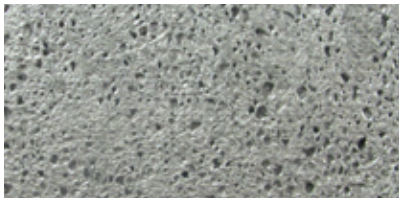
Rio Tinto Alcan

Dubuc Works
SAGUENAY, CANADA

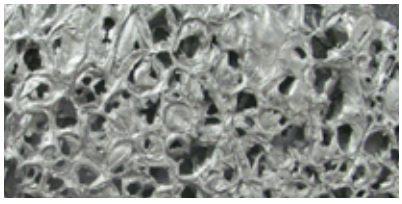
DURALCAN™

Alloying aluminium with high technology

The **DURALCAN**™ Metal Matrix Composites (MMCs) are aluminum alloys that are particulate reinforced and as a result combine the properties of the matrix aluminum alloy with increased elastic modulus and high wear resistance made possible by the presence of predetermined fine and well-distributed silicon carbide particles.



NOISE REDUCTION PANEL (F3S.20S)



ARCHITECTURAL PANEL (F3S.20S)

FIGURE 1 - BRAKE DRUM IN F3N.20S

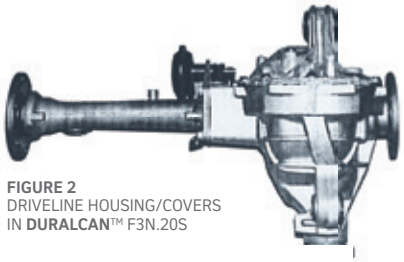


FIGURE 2
DRIVELINE HOUSING/COVERS
IN **DURALCAN**™ F3N.20S

DURALCAN™ composites are a family of aluminum matrix composites containing particulate aluminum oxide (for the wrought materials) or silicon carbide (for the gravity-casting and diecasting materials). The composites are manufactured by mixing the ceramic powder into molten aluminum, using a patented process and proprietary technology. The melt is then poured to extrusion billet, rolling bloom, rolling ingot, or foundry ingot. Products can be formed using conventional aluminum fabrication methods, such as extruding, forging, and casting. **DURALCAN**™ composites are thus manufactured using raw materials coming from a molten metal primary production method, and products are formed via conventional secondary fabrication methods. The combined result is a family of cost-effective composites for many applications.

DURALCAN™ MMCs for Foundry Use

The F3S.20S (AA 359/SiC/20p) composite was developed for general foundry usage from plaster cast to permanent mould, while the F3N.20S (AA 360/SiC/20p) series of composites was developed for high-pressure die-casting. The range of physical and mechanical properties, shown in Tables 1 & 2, have encouraged many uses in the manufacture of automotive products as indicated in Table 3 and shown in Figures 1, 2 and 3. In non-automotive application, MMCs are used for train brake rotors in European railways, Figure 4. A fifty percent decrease in weight, less thermo-cracking, extremely low wear, energy savings and no rotor hot spots are the properties cited for their use. The thermal stability of castings made from F3S.20S has also found a use in laser camera bases and housings.

DURALCAN™ MMCs for Extrusion Use

The W6A.xxA and W7A.xxA wrought composites (xx=volume percent Al203 particulate) are general-purpose composites, based on 6061 or 7005 aluminium alloy, for use in a broad range of applications, primarily at room température.

Typical applications are :

For the W6A.xxA family, mountain bike frame tube, tire studs, seamless automotive drive-shaft tube and various extruded shapes. For the W7A.xxA family, structural components as frame rails and posts for scenic usage or guard for safety protection. Typical tensile properties are detailled in Table 5.

FIGURE 3
BRAKE ROTOR (F3S.20S)

Table 1

DURALCAN™ typical physical properties

		A356[a]	F3S 10S[a]	F3S 20S[a]	F3N.20S-F	F3K 10S-F	F3K 20S-F
Density (g/cm³)		2.68	2.71	2.77	2.71	2.75	2.81
Electrical Conductivity (%IACS)	22°C	37.5	34.2	26.4	24.7	27.2	19.7
Thermal Conductivity (cal/cm-s-K)	22°C	0.360[b] 0.372[c]	– –	0.442[d] 0.480[d]	0.401	–	0.346
Specific Heat (cal/g-K)	25°C	–	0.210	0.200	0.193	0.201	0.197
	100°C	–	0.224	0.218	0.215	0.215	0.212
	150°C	–	0.235	0.228	0.227	0.225	0.222
	200°C	–	–	0.239	0.238	–	0.233
	250°C	–	–	0.249	0.249	–	0.243
	300°C	–	–	0.259	0.259	–	0.254
Average Coefficient of thermal Expansion (10^{-6}/K)	50-100°C	21.4	20.7	17.5	16.6	20.2	17.8
	50-300°C	–	24.7	21.1	20.0	23.4	20.0
	50-500°C	–	24.8	21.4	20.2	23.5	20.7

[a] *°F temper for electrical conductivity and specific heat: T5 temper for CTE.*
[b] *T6 temper* [c] *T7 temper* [d] *T71 temper*

