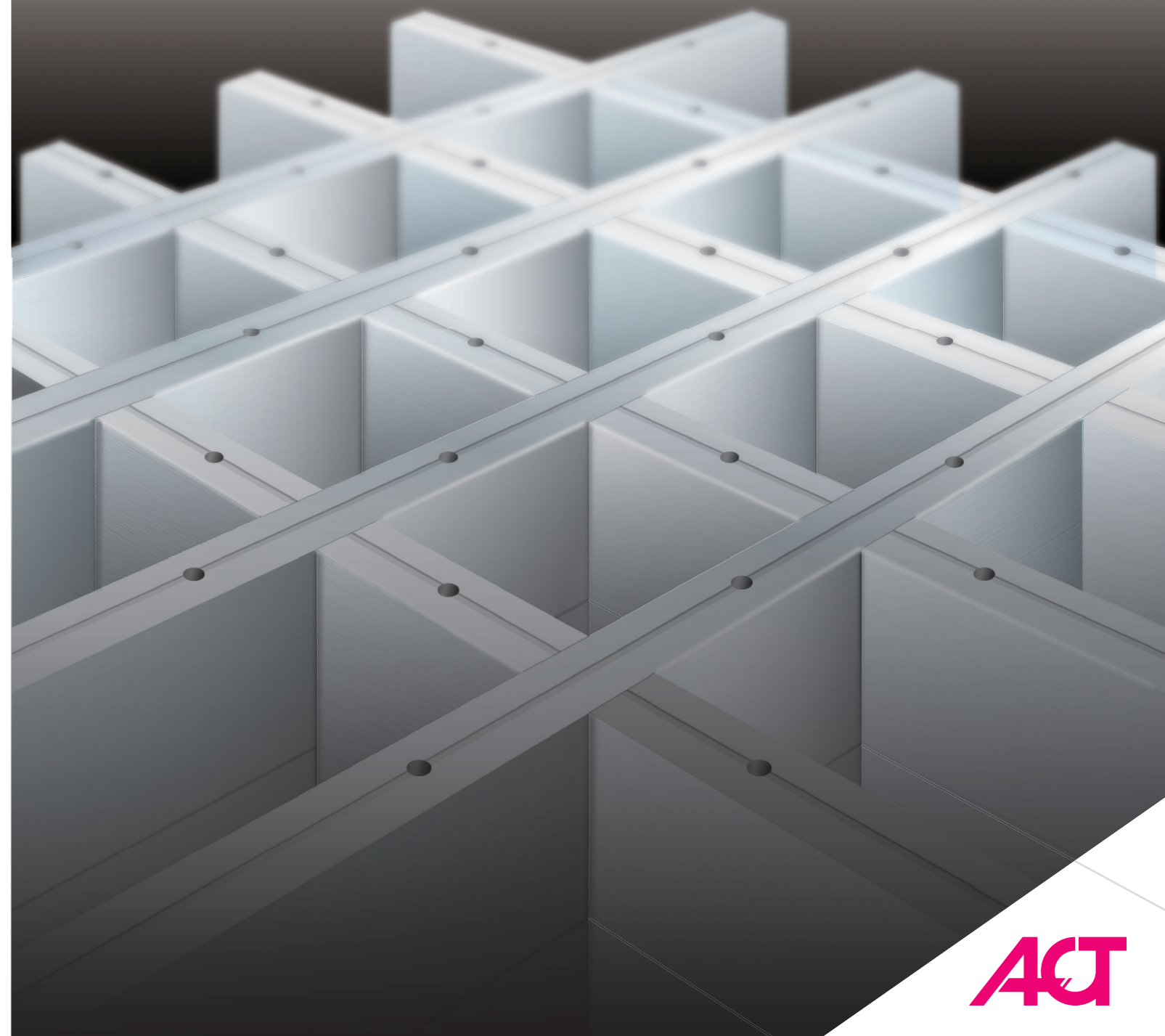


Structural Neutron Absorber

NEVUS-3000[®]

