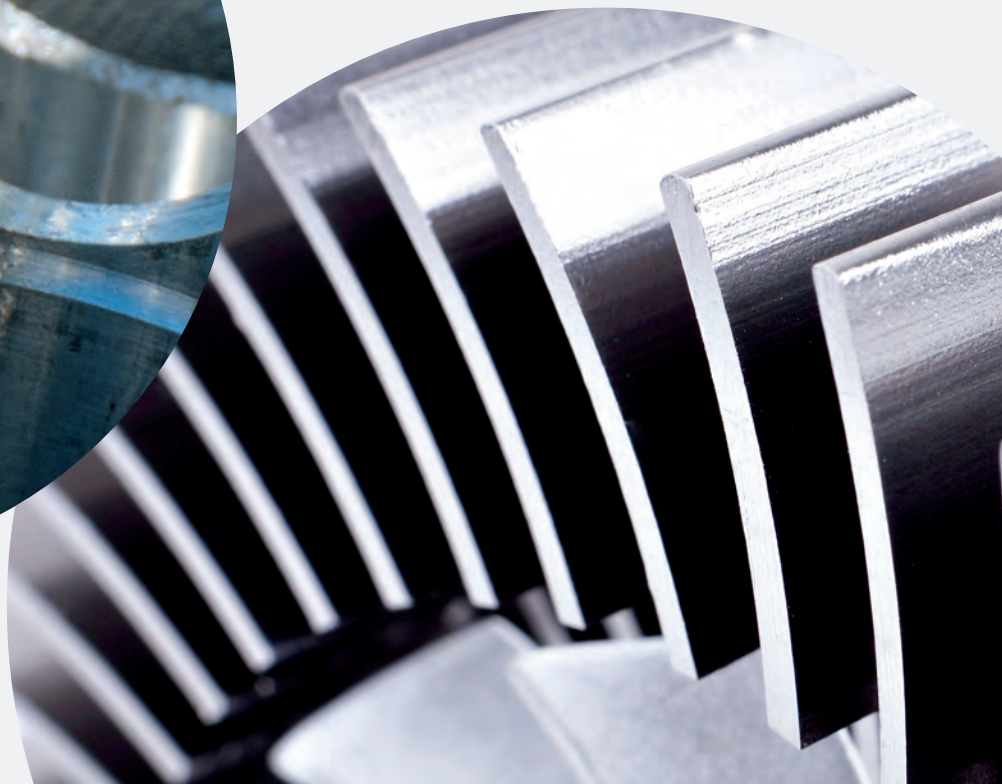
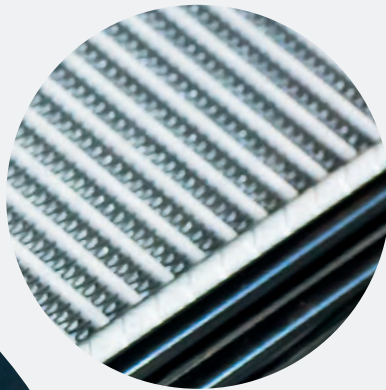


# Aluminium: Your guide to automotive innovation





# Superior Automotive aluminium, the start of a new era

Our vision for the decades to come is being a partner of choice in the automotive market by delivering value through:



## Leading technical support

- Alloy development
- Cutting-edge research
- Training and seminars
- Process improvement



## Consistent high-quality aluminium products

- Strict quality controls
- Stronger, smarter, lighter and cooler vehicles



## Commitment to industry leadership

- Enhanced collaboration strategy with OEMs
- Innovation that sharpens your competitiveness



## A responsible partnership

- Focused on light weight and low carbon emission solutions
- Responsible sourcing through ASI
- Cleaner start to your product lifecycle with RenewAl™
- Developing first carbon free smelting process



## Security of supply

- Integrated from mine to market
- Multi-sourced supply minimizing geopolitical risks
- Casthouses are strategically located to ensure just-in-time delivery



# Superior alloys equal better results

We've created a range of innovating alloys that are helping make the transition to aluminium easier. We continue to develop innovative technologies and products that will serve you for decades to come.

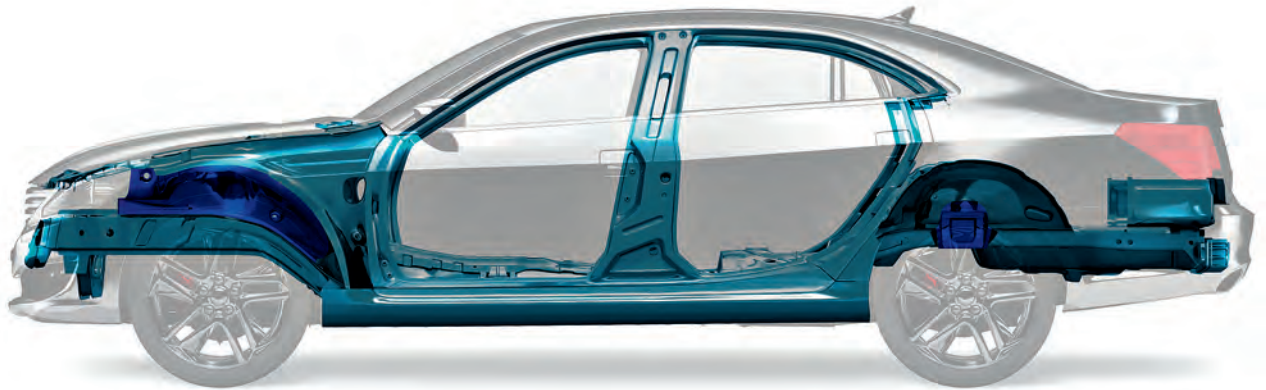
## Stronger **Structural Applications**

### **Aural™ alloys**

High Pressure Vacuum Die Casting (HPVDC)

### **High Strength/High Ductility alloys**

Controlled energy absorption applications



*Structural applications alloys are found in: shock towers, crash management systems, closure inners, and space frames.*

## Lighter **Lightweight Applications**

### **Cylinder Head alloy**

High thermo-mechanical cylinder head

### **High Formability and High Strength alloys**

Body-in-White closure panels



*Lightweight applications alloys are found in: cylinder heads, wheels, and outer skin body panels.*



## Alliances

We've enhanced our automotive expertise by developing over 25 alliances with leading universities, government labs, customers and suppliers.

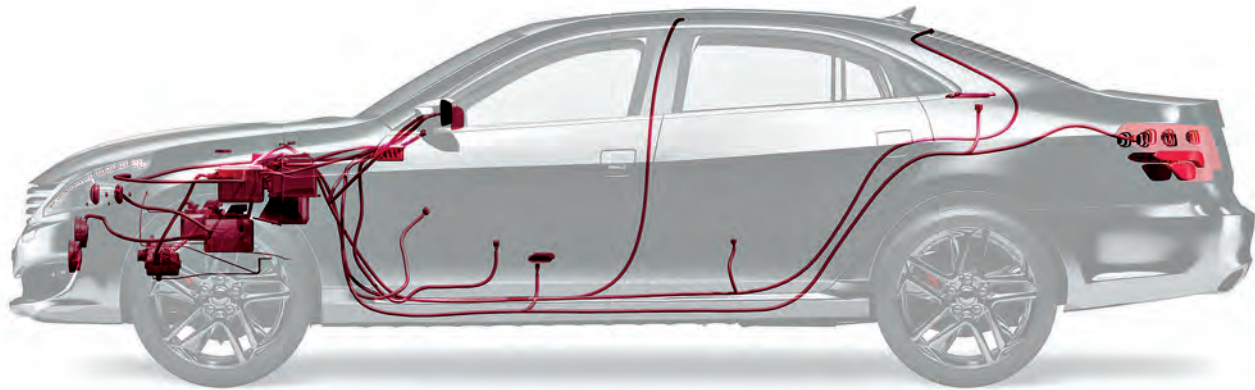
## Smarter **Electric Mobility Applications**