Table 3

Automotive applications of DURALCAN™ F3S.20S and F3N.20S composites

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

Chemical compositions of DURALCAN™ F3S and F3K matrix alloys

	Si	Fe	Cu	Mn	Mg	Ni	Ti	All other Elements	Al
F3S Alloy	8.50-9.50	0.20 max	0.20 max		0.45-0.65	–	0.20 max	0.03 max 0.10 total	Rem.
F3K Alloy	9.50-10.50	0.30 max	2.80-3.20		0.80-1.20	1.00-1.50	0.20 max	0.03 max 0.10 total	Rem.
F3N Alloy	9.50-10.50	0.80-1.20	0.20 max	0.50-0.80	0.50-0.70	–	0.20 max	0.03 max 0.10 total	Rem.

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 (Aluminium Association MMC nomenclature).

DURALCAN™ F3K.xxS composites, containing significant amounts of Cu and Ni, are designed for use at elevated temperatures. They are similar to 339/SiC/xxp.

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.

All **DURALCAN**™ composites are heat-treatable.

Table 2

DURALCAN™ F3S.20-T6, permanent mold

Tensil properties and hardness

Typical and (minimum) values[1]

	Ultimate strength (MPa)	Yield strength (MPa)	Elongation[7] (%)	Elastic modulus (GPa)	Rockwell hardness HRB
A356-T6[2]	276 (255)	200	6.0	75.2	55
F3S.10S-T6[3]	338 (310)	303 (283)	1.2	86.2	73
F3S.20S-T6[4]	359 (317)	338 (310)	0.4	98.6	77
F3S.20S-T71[5]	262	214	1.9	98.6	–
F3S.20S-O[6]	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

[1] *Minimum values represent 99% confidence interval*
[2] *Measured by direct reading from stress-strain plat*
[3] *Cast-to-size tensil bars per MIL-H-6068 and QC-A-596*
[4] *80 and 241 cast-to-size tensile bars, solutionized at 538°C for 8 hrs, aged at 154°C for 5 hours*
[5] *6 cast-to-size tensile bars, solutionized at 538°C for 8 hours, aged at 246°C for 3 hours*
[6] *6 cast-to-size tensile bars, aged at 343°C for 4 hours.*

Table 4

Tensile properties

Typical and (minimum) values*

	Ultimate strenght (ksi)	Yield strenght (ksi)	Elongation (%)	Elastic modulus (Msi)
6061-T6	45 (38)	40 (35)	20	10.0
W6A.10A-T6	51 (47)	43 (38)	10	11.8
W6A.15A-T6	53 (49)	47 (42)	6	12.9
W6A.20A-T6	54 (50)	51 (46)	4	14.1

** Minimum values represent 99 % confidence interval.*
All measurements made on extruded bar or rod (extrusion ratio ~20:1).

Table 5

Tensile properties

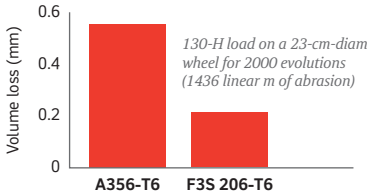
	Temper	Thickness (ins)	Typical properties Yield (%)	UTS (ksi)	Elong. (%)
7005	0		12	28	20
	T6		42	51	13
	T53		50	57	12
W7A.10A	F[(1)]	< 0.25	30	46	
	F	0.25-2.0	34	48	10
	F	> 2.0-3.0	33	47	7
	T53[(2)]	< 0.25	47	51	5
	T53	0.25-1.0	44	50	8
	T6[(3)]	0.25-1.0	47	55	7
W7A.15A	T6	0.25-1.0	47	54	6
W7A.20A	T6	0.25-1.0	46	53	4

[1] *F or A/Q (air quenched) temper. As extruded or air cooled at the press[4].*
[2] *Air cooled at the press[4] and duplex aged[5]. T53 is an averaged stress corrosion resistant temper.*
[3] *T6 - solution heat treated and peak aged. T6 temper maximizes strenght with some loss in stress corrosion resistance. T6 is not a recommended temper for stress corrosion vulnerable applications.*
[4] *Air cooled at no more than 2°F/sec averaged from the die emergence temperature to 250°F. Faster cooling rates may be applicable for thick profiles, and when agreed with the customer, and proven to have no significance on stress corrosion cracking resistance.*
[5] *T53 duplex recommended aging treatment is 8 hours at 220°F followed by 8 to 16 hours at 300°F. After press quenching, it is usual for a 72 hours natural age at room temperature to be employed prior to the duplex aging treatment.*

DURALCAN™ F3S.20S-T6 sand cast

Abrasion resistance

Sand abrasion test: ASTM G-65, Procedure B



Wear resistance

Block-on-ring wear test: ASTM G-77

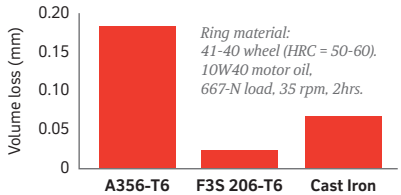


FIGURE 4
TRAIN BRAKE ROTORS F3S.20S

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