Metal Matrix Composite



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Structural Neutron Absorber

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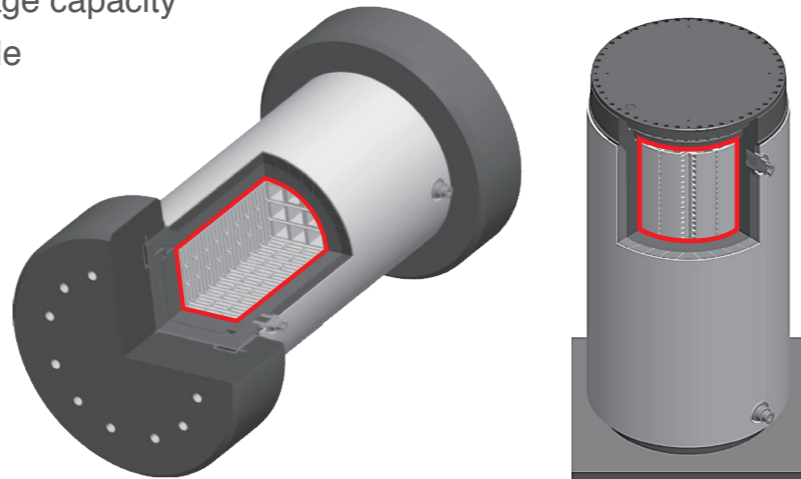
Merits of Aluminium-based Absorbers

Utilities seek effective and easy to handle dry casks for spent fuel storage, and thus require dry cask designs and material that:

1. have optimal spent fuel storage capacity
2. are as light weight as possible

Further, dry cask baskets have three important functions:

- Sub-criticality
- Structural Strength
- Heat Transfer



To meet these design requirements & functions, aluminium-based absorbers:

- are light-weight
- easily allow a water gap design, which PWR dry casks should have for sub-criticality
- have high thermal conductivity to allow heat transfer

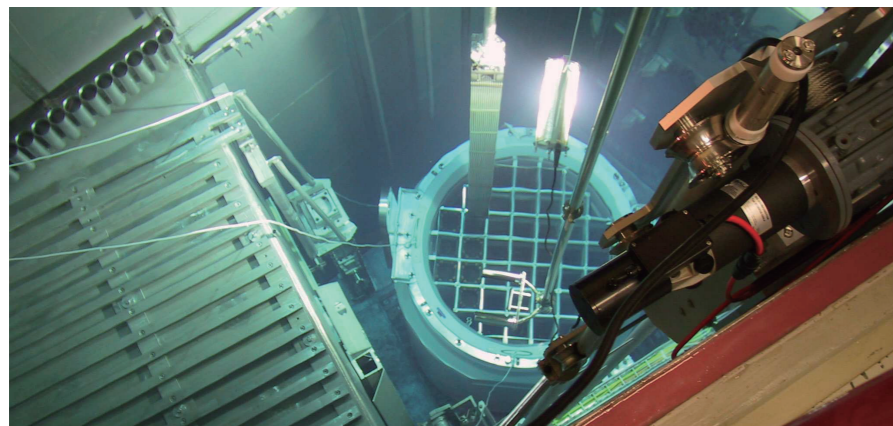
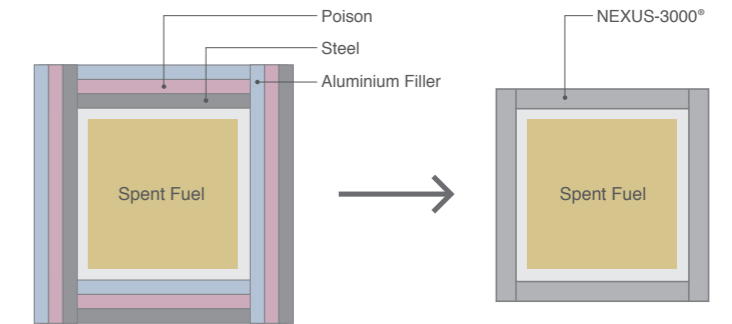


Photo: Orano NPS

What is NEXUS-3000®?

NEXUS-3000® is an extruded aluminium boron carbide metal matrix composites (Al-B₄C MMC) that has the neutron absorption, strength, and thermal conductivity to meet dry cask needs!

