noranda

INFORMATION ON NORANDA's Mg-Al-Sr CREEP RESISTANT ALLOYS

Noranda's new creep resistant magnesium diecasting alloys are based on the Mg-Al-Sr system. These were developed in 1999 and are covered with a patent application. Diecasting campaigns have been carried out on cylinder-head covers and transmission cases. Two alloys are currently being offered.

High Sr Alloy -- Mg-5Al-(1.8-2.2)%Sr : High mechanical properties and good corrosion resistance and excellent diecastability. Diecasting trials of automotive transmission cases with this alloy have proven to be very succesful.

Low Sr Alloy Mg-5Al-(1.2-1.7)%Sr : Good mechanical properties, acceptable corrosion resistance and acceptable diecastability.

Chemical compositions of alloys are given in Table I. Even though four alloy designations appear A1 and A4 are similar alloys and A2 and A3 are similar. For future commercial purposes the Mg-Al-Sr alloys will be grouped into two; Al Sr alloy with Sr ranging from 1.2 to 1.7% and a high Sr alloy with Sr ranging from 1.8 to 2.2%.

TABLE I. TYPICAL CHEMICAL COMPOSITIONS OF NORANDA ALLOYS

Sample	Al %	Cu ppm	Fe ppm	Mn %	Ni ppm	Si ppm	Sr %	Zn ppm
High Sr Alloys								
A1*	4.9	4	23	0.26	3	34	1.74	94
A4*	4.9	<2	30 max	0.30	3	68	1.94	235
Low Sr alloys								
A2**	4.9	2	11	0.29	3	60	1.23	94
A3**	4.7	2	30 max	0.27	8	70	1.35	76

Mechanical Properties of Mg-Al-Sr Alloy

Mechanical property tables of the Mg-Al-Sr alloys are given below (Tables II-III and Fig. 1).

TABLE II. TYPICAL TENSILE PROPERTIES OF NORANDA Mg-Al-Sr ALLOYS

ALLOY	T.S (MPa)			Y.S (MPa)			Elongation (%)		
	R.T.	.50 C	.75C	R.T.	.50 C	175 C	R.T.	.50 C	175 C
High Sr Mg-5Al-(1.8-2.2Sr)	232	164	148	145	108	103	5.0	13	21
Low Sr Mg-5Al-(1.2-1.7Sr)	235	152	133	131	101	100	9.5	19	21
AE42	226	142	121	135	87	81	9.0	22.5	23
AS41	249	153	127	132	94	86	9.2	17	18
AZ91D	239	170	138	157	105	89	4.7	18	21

TABLE IV. CREEP PROPERTIES OF NORANDA MG-AL-SR ALLOYS

ALLOY	CREEP (%) 35 MPa, 200hr		CREEP (%) 50 MPa, 200hr		CREEP (%) 50 MPa, 500hr		CREEP (%) '0 MPa, 200hr
	150 (	175 C	150 C	175 C	150 (	175 C	150 C
High SR : MG-5AL-(1.8-2.2SR)	0.03	0.12	0.026	-	0.033	0.092	0.29
Low SR : MG-5AL-(1.2-1.7SR)	0.07	0.05	0.072	0.11	0.092	0.35	0.44
AE42	0.07	0.14	0.064	-	0.084	0.44	0.84
AS41	0.13	0.5	0.45	F(100hr)*	0.74	F(100hr)*	0.73 (f)
AZ91D	1.21	1.84	2.7	F(100hr)*	6.35	F(100hr)*	14.6 (f)
Aluminum A380	0.18	0.15	0.082	-	0.099	0.02	0.31