### Rotor alloys

Combining conductivity and strength for electric motors

### High Conductivity and Creep Resistance alloys

Aluminium conductor cable



*Electrical applications alloys are found in: rotors, stators, wires, and connectors.*

## Cooler **Heat Transfer Applications**

### Long Life™ alloys

Heat exchanger applications

### High Extrudability alloys

High-dissipation complex heat sink shapes



*Heat transfer applications alloys are found in: condensers, A/C pipes, and heat sinks.*

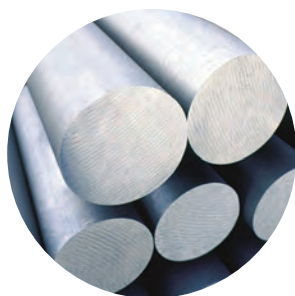


# High quality solutions within reach

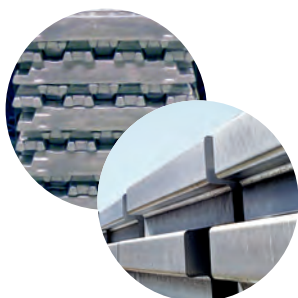
We deliver superior value to our customers by offering technical assistance and training; R&D; process improvement; alloy development; low CO<sub>2</sub> aluminium; supply chain traceability; reliable and fast delivery; and tight chemical composition with repeatable metal quality.

## Our products

<b>Rolling slab</b> Alloys 1xxx, 3xxx, 5xxx, 6xxx, 8xxx series and some 7xxx series	<b>Thickness</b> 444.5 mm-762 mm (17.5 in-30 in)	<b>Lengths</b> Up to 9,600 mm (378 in)			
	<b>Width</b> 1,030 mm-2,514 mm (38.6 in-99 in)	<i>More than 100 rolling slab formats available. Customisation possible upon request.</i>			
<b>Extrusion billet</b> Alloys 1xxx, 3xxx, 6xxx and some 7xxx series	<b>Diameters available</b> 81-355 mm (3.2 in-14 in)	<b>Lengths</b> 457-8,000 mm (18 in-315 in)			
<b>Foundry (ingot and T-bar)</b> 206 series, 242.2, 319.2, 354.2, 355 series, 356 series, 357 series, 359 series, 360, 365.1, 374.1, 375.1, 390.2, A390.1, 413 series, 5xx and 7xx series alloys	<b>Ingot weight</b> 8-24 kg (18-53 lbs)				
	<b>T-bar weight</b> 327-907 kg (720-2,000lbs)				
<b>Rod</b> Alloys 1080, 1120, 1188, 1350, 1370, 4043, 4047, 5005, 6101, 6201, 8030, 8176, Al-Zr	<b>Diameters available</b> 9.5 mm, 12.0 mm, 12.7 mm  <b>Coil dimensions</b> Width 915 mm Inner diameter 775 mm	<b>Outer diameter</b>			
		mm	in	kg	lbs
		1,533	60.4	2,400	5,292
		1,815	71.4	3,700	8,157
1,874	73.8	4,000	8,818		



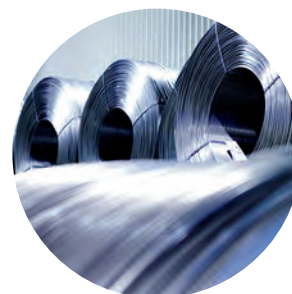
Extrusion billet



Foundry ingot and T-bar



Rolling slab



Rod



## Global reach, Local presence

As a global company, we're always close by. Meeting the needs of over 550 customers in more than 60 countries, we have a long history of just-in-time delivery and short lead-times.

We deliver  
**3.2 million tonnes**  
of aluminium annually.

**1.9 million tonnes**  
in North America

**0.2 million tonnes**  
in Europe

**1.1 million tonnes**  
in Asia-Pacific



**1 British Columbia, Canada:** Kitimat

**2 Quebec, Canada:** Grande-Baie, Laterrière, Alouette, Arvida, AP60, Alma, Dubuc, PLS, Beauharnois, Bécancour, Shawinigan

**3 Iceland:** ISAL

**4 Oman:** Sohar

**5 Australia:** Bell Bay, Boyne Island, Tomago

**6 New Zealand:** NZAS

## Our production and operations

Alloys	Rio Tinto product shape	Operations offering this solution	Production As of December 31, 2018
High formability and high Strength alloys	Rolling slab	ABI, Bell Bay, Grande-Baie, Kitimat, Laterrière, NZAS, Tomago	620,000 tonnes
High Strength and High Ductility Alloys	Extrusion billet	ABI, Arvida, Bell Bay, BSL, ISAL, NZAS, Shawinigan, Tomago	690,000 tonnes
Long Life™ alloys			
High Extrudability Alloys			
Aural™ alloys	Foundry (ingot and T-bar)	Alma, Beauharnois, Bell Bay, Kitimat, NZAS, PLS	300,000 tonnes
Cylinder Head alloy			
Rotor alloys			
High Conductivity and Creep Resistance alloys	Rod	Alma	90,000 tonnes



# The most responsible aluminium for the cleanest car

As pioneers, we are the first to earn Chain of Custody (CoC) ASI certification; we were the first fostering low CO<sub>2</sub> aluminium use with RenewAl™ and we are partnering to develop Elysis breakthrough smelting technology.

## We invite you to take part in the new sustainability benchmark

ASI is a third party certification assessing transparency in the aluminium value chain based on these criteria:



### Social

- Human rights
- Labour rights
- Occupational health and safety



### Governance

- Business integrity
- Policy and management
- Transparency
- Material stewardship



### Environment

- Greenhouse gas emissions
- Emissions, effluents and wastes
- Water Stewardship
- Biodiversity

### Performance Standard

1st level of certification



### Chain of Custody Standard

2nd level of certification



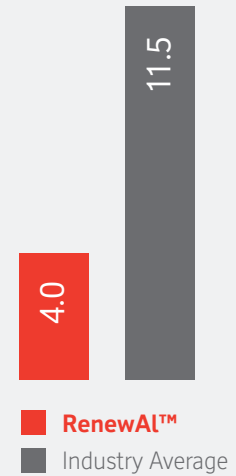
Rio Tinto is the first company to earn both the ASI performance standard and Chain of Custody certification.



We produce a  
**3x** lower CO<sub>2</sub>  
footprint  
with RenewAl™

Certified CO<sub>2</sub> content  
**4tCO<sub>2</sub>/tAL**  
or below

Tonnes of CO<sub>2</sub> emitted  
per tonne of aluminium  
produced (Scope 1&2)



## Recycling is not enough... That's why we created RenewAl™

RenewAl™ is a comprehensive package of aluminium with a certified CO<sub>2</sub> content of 4tCO<sub>2</sub>/tAL or below and customised services.

RenewAl™ offers a cleaner start to your product lifecycle.

### Customised services



**Certification** Third-party certified CO<sub>2</sub> emissions (Scope 1&2)



**Technical expertise** Assistance in leveraging low CO<sub>2</sub> aluminium



**Traceability** Product tracked from mine to metal



**CO<sub>2</sub> reduction strategies** Support to optimise your low CO<sub>2</sub> sources



**Life cycle analysis** Contribution to specific calculation on lifecycle



**Co-branding** Unique partnerships with RenewAl™



## Our partnership created a revolution

Joining know how and expertise to create a revolutionary way to make aluminium. As the world's first carbon-free aluminium smelting process, it eliminates all direct greenhouse gases and produces pure oxygen.

**ELYSIS**





# Committed to innovation that sharpens your competitiveness

We're known for outstanding products and technical support, plus excellent customer service. With so much at stake in your automotive business, consider all the benefits of making us your primary aluminium supplier of choice.

## **Alloy and product development**

If you don't find the perfect alloy or solutions for your needs among our offering, talk to us. We'll work with you to develop precisely what you need.