It can be used solely in dry cask baskets instead of using multiple materials.



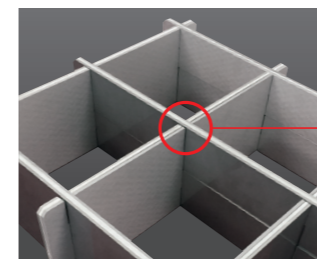
Function	Multi-Material Basket	Single Material Basket
1 Sub-criticality	Poison	Al-B ₄ C MMC (NEXUS-3000®)
2 Structural Strength	Steel	
3 Heat Transfer	Aluminium Filler	

Multi-Material vs Single Material

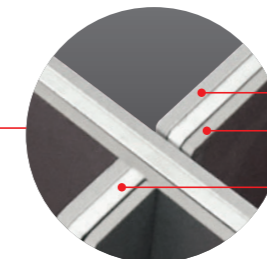
Function	Characteristic	Multi-Material Basket	Single Material Basket
Sub-Criticality	Neutron Absorption Material	Poison (Non-Structural Material)	Al-B ₄ C MMC (NEXUS-3000®)
	Water Gap Design (for PWR Casks)	× Difficult	○ Possible
Structural Strength	Weight	× Heavy	⊙ Light
	Material Strength	⊙ Excellent	○ Good
Heat Transfer	Thermal Conductivity	Poison: ○ Good Steel: × Bad Al Filler: ⊙ Excellent	○ Good

Examples of Dry Cask Baskets

Multi-Material Basket
MAXUS®, Steel & Aluminium

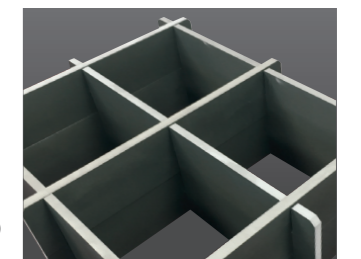


Multi-Material Basket Close Up



- MAXUS® - Sub-criticality
 - Steel - Structural Strength
 - Aluminium - Heat Transfer
- (*MAXUS® is our Al-B₄C MMC non-structural material)

Single Material Basket
NEXUS-3000®



Aluminium Alloy Matrix

There are different aluminium alloys used for extruded aluminium boron carbide metal matrix composites.

Our company has researched the different aluminium alloys and found that our special aluminium alloy for NEXUS-3000® has very stable strength even at high temperature.

Material	Aluminium Alloy Matrix
NEXUS-3000®	Enhanced 3004 (Al-Mn-Mg alloy)
Other	6061 (Al-Mg-Si alloy)
Other	6351 (Al-Mg-Si alloy)



NEXUS-3000® for use in dry storage casks

Photo: Orano NPS

Chemical Composition

● 3004 vs 6061 (Mn, Mg is key to strength)

(unit: mass%)

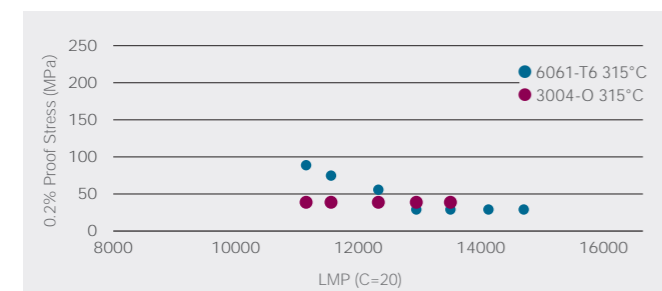
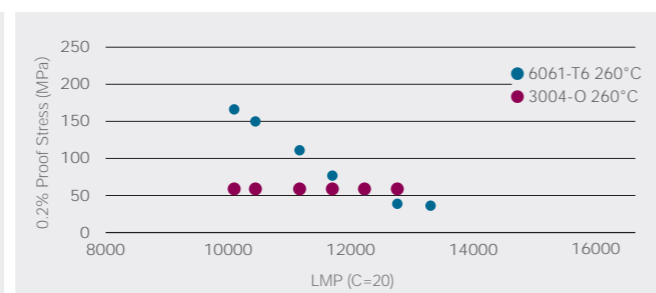
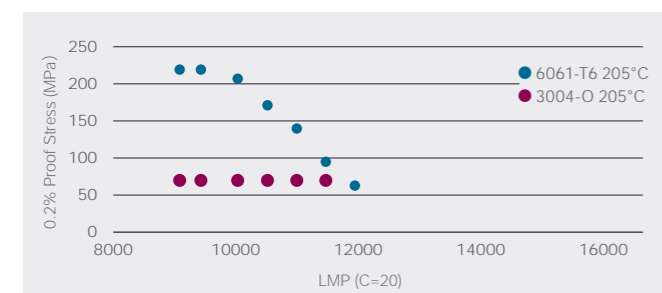
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
3004	≤0.30	≤0.7	≤0.25	1.0~1.5	0.8~1.3	—	≤0.25	—
6061	0.40~0.8	≤0.7	0.15~0.40	≤0.15	0.8~1.2	0.04~0.35	≤0.25	≤0.15
6351	0.7~1.3	≤0.5	≤0.1	0.40~0.80	0.40~0.80	—	≤0.20	≤0.20

