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O T T A W A August 2nd, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1464.

Examination of Aluminium Alloy Wires
for Screws.

(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 Problem:

In a letter dated July 22, 1943, (File No. 902-38-1 (AMAE DAI), A/C A.L. Johnson, for Chief of Air Staff, Department of National Defence, Air Service, Ottawa, Ontario, requested the examination of aluminium alloy wires used for manufacture of screws by the Stowell Screw Company, Montreal, Quebec. These wires were made by the Aluminum Company of Canada from 2430 aluminum alloy and delivered during a period extending over 15 months. The possibility was indicated that the wire used may have been in too hard a condition to head up satisfactorily.

It was requested that the material be given a metallurgical examination to establish its suitability for the manufacture of screws. In addition, it was also requested that some finished screws be examined for grain flow and the condition of the material in the vicinity of the threads, which are produced by rolling.

Description of Samples:

Five batches of wire were submitted, as listed in Table I. Date of delivery from the Aluminum Company of Canada indicates the time of storage of the various batches.

TABLE I.

Batch No.	Diameter in inches	Date of delivery from Aluminum Company of Canada.
CFNO	0.094	March 2, 1942.
CSFL	0.140	April 15, 1943.
CMXU	0.142	December 18, 1942.
CTSS	0.165	May 31, 1943.
CSXV	0.221	May 7, 1943.

In addition, some finished screws manufactured from batches CMXR and CTSS were submitted. The screws from batch CTSS were submitted after heading and rolling, but before heat treatment and anodising. The screws from batch CMXR had been heat treated and anodised, and it was stated that they may have been overheated subsequent to manufacture.

MECHANICAL PROPERTIES:

Tensile Tests -

Table II gives the results of tensile tests carried out on 6-inch lengths cut from the submitted samples of wire.

Samples marked 1-10 (without "a") were tested in the "as received" condition.

Samples marked 1a-10a were tested after being given an annealing treatment at 370° C. (700° F.) for 1 hour and subsequent slow cooling (cooling rate, approximately 30° C. per hour).

(Continued on next page)

(Mechanical Properties, cont'd) -

Tensile Tests, cont'd -

TABLE II.

Sample No.	Batch No.	Wire Diameter, inches	0.1% Proof Stress, p.s.i.	Ult. Tensile Strength, p.s.i.	Elongation, per cent in 1 inch.
1	CFNO	0.094	14,400	29,500	15
2			13,000	29,000	15
1a			11,500	28,200	14
2a			10,100	28,100	14
3	CSFL	0.140	16,100	32,660	17
4			18,000	32,900	20
3a			9,600	27,600	22
4a			10,500	28,500	17
5	CMXU	0.142	18,000	33,200	--
6			17,700	33,000	24
5a			9,400	26,900	19
6a			10,750	28,500	20
7	CTSS	0.165	17,000	31,100	22
8			17,200	32,350	19
7a			10,500	28,300	22
8a			11,900	27,900	25
9	CSXV	0.221	14,700	31,700	10
10			15,500	31,000	14
9a			12,100	27,300	20
10a			11,200	28,700	22

Hardness Tests:

The hardness was determined by the Vickers method, using a 10-kilogram load.

The hardness tests were carried out on cross-sections of the wire in the "as received" condition and after annealing.

Table III lists the hardness results (average of 5 readings each).

(Contined on next page)

(Mechanical Properties, cont'd) -

Hardness Tests, cont'd -

TABLE III

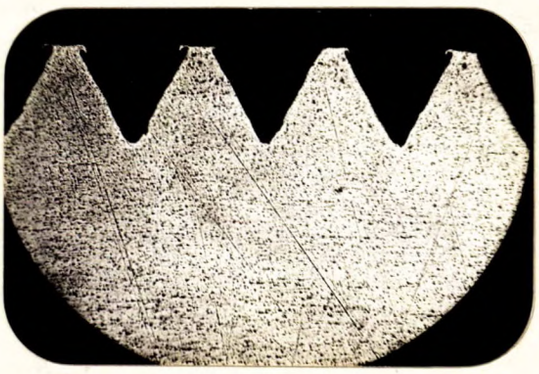
Sample No.	Batch No.	Vickers Hardness Numbers "As received"	After annealing
1	CFNO	57.8	52.5
2	CSFL	60.9	53.6
3	CMXU	63.1	53.9
4	CTSS	59.5	51.6
5	CSMV	64.2	55.3

Microscopic Examination:

Figures 1 and 2 show the cross-section of a portion of the threads of the screws from both submitted batches.

