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OTTAWA   January 28th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1584.

Corrosion of an Aluminium Alloy Propeller Dome.

(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 Sample and Object of Investigation:

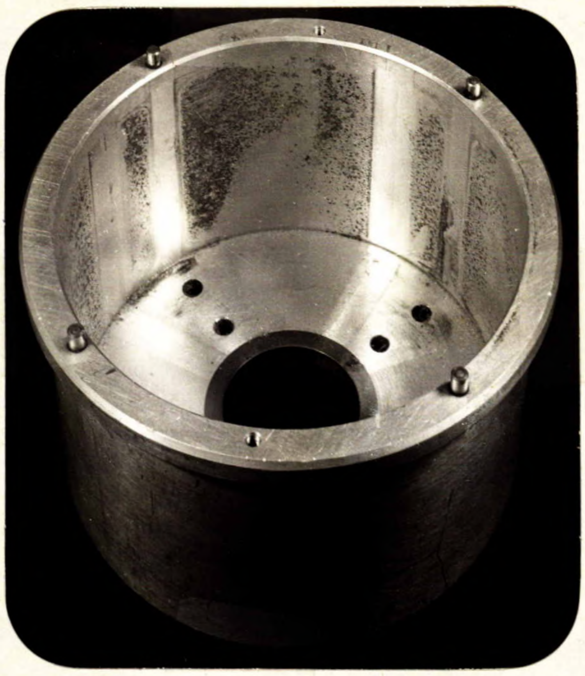
A Hoover propeller dome, Pt. No. P.40A519C Serial No. D.2 E0234, was received on January 11th, 1944, from A/C A. L. Johnson, for Chief of Air Staff, Department of National Defence for Air, Ottawa, Ontario. The covering letter (File No. 902-69-10 (AMAE DA1)) stated that the part, an AC26S aluminium alloy forging, had corroded on its internal surface. Request was made for an examination to determine the nature of the corrosion and whether or not there was any metallurgical deficiency that might tend to aggravate the condition.

120
·1584
L.P.T.

Macro-Examination:

A view of the forging as received, showing roughness on the interior surface, is given in Figure 1.

Figure 1.



DOME AS RECEIVED.

(Approximately ½ size).

Hardness:

The Vickers hardness (10-kilogram load) of this part was 138.

Chemical Analysis:

Drillings from the dome were chemically analysed. Results were:

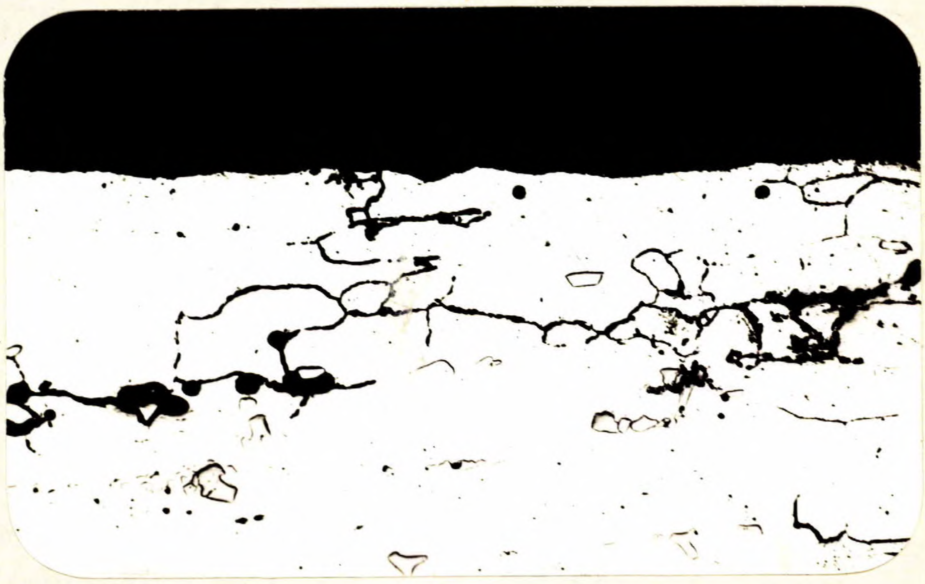
		As Found	AC26S (Alcoa 14S) Specification, Nominal Composition
		- Per cent -	
Copper	-	3.54	4.4
Magnesium	-	0.33	0.4
Manganese	-	0.77	0.8
Iron	-	0.70	-
Silicon	-	0.72	0.8
Titanium	-	0.02	-
Chromium	-	Very faint trace.	-
Nickel	-	Faint trace.	-

12 cc
1084
L. P. J.