Alloy Selection

Why was 3004 aluminium alloy selected?

When compared with 6000 series aluminium alloy, proof stress remains high even after long overaging at high temperature.

6000 series aluminium alloy proof stress vs 3004 aluminium alloy proof stress



LMP : Larson Miller Parameter
 $LMP = (T+273.15) \cdot (20+\log(t))$
 where T= overaging temperature (°C)
 t= overaging time (hours)

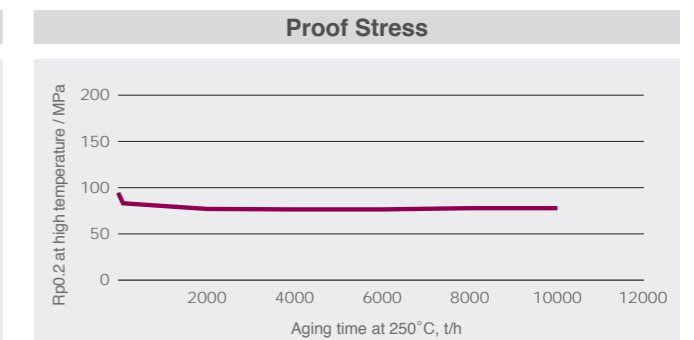
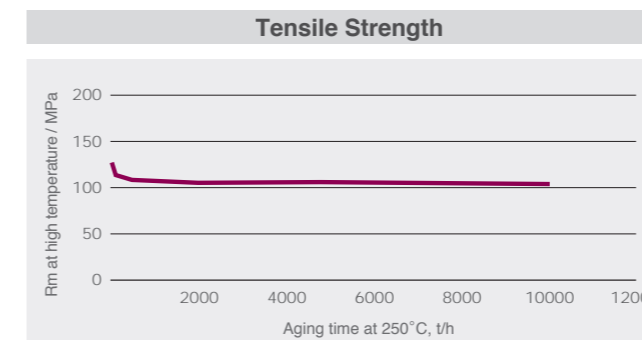
● NEXUS-3000® (Enhanced 3004 - Our aluminium alloy for improved mechanical properties. Mn, Mg is key to strength)

(unit: mass%)

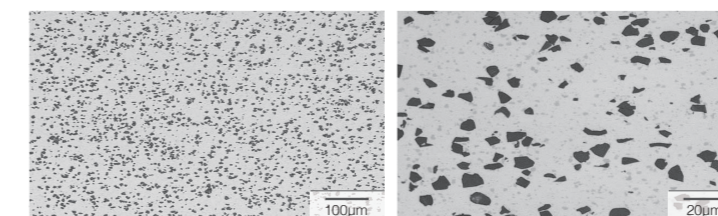
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
NEXUS-3000®	≤0.5	0.3~1.0	0.4~0.8	1.5~2.5	1.0~1.8	≤0.3	≤0.2	≤0.03