It is through global partnerships and alliances with universities, colleges, institutions and private R&D centres, that we give you access to cutting-edge alloys and products.

## **Leading technical support**

It's not just about alloys, of course. We're the preferred automotive partner because of our outstanding services. This includes training your teams, assessing your process and offering solutions that enhance your productivity.

## **Security of supply**

As a global company, we're always close by. This means we can offer a range of cost-cutting benefits, including faster response times and more robust supply chains.

## **A responsible partnership**

We're committed to reduce your supply chain's CO<sub>2</sub> footprint, improve your vehicles' fuel economy, and underscore your own commitment to sustainability. How will we do that? With one of the lowest CO<sub>2</sub> aluminium and most sustainable value chain in the industry. RenewAl™, ASI and Elysis are all initiatives allowing us to give you more in a responsive manner.

Stronger, Smarter, Lighter, Cooler

Americas

Europe, Middle East & Africa

Asia Pacific

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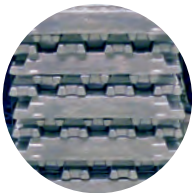
**[riotinto.com](http://riotinto.com)**

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RioTinto

# Stronger Structural Applications

Aural™ alloys



*Foundry ingot  
and T-bar*

**Aural™ series** is a family of high performance alloys specifically designed for demanding automotive safety and structural components.

Aural™ series is specially suited for High Pressure Pressure Vacuum Die Casting (HPVDC) process enabling the production of thin-walled aluminium structural parts with complex geometry for lightweight body structure components.

Aural™ alloys have a superior chemistry content that offers a good balance of strength and ductility, while also exhibiting excellent corrosion resistance. Due to their very good fluidity, these alloys are well suited to the casting of thin and large structural components.

## Key Benefits

High integrity casting made of Aural™ alloy series offers to automotive OEMs:

- Weight reduction
- Crashworthiness performance and very high energy absorption
- Casting design flexibility enabling the reduction of the number of assembly steps
- Tight geometric tolerances, as compared to welding
- Joinability: adhesives, self-piercing riveting, metal inert gas welding and laser welding
- Excellent corrosion resistance without coating
- Mechanical properties: high ductility combined with good tensile strength

## Aural™ alloys are used to create strong:

- Shock towers
- Engine cradles
- Nodes
- Torque boxes
- C-Pillars
- B-Pillars
- Bumper plates
- Instrument panels
- Steering columns
- Engine mounts
- Vibration dampers, housings

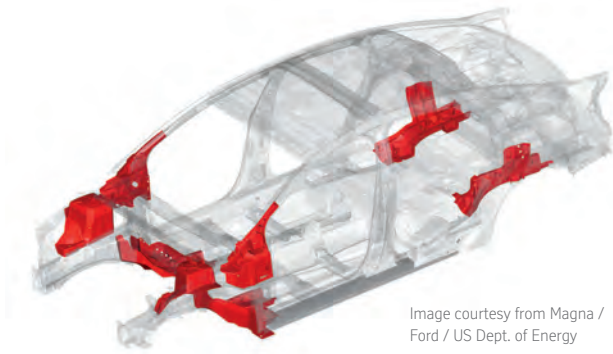


Image courtesy from Magna / Ford / US Dept. of Energy

## Lightweight components

With its enhanced mechanical properties, our Aural™ alloy series enables greater weight saving compared with equivalent steel products or less advanced castings using general-purpose alloys.

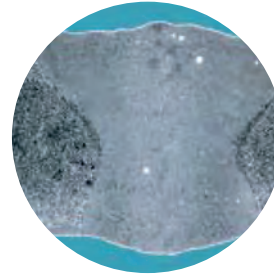
This allows OEMs to meet lightweighting targets without compromising safety.

## Joining technologies

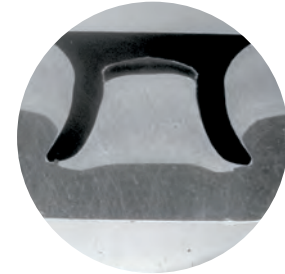
**Welding** Thanks to their composition and casting process, Aural™ alloys offer very good weldability with no tendency to hot cracking. In laser welding, the weld pool freezes markedly faster than in traditional metal inert gas welding (MIG) or tungsten inert gas welding (TIG). The alloys are also suitable to friction stir welding (FSW) and rotary stir welding (RSW).

**Adhesive** Aural™ alloys are suitable for modern automotive construction using structural adhesives bonding specially designed for aluminium joining. This enables compatibility with various extrusion, sheet or casting aluminium alloys and steel.

**Riveting** A joining technology such as self-piercing rivet (SPR) is suitable for Aural™ alloy castings made possible by the high ductility achievable with Aural™ and the appropriate temper.



Laser-welded seams are practically free of porosity, thanks to the very low gas content of the casting



Cross section of self-piercing rivet (SPR) demonstrator weld between Aural™-2 and AA6082-T6 extrusion

## Aural™ alloys typical mechanical properties achievable at various heat treatment processing conditions

Alloy/Temper	R <sub>PO,2</sub> YS [MPa]	R <sub>M</sub> UTS [MPa]	A <sub>5</sub> [%]
Aural™-2 / F	130 – 160	280 – 320	5 – 11
Aural™-2 / T5	165 – 220	270 – 320	4 – 8
Aural™-2 / T6	100 – 160	210 – 250	8 – 14
Aural™-2 / T7	120 – 150	190 – 220	12 – 18
Aural™-3 / F	160 – 180	300 – 340	6 – 10
Aural™-3 / T5	190 – 240	300 – 340	4 – 6.5
Aural™-3 / T7	170 – 190	225 – 245	8 – 11
Aural™-5 / F	110 – 130	240 – 270	8 – 11
Aural™-5 / T5	120 – 160	190 – 260	7 – 11
Aural™-6 / F	100 – 120	250 – 280	10 – 14

F = as-cast

T4 = solutionised, water quench

T5 = as-cast, artificially aged only

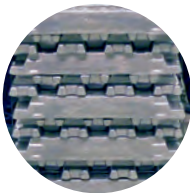
T6 = solutionised, water quench, artificially aged

T7 = solutionised, air quench, artificially aged (Low distortion for thin large castings)

RioTinto

# Lighter Lightweight Applications

Cylinder Head alloy



Foundry ingot

Compared to traditional engines, turbo charged, direct injection and diesel engines offer lower fuel consumption and higher torque. The trend towards high specific output engines has been accelerating with continuing pressure to improve fuel economy, lower emissions and downsize the engine.

Our **Cylinder Head alloy** was developed for highly stressed engine cylinder heads, enabling the use of higher operating temperatures and pressures.

This alloy, mainly intended for high thermo-mechanical cylinder heads, has excellent properties in the critical 250–300°C temperature range, now reached in the hottest spots of the combustion chamber. At room temperature, it exhibits high UTS (> 330 MPa), good ductility

## Key Benefits

Our Cylinder Head alloy for high thermo-mechanical cylinder head castings offers to automotive OEMs:

- High specific outputs for engines
- Weight reduction
- Creep strength performance
- Primary Al-Si-Mg (Cu, Ti, Zr) and Al-Si-Cu-Mg (Ti, Zr, V) compositions to increase mechanical properties, particularly ductility
- The addition of dispersoid formers to increase creep strength and thermal fatigue life
- Optimised chemistries for cylinder head endurance without expensive and unnecessary exotic chemical additions

(6–8%) and excellent high cycle fatigue strength (HCF) for a T7 treated alloy: 120-135 MPa at 10 million cycles (R=-1).

