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O T T A W A April 3rd, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1621.

Examination of Castings in Frontier 40E Aluminium Alloy.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals.

Ore Dressing
and Metallurgical
Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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Origin of Material and Object of Investigation:

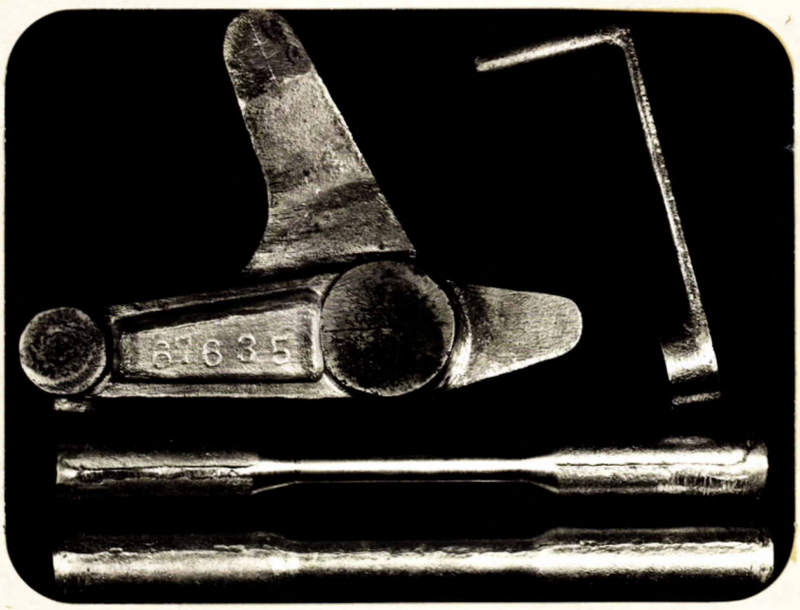
On March 2nd, 1944, a letter (File No. 902-38-1 (AMAE DAI)) was received from the Department of National Defence for Air, Ottawa, Ontario, describing a number of sample castings which had been received at these Laboratories the previous day. The castings were of Frontier 40E aluminium alloy and consisted of two lots of test bars and two typical castings. It was reported that one set of four test bars had been artificially aged for 10 hours at 356° F. (180° C.) and that the second set of five bars had been aged at room temperature for an unspecified time.

It was requested that samples be tested to determine (a) whether this material conforms to U.S. Specification AN-A-17, and (b) its general suitability for cast aircraft components.

Macro-Examination:

Figure 1 illustrates two test bars, one machined and the other unmachined, and the two typical castings as received.

Figure 1.



TEST BARS AND CASTINGS,
AS RECEIVED.

X-Ray Examination:

All nine test bars and the two castings were radiographed at the National Research Laboratories by Mr. W. A. Morrison. Examination of the radiographs showed all the samples to be sound castings, free from porosity, shrinkage, and other defects.

Chemical Analysis:

Three pieces of the broken test bars were prepared for chemical analysis and the resulting sample analysed, with

(Chemical Analysis, cont'd) -

the following results:

		AS FOUND	SPECIFICATION AN-A-17
		- Per cent -	
Zinc	-	5.10	4.75-5.75
Chromium	-	0.43	0.40-0.60
Magnesium	-	0.64	0.40-0.60
Titanium	-	0.19	0.15-0.25
Iron	-	0.29	1.0 max.
Copper	-	0.09	0.4 max.
Manganese	-	0.05	0.3 max.
Silicon	-	0.14	0.3 max.
Nickel	-	None detected.	--
Aluminium	-	Remainder*	Remainder*

* By subtraction.

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Mechanical Properties:

The following table lists the results of tensile tests on the test bars. The hardness values shown were determined on transverse sections of the test bars, using the Vickers machine with the 10-kilogram load, and are the average of at least three readings.

No.	Area, sq. in.	Maximum stress, p.s.i.	0.2 per cent proof stress, p.s.i.	Reduction of area, per cent	Elongation, per cent in 2-in. gauge length	Hardness, V.P.N., (10-kg. load)
		Naturally aged; gauge length unmachined -				
3	0.199	38,000	25,000	19.1	8.0	81.8
6	0.237	33,800	23,300	8.9	7.0	79.6
		Naturally aged; gauge length machined -				
5	0.174	34,500	24,700	5.2	7.0	78.1
7	0.189	36,200	26,100	10.6	7.5	77.6
8	0.191	37,400	26,100	9.4	9.5	81.8
		Artificially aged, 10 hrs. at 356° F.; gauge length machined -				
1	0.170	35,800	28,200	8.8	5.0	85.7
2	0.166	36,500	29,600	4.8	4.0	81.7
4	0.166	35,500	29,100	4.8	4.5	86.2
9-	0.170	34,100	28,600	10.0	6.0	85.3
		Army-Navy Aeronautical Specification AN-A-17 -				
		32,000 (min.)	20,000 (min.)		3.0 (min.)	