*F(100hr)= failed at 100 hours (f) Some samples fractured before the end of test

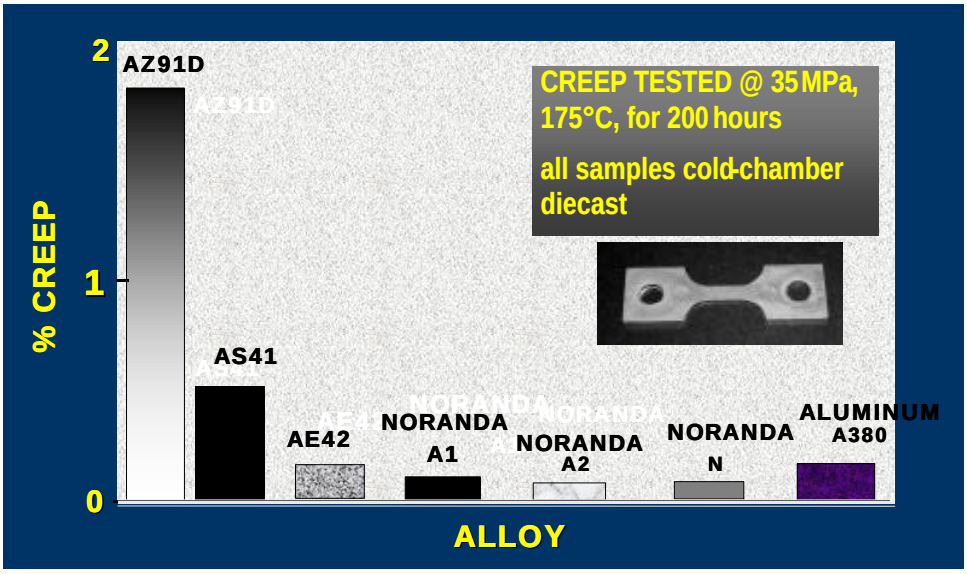

Fig.1. Comparison of the creep deformation of diecast magnesium alloys and the aluminum A380 diecasting alloy after 200 hours at 175 C, 35 MPa creep loading

Microstructure of Noranda's Mg-Al-Sr Alloys

High Sr Alloys (Sr 1.8-2.2% such as A1 and A4)

Microstructure of these alloys is shown in Fig. 2. Extensive TEM, STEM and SEM analyses have shown that the structure is characterized by two types of intermetallics, for which some stoichiometry has been proposed below. No $Mg_{17}Al_{12}$ phase is present in the alloy.

Intermetallics in A1 Alloy (Mg-5Al-1.8Sr)
Type A : Al_{17} Mg_5Sr_3 or $Al_2Mg_{1-x}Sr_x$ Type B : Al_3 $Mg_{13}Sr$

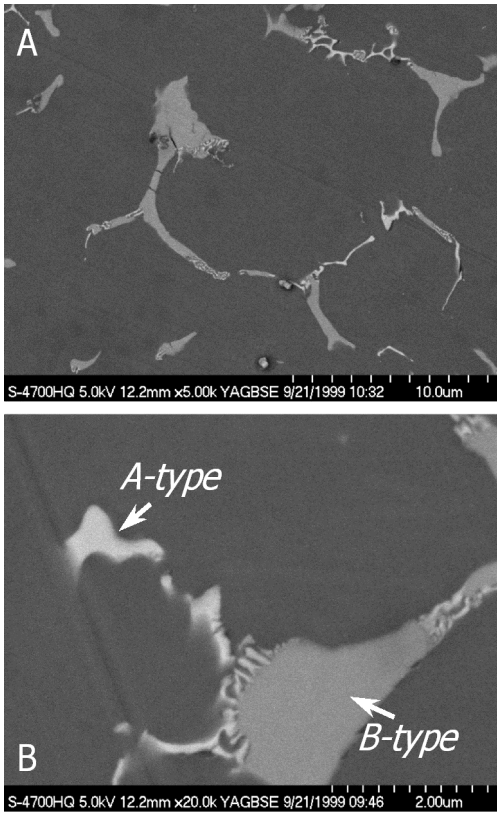

Fig.2. Compositional contrast image (A), obtained with BEI in the FEG-SEM,of die cast Mg-5Al-1.8Sr (A1) showing the two types of second phase surrounding the grain boundaries (see zoomed image (B)).

Low Sr Alloys (Sr 1.2-1.7% such as A2 and A3)

Microstructure of these alloys is shown in Fig. 3. TEM, STEM and SEM analysis have shown that the structure is characterized by one type of intermetallic as shown below. No $Mg_{17}Al_{12}$ phase is present I the microstructure.