## Cylinder Head alloy is used to create light:

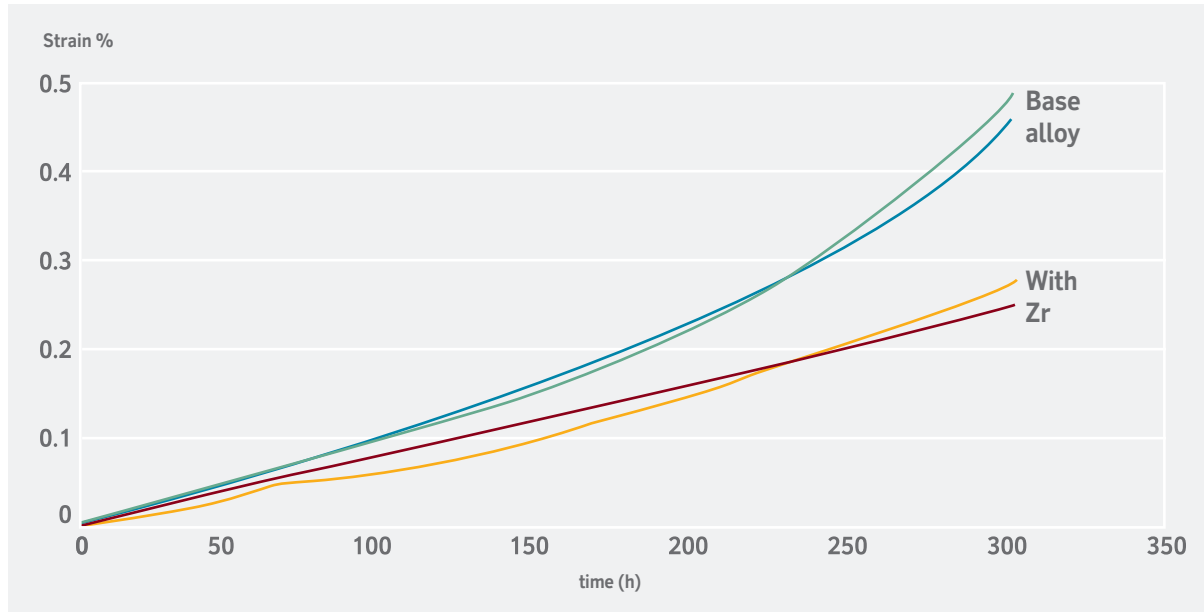
- Cylinder heads

## High thermo-mechanical cylinder head properties

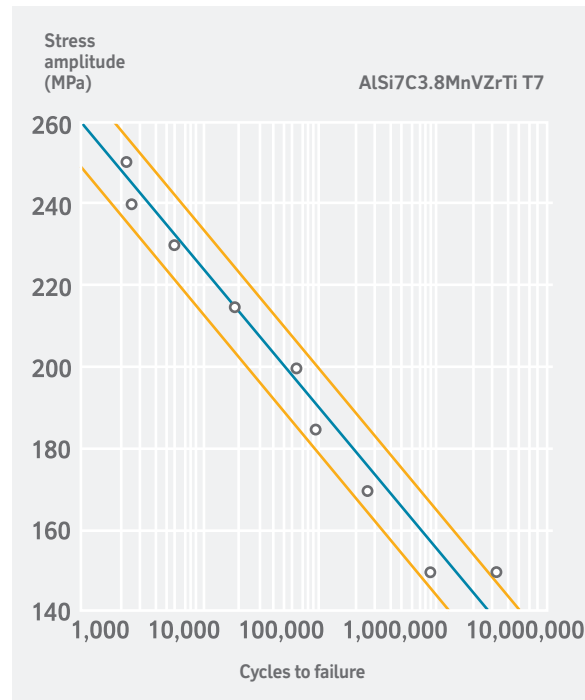
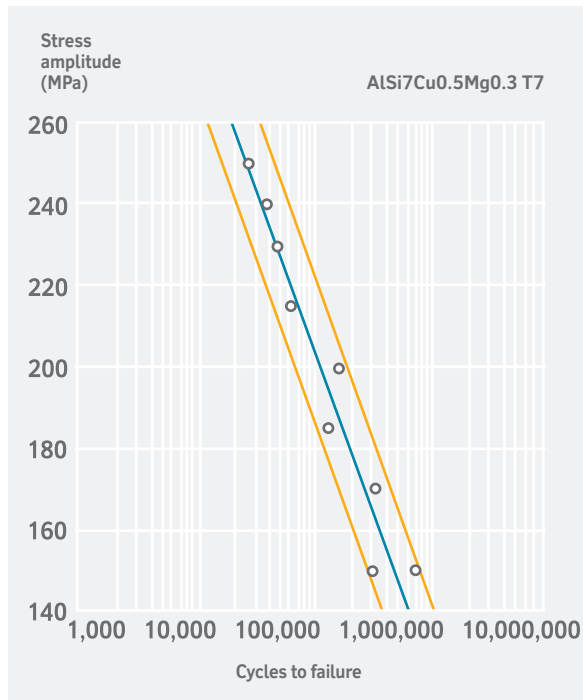
During full load operation, the inter-valve bridge reaches ~300°C near its combustion chamber surface. As the engine cools, the inter-valve bridge tends to contract. Repetition of this thermal

cycling leads to a low cycle mechanical fatigue phenomenon and causes the initiation of cracks at or near the surface of the combustion chamber.

Creep at 300°C under 22MPa Load (A356+0.5%Cu)



## Comparative low cycle fatigue (LCF) strength performance



Our Cylinder Head alloy provides higher creep resistance, reducing mechanical fatigue in the inter-valve bridge region through the addition

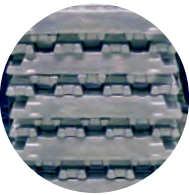
of peritectic elements. Its higher mechanical properties improve inter-valve bridge resistance to the initiation of cracks.



RioTinto

# High Wear Resistance Applications

Duralcan™ alloys



Foundry ingot

The **Duralcan™** Metal Matrix Composites (MMCs) are high technology aluminium alloys providing increased elastic modulus and high wear resistance for demanding automotive safety and structural components.

Duralcan™ composites contain aluminium oxide or silicon carbide particulate. The composites are manufactured by mixing the ceramic powder into molten aluminium. By using a proprietary technology the melt is then cast into extrusion billet, rolling slab or foundry ingot.

## Key Benefits

High technology products made of Duralcan™ offer to automotive OEMs:

- Weight reduction
- High wear resistance and no rotor hot spots
- Casting design flexibility
- Noise reduction
- Mechanical properties: increased elastic modulus

The F3S.20S composite was developed for general foundry usage from plaster cast to permanent mould, while the F3N.20S series was developed for high-pressure die-casting.

## Duralcan™ alloys are used to create:

- Brake rotors, drums
- Brake calipers
- Brake-pad back plates
- Cylinder liners
- Suspension arms
- Brackets
- Crankcase girdles/ladders
- Turbocharger impellers
- Housings
- Valve train components
- Steering links
- Stabilizer bars
- Clutch plates
- Differential housings

## Duralcan™ typical physical properties

		A356 <sup>a</sup>	F3S 20S <sup>a</sup>	F3N.20S-F
Density (g/cm <sup>3</sup> )		2.68	2.77	2.71
Electrical Conductivity (%IACS)	22°C	37.5	26.4	24.7
Thermal Conductivity (cal/cm-s-K)	22°C	0.360 <sup>b</sup> 0.372 <sup>c</sup>	0.442 <sup>d</sup> 0.480 <sup>d</sup>	0.401
Specific Heat (cal/g-K)	25°C	–	0.200	0.193
	100°C	–	0.218	0.215
	150°C	–	0.228	0.227
	200°C	–	0.239	0.238
	250°C	–	0.249	0.249
	300°C	–	0.259	0.259
Average Coefficient of thermal Expansion (10 <sup>-6</sup> /K)	50-100°C	21.4	17.5	16.6
	50-300°C	–	21.1	20.0
	50-500°C	–	21.4	20.2

<sup>a</sup> °F temper for electrical conductivity and specific heat; T5 temper for CTE.