Tensile Strength & Proof Stress

NEXUS-3000®'s strength is stable over aging time

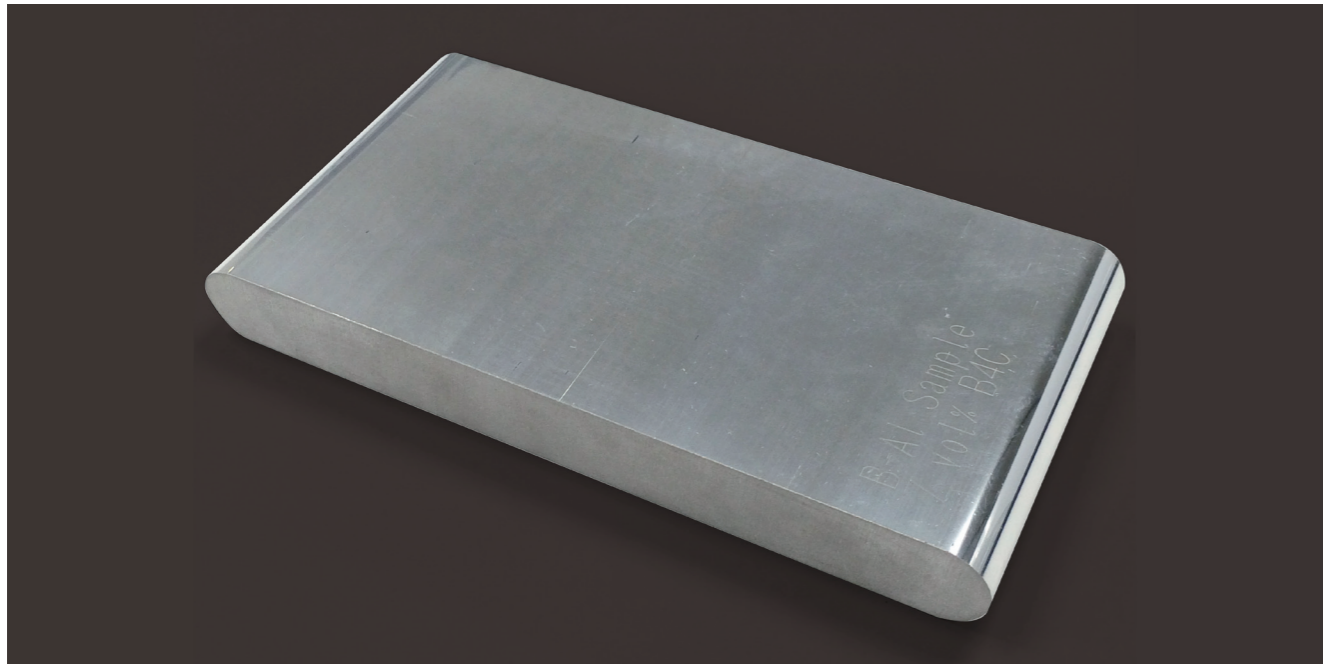


B4C Distribution (microstructure)



Manufacturing process has B4C uniformly distributed within the aluminium alloy matrix

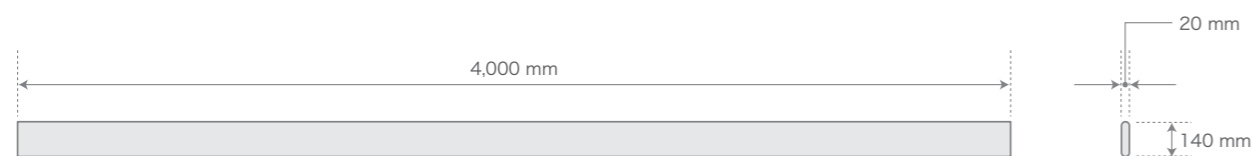
dark gray : B4C (10.5 vol%)
 light gray : Aluminium Alloy Matrix