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Micro-Examination:

Transverse sections from two test bars, one which had been naturally aged and one which had been artificially aged, were prepared for metallographic examination. Figures 2 and 3, photomicrographs at X250, show the unetched structures of the naturally and artificially aged materials respectively. The grey constituent is apparently a magnesium-zinc compound. Figures 4 and 5, photomicrographs at X100, show the structures of the naturally and artificially aged materials respectively after etching in 0.5 per cent hydrofluoric acid. The magnesium zinc constituent is still visible at the grain boundaries.

(Figures 2, 3, 4, and 5
(appear on Pages 6 and 7.)

Discussion:

Of the two typical castings received, one was made up of fairly heavy sections while the other had a thin section connecting two heavier sections. Since the radiographic and microscopic examinations showed the material to be sound, it may be assumed that the castability of this alloy is good.

The chemical analysis shows the magnesium content to be slightly above the 0.60 per cent maximum specified. However, this slight amount should have no deleterious effect on the properties of the alloy. Otherwise, the alloy meets the chemical requirements of Specification AN-A-17 satisfactorily.

The mechanical properties of the alloy, as determined by tensile tests on the cast test bars, are above the specification limits of AN-A-17. Little difference could be observed between the naturally and artificially aged bars. The latter tended to have slightly higher yield strengths than the naturally aged bars. Also, the hardness of the artificially aged

(Discussion, cont'd) -

bars was slightly higher, being 81.7 to 86.2 V.P.N. as opposed to 77.6 to 81.8 V.P.N. for the naturally aged bars. The fractures of all the test bars showed the material to be sound, as was to be expected from the radiographic examination.

Microscopic examination revealed no difference between the naturally and artificially aged material. The grain size shown appears to be somewhat large, indicating a rather high pouring temperature.

From the results of these tests it appears that Frontier 40E aluminium alloy would be suitable for cast aircraft components at normal temperatures whether artificially aged at 350° F. or naturally aged at room temperature. It is said that its corrosion resistance is about equal to that of the heat-treated 4 per cent copper-aluminium alloy. It is known that aluminium alloys with high zinc content should not be used at temperatures much above normal, as their high-temperature properties are not satisfactory.

CONCLUSIONS:

1. The samples of Frontier 40E aluminium alloy submitted conform with the chemical and mechanical property requirements of U.S. Specification AN-A-17.

2. The castability of the alloy is satisfactory.

3. The alloy should be suitable for cast aircraft components, provided the corrosion is not severe and the operating temperature not far above normal temperatures.

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Figure 2.

X250, unetched.
NATURALLY AGED MATERIAL.
Grey constituent: magnesium-zinc compound.

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Figure 3.

X250, unetched.
ARTIFICIALLY AGED MATERIAL.
Grey constituent: magnesium-zinc compound.

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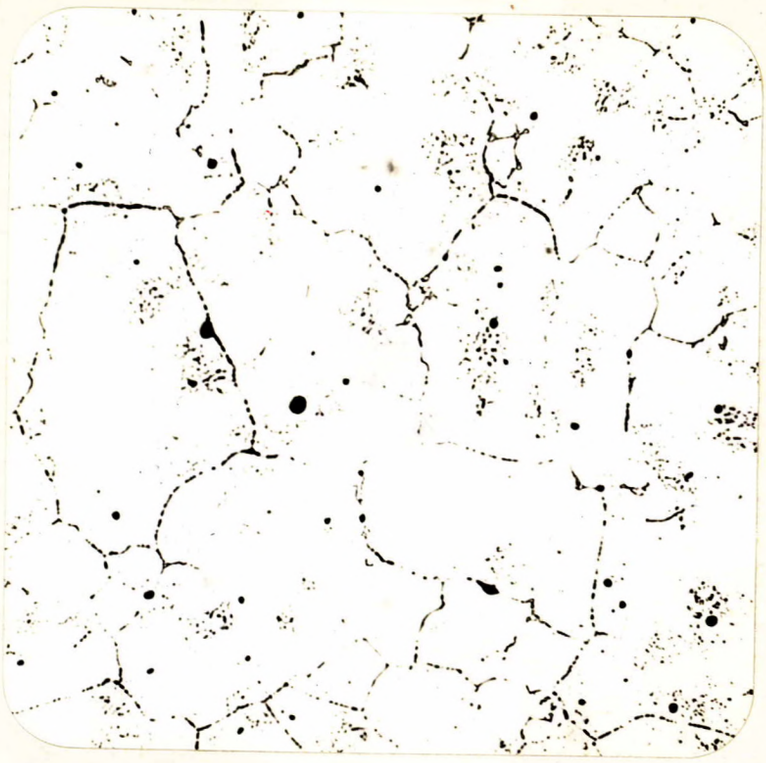
Figure 4.



X100, 0.5 per cent HF etch.

NATURALLY AGED MATERIAL.

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Figure 5.

X100, 0.5 per cent HF etch.

ARTIFICIALLY AGED MATERIAL.

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