<sup>b</sup> T6 temper <sup>c</sup> T7 temper <sup>d</sup> T71 temper

## Chemical compositions of Duralcan™ F3S and F3N matrix alloys

	Si	Fe	Cu	Mn	Mg	Ni	Ti	All other elements	Al
F3S Alloy	8.50 -	0.20	0.20		0.45 -	–	0.20	0.03 max	Rem.
	9.50	max	max		0.65		max	0.10 total	
F3N Alloy	9.50 -	0.80 -	0.20	0.50 -	0.50 -	–	0.20	0.03 max	Rem.
	10.50	1.20	max	0.80	0.70		max	0.10 total	

Numerical values denote weight percent.

Duralcan™ F3S.xxS composites (xx = volume percent SiC particulate) are general-purpose composites for room-temperature applications. They are similar to 359/SiC/xxp (Aluminum Association MMC nomenclature).

Duralcan™ F3N.xxS composites, containing virtually no Cu and Ni, are designed for use in corrosion-sensitive applications. They are similar to 360/SiC/xxp.

Duralcan™ composites are heat-treatable.

## Tensile properties and hardness of Duralcan™ F3S and F3N matrix alloys

	Ultimate strength (MPa) <sup>1</sup>	Yield strength (MPa) <sup>1</sup>	Elongation (%)	Elastic modulus (GPa)	Rockwell hardness HRB
A356-T6 <sup>2</sup>	276 (255)	200	6.0	75.2	55
F3S.20S-T6 <sup>3</sup>	359 (317)	338 (310)	0.4	98.6	77
F3S.20S-T71 <sup>4</sup>	262	214	1.9	98.6	–
F3S.20S-O <sup>5</sup>	221	165	2.6	98.6	–
F3N.20S-F	303 (262)	248 (221)	0.5	108.2	73
F3N.20S-T5	365 (338)	338 (317)	0.3	108.2	73

<sup>1</sup> Typical and (minimum) values. Minimum values represent 99% confidence interval.

<sup>2</sup> Measured by direct reading from stress-strain plot.

<sup>3</sup> 80 and 241 cast-to-size tensile bars, solutionized at 538°C for 8 hours, aged at 154°C for 5 hours.

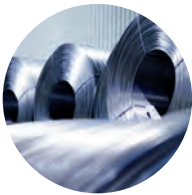
<sup>4</sup> 6 cast-to-size tensile bars, solutionized at 538°C for 8 hours, aged at 246°C for 3 hours.

<sup>5</sup> 6 cast-to-size tensile bars, aged at 343°C for 4 hours.

RioTinto

# Smarter Electric Mobility Applications

High Conductivity and Creep Resistance alloys



Rod

Our **High Conductivity and Creep Resistance series** is a family of 6000 series electrical rod alloys specifically designed for demanding automotive aluminium conductor components that combine strength and conductivity.

As a supplier of value added aluminium rod, we are committed to consistently high product quality:

**Eddy current** 100% tested as a routine quality control measure.

**Surface inspection** 100% visual inspection to ensure cleanliness and freedom from surface defects.

## Key Benefits

High Conductivity and Creep Resistance series for aluminium conductor cable offers to automotive OEMs:

- Maximum conductivity and creep resistance for automotive applications
- Aluminium conductor is half the weight of an equivalent copper conductor
- Specific alloy formulation that allows wiredrawing down to 0.2 mm diameter
- Tight chemical control to guaranty electrical conductivity

**Property inspection** Diameter, roundness, mechanical properties and electrical conductivity.

## High Conductivity and Creep Resistance alloys are used to create smart:

- Wire harnesses
- Conductor cables

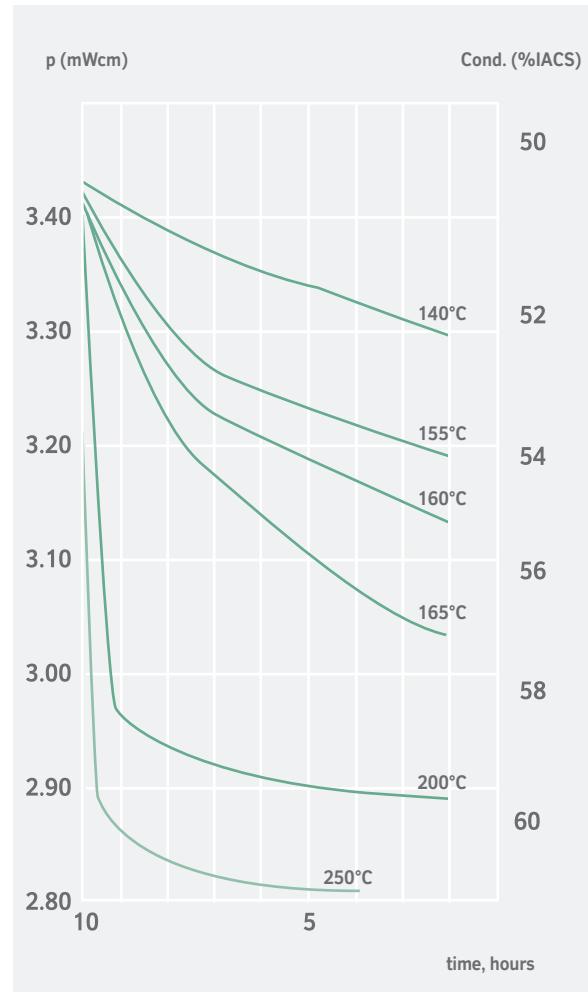
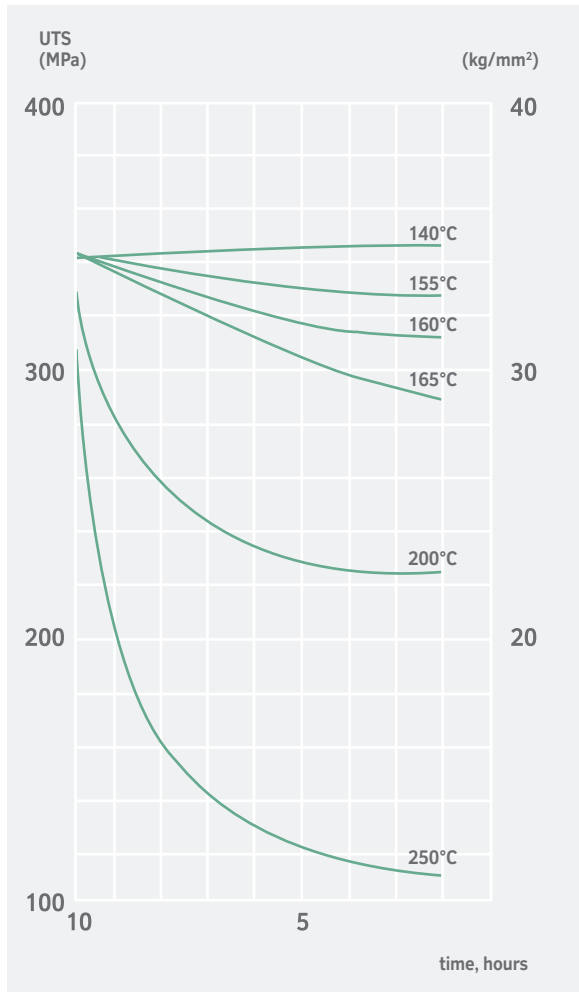
## Aluminium conductor cable properties

The conversion of the quenched High Conductivity and Creep Resistance series redraw rod to the final wire involves the following series of operations:

- Wiredrawing to the final diameter
- Artificial ageing treatment
- Stranding

The properties of the drawn wire are checked after the artificial ageing process, which is required in order to achieve a satisfactory combination of mechanical and electrical properties.

The following curves for our High Conductivity and Creep Resistance 6000 series alloy illustrate tensile strength and resistivity at treatment time and temperatures.