Figure 2 reveals definite evidence of overheating of the screws and intercrystalline corrosion on their surface.

Figure 1.



X25, unetched.
BATCH CTSS.

(Before heat treatment).

Figure 2.

X25, unetched.
BATCH CMXR.

(Over-heated and anodised).

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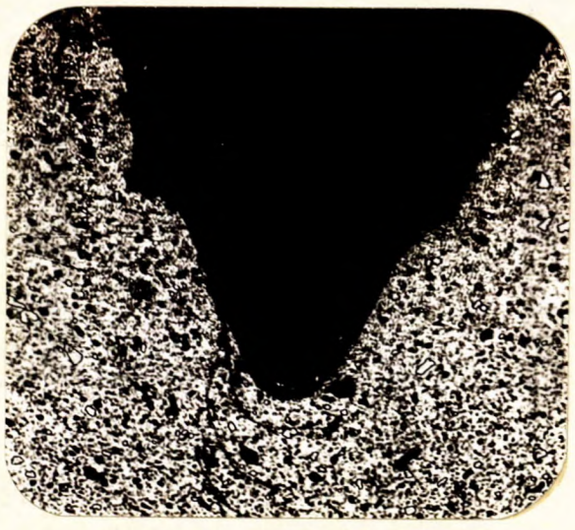
(Microscopic Examination cont'd) -

Figure 3 shows the normal structure of cold-worked 24ST aluminiumalloy, and Figure 4 the structure of overheated and corroded material.

Figure 3.



X250, Keller's etch.
BATCH CTSS.

(Before heat treatment).

Figure 4.

X100, Keller's etch.
BATCH CMXR.

(After overheating and anodising).

DISCUSSION OF RESULTS:

The comparison of the results of the tensile tests and hardness tests obtained on the material in the "as received" condition and immediately after annealing reveals some hardening of the material due to ageing.

It is known that annealed aluminiumalloys of the duralumin type show ageing effect when stored. The extent of this ageing depends on the annealing conditions (temperature and time) and the cooling rate after annealing (the more satisfactory the annealing conditions -- the less ageing effect during storage).*

(Continued on next page)

* P. L. Teed - "Duralumin and Its Heat-treatment", London 1937, p. 36-54.

(Discussion of Results, cont'd) -

It is therefore recommended* that material which has been stored in the annealed condition for any considerable length of time be re-annealed before heading or similar cold deformation.

The degree of hardening of the examined wire batches, although it will effect the formability of the material, does not seem to be sufficient to render the wire unsuitable.

As shown in the microscopic examination, screws from batch CMXR were badly overheated and reveal, on their surfaces, intercrystalline corrosion caused by loosening of the grain boundaries due to overheating and subsequently aggravated by the annodising treatment.

CONCLUSIONS:

The examination showed that the submitted batches of wire reveal some hardening due to ageing.

Although the degree of hardening does not seem to be sufficient to render the material unsuitable for cold deformation, it would be advisable that material that has been stored for a period of time be re-annealed immediately prior to use.

Screws from batch CMXR show definite overheating and intercrystalline corrosion, and should be rejected.

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* British Standard Specification 2L37, paragraph 4:
"Note: Rods, wire and tubes, which are not worked within a reasonable time after delivery may have hardened sufficiently to prevent them heading satisfactorily, in which case they should be annealed at a temperature of not less than 360° C. nor more than 400° C."