Intermetallics in A2 Alloy (Mg-5Al-1.2Sr)
Type C : $Al_{12-y}Mg_{17-x}$-Sr_{x+y} or $Al_{10}Mg_{13}Sr$

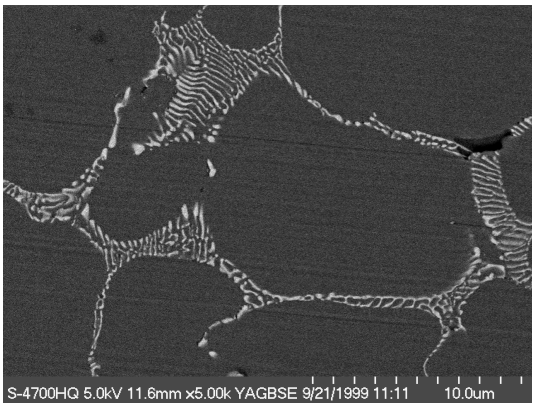

Fig.3. Compositional contrast image, obtained with BEI in the FEG-SEM, of diecast Mg-5Al-1.2Sr (A2) showing the second phase surrounding the grain boundaries.

Corrosion Properties

Noranda Mg-Al-Sr alloys have very good corrosion resistance. Corrosion properties of low Sr-alloys (1.2-1.7%Sr such as A2 and A3) are better than the AS41 alloy and the corrosion properties of the high-Sr alloys (1.8-2.2%, such as the A1 and A4) are even better than AZ91D. The comparison is given in Fig.4 below. To insure the good corrosion resistance Fe, Ni, Cu levels need to be controlled within the same ASTM specification as the AM50 alloy.

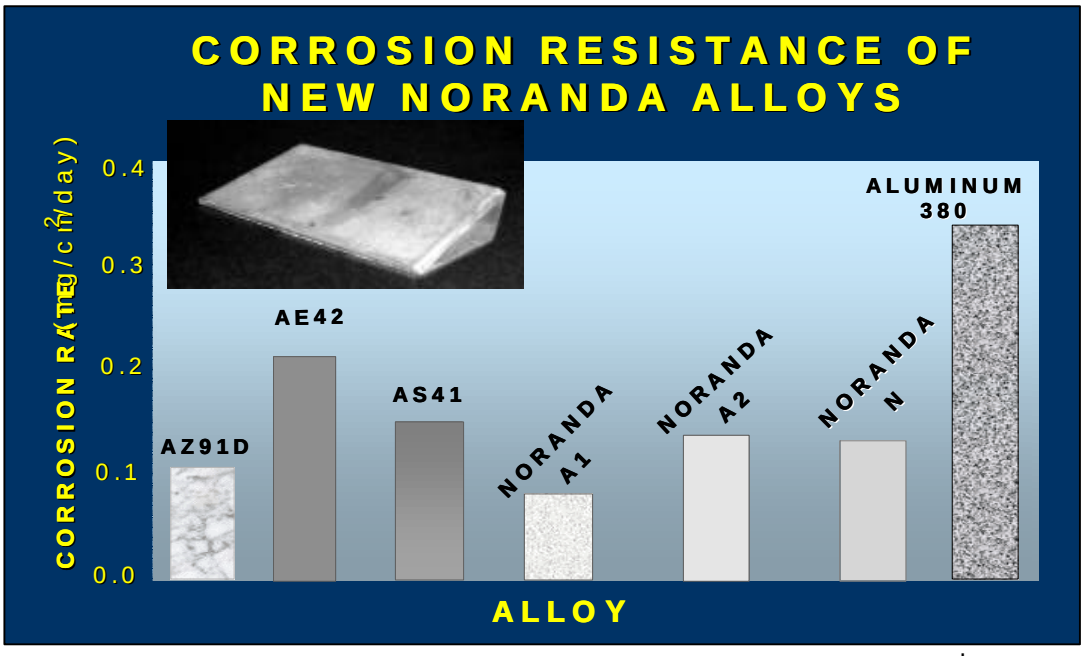

Fig. 4. Corrosion behavior of diecast Noranda alloys compared to other diecasting alloys.

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