Typical conductivity and property values for as-drawn 2.5 mm diameter wire are tabulated below:

Grade	Non-slip machine			
	UTS MPa	Resistivity $\mu\Omega\text{ cm}$	Conductivity	
			%IACS	mS/mm <sup>2</sup>
610145	320	3.35	51.4	29.8
610155	325	3.400	50.7	29.4
610166	370	3.515	49.0	28.4

RioTinto

# Cooler Heat Transfer Applications

High Extrudability alloy



*Extrusion billet*

Our High Extrudability alloys such as the **6360 High Performance alloy** is specifically designed to provide more than 6% higher thermal conductivity than comparable 6000 series alloys.

The alloy composition is tailored to provide higher extrudability, enabling the extrusion of complex profiles with high aspect ratio, multi-hollow and large cross section areas.

## Key Benefits

6360 High Performance extrusion alloy for heat transfer applications offers to automotive OEMs:

- At equal heat transfer, aluminium allows weight savings of more than 60% compared to copper
- Cost effectiveness in comparison to general purpose alloys
- Design flexibility for complex shapes
- Tight dimensional tolerances
- High formability
- Suitable for high speed machining
- Excellent post-extrusion treatment (ie, anodisation)
- Joinable by all modern processes
- Excellent corrosion resistance without coating

## High Extrudability alloy is used to create cool:

- Heat sinks: Semiconductor, Cooling system, LED lighting
- Electric components
- Radiators

## Thermal conductivity for 6360 High Performance alloy

Thermal conductivity value quoted by the Aluminum Association for AA6063-T6 is 201W/m.K while AA6360-T6 is 214W/m.K at 25°C. This is equivalent to about 6% better value when comparing AA6360 to AA6063.

Conduction and mechanical performance work together in perfect harmony, with 6360 High Performance: The alloy combines high-dissipation heat transfer with T5 or T6 mechanical properties, guaranteeing high conductivity as well as performance features through post-extrusion treatments and machining.

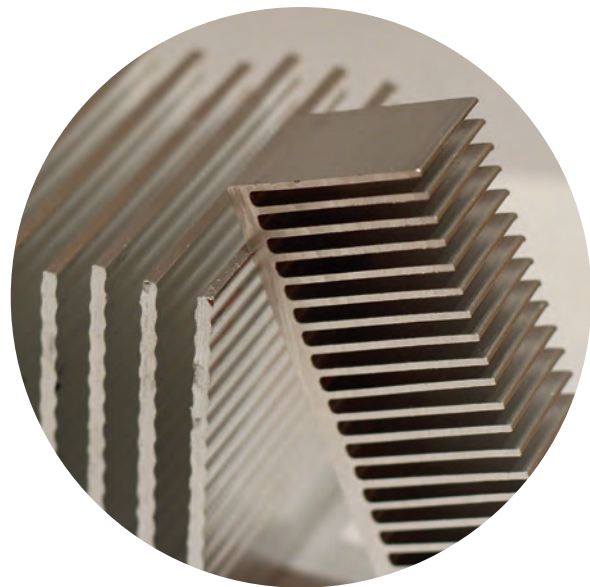
Thermal conductivity at various temperatures for our AA6360-T6 and AA6063-T6:

Thermal Conductivity		
Temperature °C (°F)	Thermal Conductivity in W/m-K	
	AA6360-T6	AA6063-T6
23°C (73.4°F)	214	203
50°C (122°F)	217	208
100°C (212°F)	226	214

Registered mechanical properties for our AA6360-T5 and T6:

Alloys and tempers*	Thickness	Registered properties		
	Up through (millimeters)	UTS (MPa)	YS (MPa)	Elongation (%)
AA6360-T5	6.30	150	110	8
AA6360-T6	3.20	205	170	8
	3.20-6.30	205	170	10
Typical AA6360-T6		228	207	10-14

\*Registered properties with The Aluminum Association, Inc.



*Comb shape with fin thickness of 0.8-1.2 mm and height of up to 140 mm can be extruded with 6360 High Performance alloy, creating fins that are more lightweight than typical extruded fins*

RioTinto

# Lighter Lightweight Applications

High Formability and High Strength alloys



*Rolling slab*

Lightweight aluminium designs offer the possibility of improving a vehicle's safety performance while simultaneously reducing its mass.

Aluminium's mass-specific energy absorption capacity is twice that of mild steel and also compares favourably to the newly developed high strength steel grades. Car safety is not only a question of material selection. Design and the manufacturing concept are even more important.

Rio Tinto offers a variety of 5000 and 6000 series **High Formability and High Strength alloys** for automotive closure and panel applications.

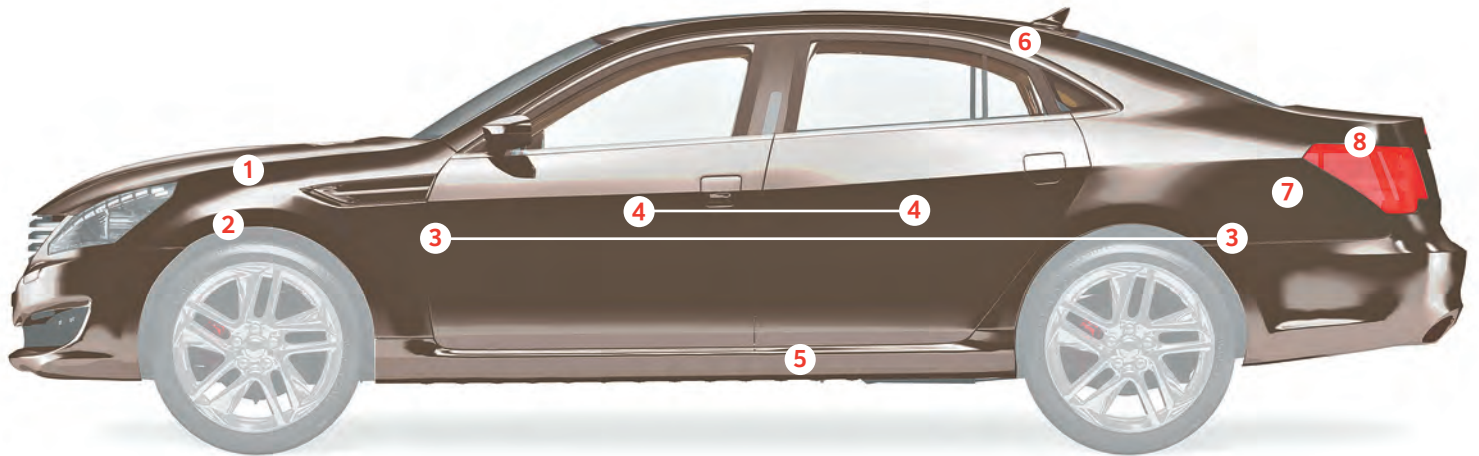
## Key Benefits

High Formability and High Strength alloys for automotive aluminium stamping offer to automotive OEMs:

- Weight reduction, for improved vehicle handling and reduced braking distances
- High surface quality for outer skin application
- Increased pedestrian protection, owing to high energy absorption characteristics
- Corrosion resistant alloys for under and outer body
- Complex shapes and high formability to avoid cracking during hemming operations
- Deep stamping possibilities for enhanced car body panels
- High strength for demanding structural and reinforcement parts

## High Formability and High Strength alloys are used to create light:

- Hood or bonnet panels
- Liftgate panels
- Floor panels
- Door panels
- Roof panels
- Fenders or wings



**We deliver superior quality and low CO<sub>2</sub> primary rolling slab suitable for automotive closure and panel applications.**

- 1 Hoods or bonnets** have a double-layered internal (5000 alloy series) and external (6000 alloy series) panel structure. These are the largest panels on the vehicle and are designed to crumple on impact.
- 2 Fenders or wings** are one of the earliest non-structural parts made of aluminium 6000 alloys.
- 3 The firewall or bulkhead** using 5000 series alloys is a structure used to separate the passenger compartment from the engine room and trunk.
- 4 Doors** are constructed from inner (5000) and outer (6000) panel sections. Front doors have typical gauge ranges of 1 to 1.2 mm and rear doors typically 0.8 to 1 mm.
- 5 Floor panels** are key components of the all-aluminium alloy monocoque, using 5000 series alloys with a typical gauge of 1.2 to 1.5 mm.
- 6 Roofs** are typically made of 5000 series alloys with a gauge of 1 mm. These large panels bear the stresses acting on each of the pillars.
- 7 Side panels** are structural parts typically made of 6000 series alloys, with a gauge of 1 mm, that form the structural skin of the vehicle.
- 8 Trunk or boot lid and package tray** use the same alloys as hoods or bonnets.