Micro-Examination:

A specimen was removed from the rough portion of the forging, and was mounted in bakelite, polished, and examined. Corrosion of the intercrystalline type was found to be present. This corrosion is shown, before and after etching, in Figures 2 and 3.

Figure 2.



X250, unetched.

Note intercrystalline corrosion.

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Figure 3.

X100, Keller's etch.

Note intercrystalline nature of corrosion (particularly noticeable near A).

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Discussion of Results:

The aluminium alloy used in the dome under discussion is of the duralumin type. Its copper content is slightly low as compared to the nominal, but the composition may be considered satisfactory. Certainly, a small lowering of the copper content would not be expected to increase the propensity toward corrosion; rather, it would be expected to decrease it.

The fact that the corrosion present is of the intercrystalline type indicates that there was some shortcoming in the thermal history of this part. If there is a possibility that this dome may rise to a temperature of over 100° C. in service the harmful effect of this on the resistance to intercrystalline corrosion is a point to bear in mind. These points are fully discussed in the following quotations.

J. C. Arrowsmith and G. Murray, in "The Influence of Delayed Quenching During Solution Heat-Treatment on the Resistance of Duralumin to Intercrystalline Corrosion" (SHEET METAL INDUSTRIES, Vol. 16, No. 1886, December 1942, Page 1879), state:

> "It was found that although variations in composition did slightly affect the tendency to intercrystalline corrosion neither composition nor visible structural conditions could be regarded as of major importance, and it was realized that the tendency to intercrystalline attack was controlled by the heat treatment which the duralumin had undergone. Factors in the heat-treatment which lead to intercrystalline corrosion are:-
>
> (1) An abnormally large drop in temperature during interval between removal of metal from furnace and quenching.
>
> (2) Slow quenching speeds, such as are obtained when using hot water or oil as quenching media.
>
> (3) Reheating the heat-treated duralumin to temperatures in excess of, say, 120° C."

Willard Mutchler in "Corrosion of Metals Used in Aircraft, U.S. Bureau of Standards, Journal of Research, Research Paper RP 1316, Volume 25, July 1940, brings out the

(Discussion of Results, cont'd) -

following points:

"Intercrystalline attack was shown to be responsible for the serious embrittlement of duralumin. It was found to be associated with certain microstructural conditions that resulted from incorrect heat treatment, namely, those in which particles of the constituent $CuAl_2$ were precipitated along the grain boundaries and quite abundantly within the grains. The rate of cooling during the quenching that followed the preliminary "solution" heat treatment was found to be a determining factor. After a solution heat treatment at 500° C., it had been the practice to quench duralumin in warm water to minimize distortion. It was shown (Figure 4)* that quenching in cold water, preferably below 25° C., resulted in retention of the $CuAl_2$ particles in solid solution. This eliminated intercrystalline corrosive attack. Reheating above 100° C. of properly quenched-and-aged material also caused precipitation of the $CuAl_2$ compound and so promoted intercrystalline corrosion. Specifications now require proper heat treatments, which eliminate the intercrystalline attack."

CONCLUSION:

Corrosive attack was definitely found to be of the intercrystalline type, which indicates either overheating in service or some defect in heat treatment. Operational and heat treatment procedures should be reviewed with this in mind. The possibility of the lubricant being unusually corrosive should not be overlooked and this should also be checked.

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LPT:GHB.

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* This figure appears in the original paper but is not shown in this report.