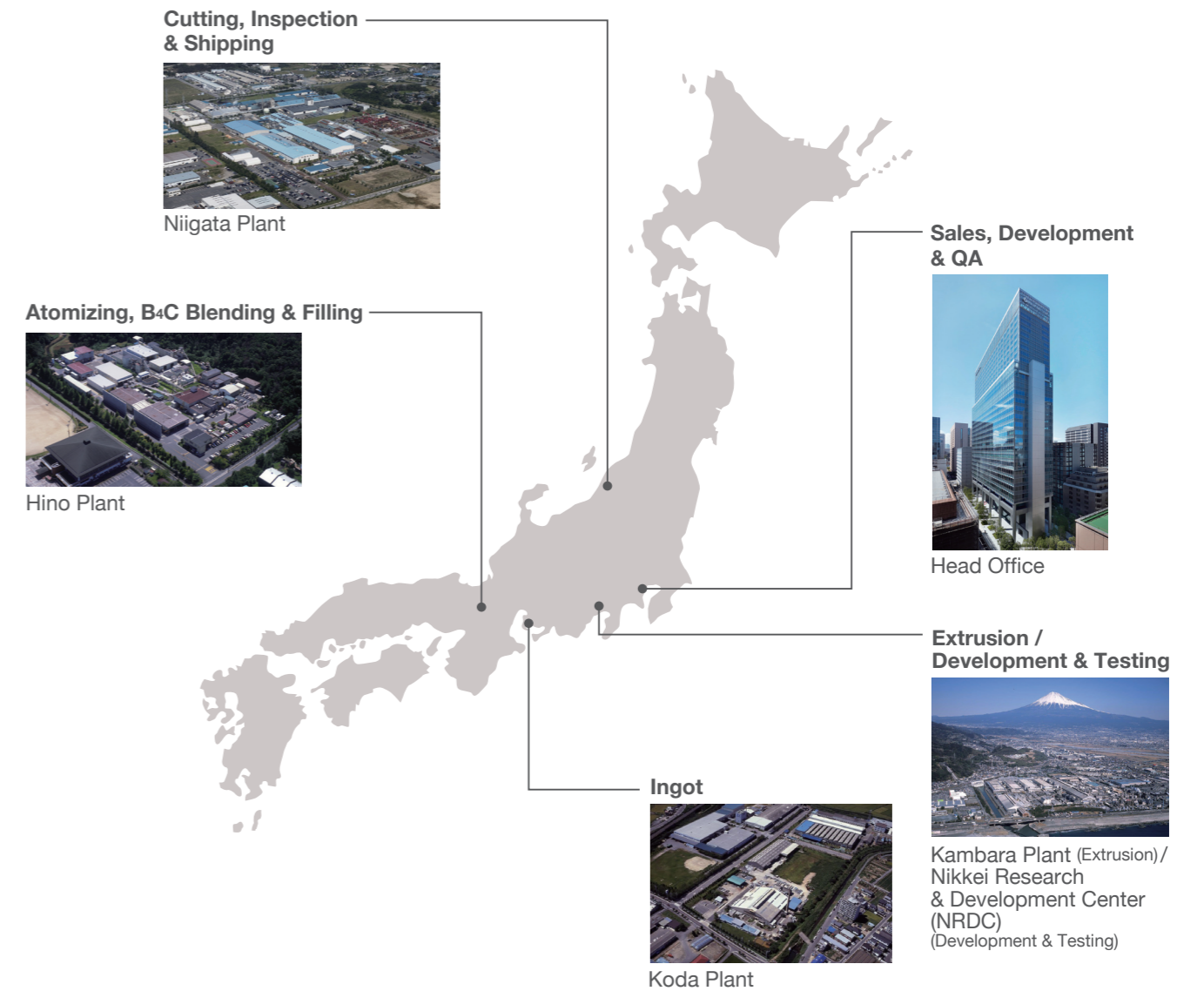
Main Characteristics

Typical Length*	4,000 mm (157 inches)
Typical Width*	140 mm (5.6 inches)
Typical Thickness*	20 mm (0.787 inches)
B ₄ C content	Up to 10.5 vol%
Density (for B ₄ C 10.5 vol%)	2.73 g/cm ³
Thermal Conductivity (for B ₄ C 10.5 vol%)	120 W/m-K

*The dimensions are adjustable to a degree
 **B₄C content can be adjusted depending on customer needs



Plant Location



Manufacturing Process of NEXUS-3000® [Summary]