**More Benefits**

**Independent** We're an independent third-party supplier. We don't compete with our customers, we partner with them.

**Partners** We have long-term partnerships with all of the world's leading auto sheet rollers.

**Expert** Strong casting expertise, metal quality and purity make us a supplier of choice to the automotive industry for all its specialty alloys.

**Proximity** As a global company, we're always close by. We offer short lead times and on-time delivery to meet the exact demands of the automotive supply chain.



RioTinto

# Stronger Structural Applications

High Strength/High Ductility alloys



*Extrusion billet*

Our **High Strength/High Ductility alloys** are a family of specialty extrusion alloys for automotive safety and structural components. These alloys offer a range of formability for various energy absorption demands with no brittle fragmentation.

Based on the energy absorption requirements of a vehicle, our metallurgists have tailored composition and processing conditions for each alloy available.

## Key Benefits

High Strength and High Performance alloys for structural extrusion offer to automotive OEMs:

- Cost effectiveness
- At equal energy absorption, aluminium allows weight savings of roughly 40% compared to steel designs
- Crashworthiness performance, superior energy absorption
- Unlimited design flexibility of complex extrusion shapes
- Tight tolerances and variable wall thicknesses for optimised designs
- Consistent formability for tight bend
- Joinable by all modern processes
- Excellent corrosion resistance without coating

## High Strength/High Ductility alloys are used to create strong:

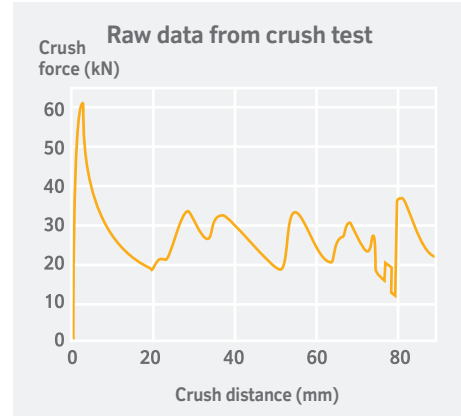
- Crash boxes (front and rear)
- Longitudinal bumper beams (front and rear)
- Bumper plates (front and rear)
- Closure hinge reinforcements

## Crash performance behavior of High Strength/ High Ductility alloys

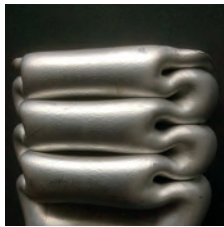
In an automobile, the crash energy is primarily absorbed by the front and rear crash management systems, followed by the deformation of the longitudinal beams. The following chart shows the measure of energy absorbed as the area under the crush force / distance curve.

The data for crash performance behaviour of High Strength/High Ductility alloys at various aging conditions is available to optimise the OEM's structural design of collision management systems.

Proper alloy selection and processing conditions ensure that the crash management systems deform extensively before crack formation starts. We offer materials with a range of folding behaviour and energy absorption with no brittle fragmentation, guaranteeing extrusion integrity in the event of a collision.



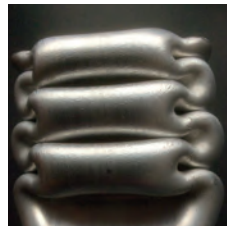
## Rio Tinto offers a crush simulation capability to predict the performance of the selected alloy for the customer's profile geometry



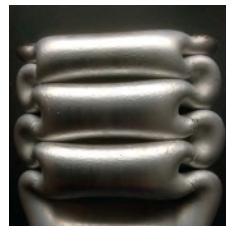
Grade 1



Grade 2



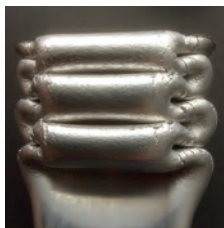
Grade 3



Grade 4



Grade 5



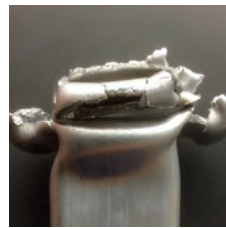
Grade 6



Grade 7



Grade 8



Grade 9

*Folding evaluation of various crash alloys and extrusion conditions*

Typical properties for crash box application with various AA6000 series alloys.

Low Strength 6060	Medium Strength 6060-6063	Medium/High Strength 6063-6008	High Strength 6063
UTS: 150 MPa ± 15	UTS: >220 MPa	UTS: >230 MPa	UTS: 240-290 MPa
YS: <b>70 MPa</b> ± 10	YS: <b>&gt;170 MPa</b>	YS: <b>&gt;200 MPa</b>	YS: <b>210-250 MPa</b>
Elongation: >18%	Elongation: >10%	Elongation: >11%	Elongation: >10%



Typical properties for beam application

Medium Strength 6005A, 6008, 6061	Medium Strength 6082	High Strength 6082	High Strength 6XXX
UTS: >300 MPa	UTS: >320 MPa	UTS: >350 MPa	UTS: >380 MPa
YS: <b>&gt;260 MPa</b>	YS: <b>&gt;280 MPa</b>	YS: <b>&gt;320 MPa</b>	YS: <b>&gt;350 MPa</b>
Elongation: >10%	Elongation: >10%	Elongation: >10%	Elongation: >10%

*Crushing evaluation of High Strength and High Performance alloys in all extrusion conditions*

RioTinto

# Cooler Heat Transfer Applications

Long Life™ alloys



*Extrusion billet*

Our **Long Life™** alloy family is designed to provide advanced performance in heat exchanger applications that utilise thin wall extruded mini micro port (MMP) heat transfer tubing. These alloys deliver superior corrosion resistance for brazed heat transfer applications, such as automotive AC condensers and oil coolers, as compared with standard alloys such as AA3102.

Long Life™ alloys have been developed for demanding brazed applications requiring maximum corrosion resistance and have a proven track record in the automotive and HVAC industries.

Due to primary aluminium source with controlled trace elements, the Long Life™ alloy family ensures high corrosion resistance.

## Key Benefits

Long Life™ extrusion alloys for heat transfer applications offer to automotive OEMs:

- Extended corrosion resistance in accelerated corrosion tests
- Available as extruded MMP tubing down to 0.15 mm wall thickness
- Excellent galvanic compatibility with standard header and fin materials
- Cost effectiveness in comparison to copper solutions
- Standard post-extrusion zincating treatments (ie, thermal arc spray, plasma or roll coating) can be applied to enhance corrosion performance
- Controlled atmosphere brazing (CAB) compatibility

## Long Life™ alloys are used to create cool:

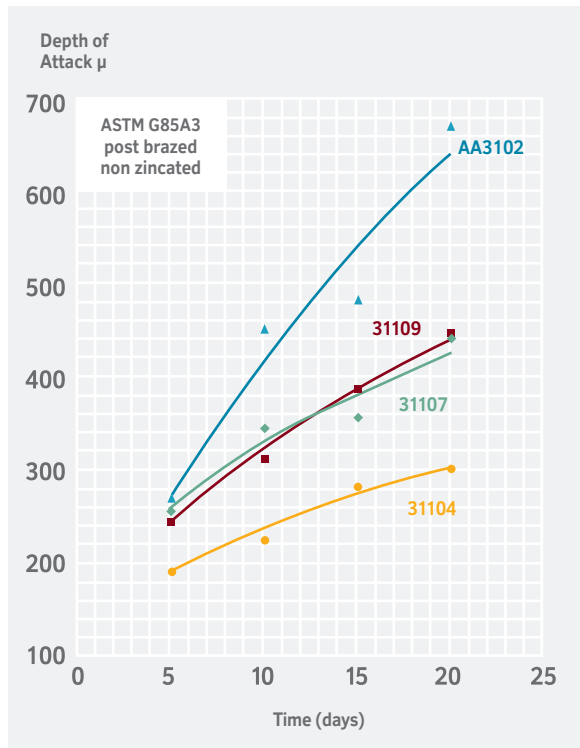
- AC condenser and evaporators
- Radiators
- Charge air and oil coolers
- Tubing
- Micro channel
- Mini micro port

## Long Life™ alloy properties

Long Life™ alloys have a controlled composition and tubing microstructure to give excellent self-corrosion behaviour and galvanic compatibility.

Long Life™ alloys are suitable for applications where superior performance in the ASTM G85A3 Sea Water Acetic Acid Test (SWAAT) and similar protocols are required.

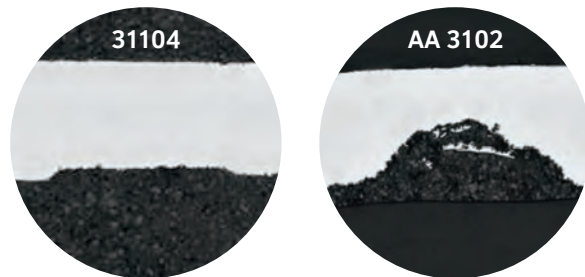
SWAAT (ASTM G85A3) comparison results for our Long Life™ alloys



31104 exhibits a 50% reduction in pit depth after 20 days exposure compared to standard AA3102. Commercially, a zincated surface layer is applied which extends the SWAAT life beyond 90 days.

- **31104** is compatible with most AA3003-based finstocks containing 1.0 wt% zinc or more. Best results are obtained when the finstock has no deliberate copper addition.
- **31109** and **31107** alloys are suitable for less severe environments and offer combinations of superior processing speed and intermediate corrosion performance.

### Pit morphology after 20-day SWAAT exposure



Long Life™ alloys such as 31104 tend to produce wide, flat bottomed corrosion pits as opposed to the deleterious localised attack typical of AA3102.

## Composition and performance

Typical composition and performance data for our Long Life™ alloys in bare tube condition as compared to standard AA3102

Rio Tinto alloy	AA	wt% Mn	wt% Fe	Pit Depth* µ 20D SWAAT	Brazed UTS MPa	Ecorr** mV	Post Brazed Grain Structure
30016	3102	0.25	0.5	640	75	-742	coarse
31109		0.4	0.3	440	75	-742	coarse
31107		0.6	0.1	420	70	-731	coarse
31104	3012A	1	0.1	300	87	-722	fine

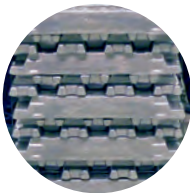
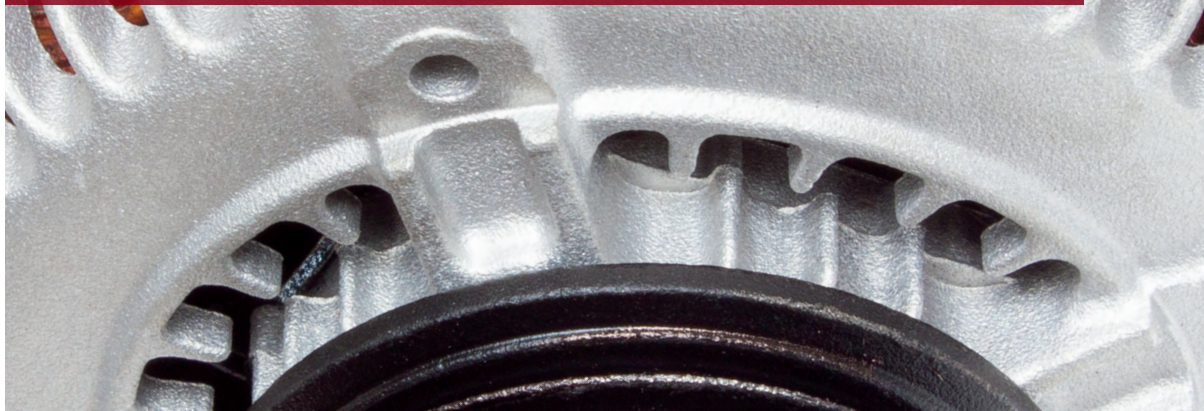
\* Brazed bare tube non zincated. ASTM G85A3

\*\* ASTM G69

RioTinto

# Smarter Electric Mobility Applications

Rotor alloys



*Foundry ingot*

Our **Rotor alloy series** is a family of high electrical conductivity alloys specifically designed for demanding automotive motor components.

The ease with which aluminium squirrel cage induction motors, from 2.5 mm to 760 mm diameter, can be cast, makes it difficult to justify the cost of producing wire round assemblies.

The typical casting method is High Pressure Die Casting (HPDC), although other processes can be used, depending on the size and intricacy of the casting.

## Key Benefits

Rotor alloys for high electrical conductivity offer to automotive OEMs:

- Aluminium conductor is half the weight of an equivalent copper conductor
- Tailor-made aluminium alloys suited for electrical conductivity and castability
- Tight composition control to guaranty electrical conductivity higher than 59% IACS

## Rotor alloys are used to create smart:

- Rotors
- Motors
- Stators
- Squirrel cages

## High conductivity aluminium Rotor alloys

The electrical conductivity of aluminium alloys depends on their composition – the fewer alloying elements added, the higher the conductivity. However, the higher the purity, the lower the

castability. The alloying ingredients added to produce high conductivity Rotor alloys, such as iron and silicon, improve the castability and reduce the tendency to hot cracking.

AA No.	Al	Si	Cu	Fe	Zn	Sum of Mn+Cr+Ti+V	Fe/Si Ratio	Others Max.		Electrical Conductivity (Min. %IACS)
								Each	Total	
100.1 Max Min	99.00	0.15	0.10	0.8 0.6	0.05	0.025		0.03	0.10	54
130.1 Max Min	99.30		0.10		0.05	0.025	2.5	0.03	0.10	56
150.1 Max Min	99.50		0.05		0.05	0.025	2.0	0.03	0.10	57
160.1 Max Min	99.60	0.10		0.25	0.05	0.025	2.0	0.03	0.10	58
170.1 Max Min	99.70				0.05	0.025	1.5	0.03	0.10	59

## Castability

Conductivity and castability are interrelated. The purer the aluminium the higher its conductivity but the poorer its castability. Each alloying element has a somewhat different effect, but certain alloying elements improve castability with only a slight

effect on conductivity. Using our metallurgical know-how, we have balanced and controlled the composition of our high conductivity rotor alloys, so that they provide maximum castability at each conductivity level.

## Advantages of cast aluminium rotors

The table shows that on a volume basis, aluminium has 62% the conductivity of copper. The required conductivity in cast aluminium rotors is achieved simply by increasing the size of the slots and the end rings, while the overall dimensions remain approximately the same. Because of the relative

densities of the two metals, the weight of an aluminium conductor is half that of an equivalent copper conductor. This means less stress from centrifugal forces, less starting inertia, and less vibration while running.

Property	Aluminium	Copper	Aluminium as percent of copper
Specific Gravity	2.7	8.9	30%
Relative Conductivity	62%	100%	62%
Specific heat (heat capacity) cal/g°C or Btu/lb°F	0.22	0.09	244%
Thermal Conductivity cal/cm sec°C	0.5	0.9	56%
Thermal Conductivity Btu/inch sec°F	0.0028	0.005	56%