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OTTAWA February 7th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1591.

Investigation of Corrosion of Aircraft De-Icer Tanks.

(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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Introduction and Origin of Material:

On January 22nd, 1944, Mr. A. S. Lane, Inspection Representative of the British Air Commission, Montreal, Quebec, on behalf of the Transport Command of the Royal Air Force requested (by telephone) the assistance of the Physical Metallurgy Research Laboratories in determining the cause of corrosion in welded de-icer tanks of aircraft. Initially it appeared to be an isolated case involving a Mitchell bomber made in the U.S.A. and in ferry transit to the United Kingdom. It was subsequently discovered that the same trouble was being encountered in widely scattered areas along the ferry lines.

It appears that the corrosion problem of de-icer tanks has already been investigated by both American and English authorities. Their investigations and reports all call attention to the high chlorine ion concentration present

(Introduction and Origin of Material, cont'd) -

and attribute the cause to a Friedel-Craft reaction. This is a chemical reaction between an aromatic compound (as present in de-icer fluids) and an alkyl halide (such as carbon tetrachloride) occurring in the presence of aluminium and resulting in the production of free hydrochloric acid. It is their opinion that the hydrochloric acid thus produced is responsible for the corrosion.

The writer visited Dorval Airport, Montreal, and there was shown corroded de-icer tanks from Dakota, Mitchell and Liberator bombers. In all, three tanks were submitted to these Laboratories for examination, as follows:

(1) Windshield de-icer tank from Liberator A.L. 593. In service approximately 1,000 hours. Welded bottom of tank fell out and the remainder was perforated in a large number of places.

(2) Propeller de-icer tank from Dakota III, F.L. 530. In service approximately 500 hours. Severe localized corrosion in vicinity of welds at inlet and outlet fittings.

(3) Wing de-icer tank from Mitchell bomber. This tank showed severe localized corrosion with many complete perforations.

Object of Investigation:

To determine the cause of the corrosion and to offer recommendations to prevent its recurrence.

Procedure:

1. All tanks were subjected to a thorough visual examination. Figures 1 to 3 show various views of the windshield de-icer tank from the Liberator bomber. Figures 4 to 6 show various views of the propeller de-icer tank from the Dakota. Figure 7 is a close-up of a corroded section of the wing de-icer tank from a Mitchell bomber.

2. Metal samples from each of the tanks were subjected to a complete chemical analysis. The table below lists

(Procedure, cont'd) -

a typical chemical analysis of the metal of these tanks:

		Per cent
Copper	-	0.03
Manganese	-	0.02
Magnesium	-	2.34
Silicon	-	0.13
Iron	-	0.22
Chromium	-	0.311

In the Liberator windshield de-icer tank was found a yellow corrosion product. Chemical and spectrographic analyses revealed that this material contained 44.07 per cent water, 0.027 per cent fluorine and very high chlorine content, together with magnesium, aluminium and manganese.

The Dakota and Mitchell tanks both contained a white powdery corrosion product, which on analysis proved to contain 0.66 per cent fluorine and 0.03 per cent fluorine respectively, and again a very high chlorine content.

Several one-inch squares of badly corroded tank wall from the Mitchell tank when analyzed for fluorine showed 0.0004 grams of this element.

3. A microscopic examination of corroded tank material in all cases showed a general washing away of material, characteristic of chemical attack. No evidence was found of intercrystalline corrosion.

4. Cross-sections were cut from the welds of every tank. None showed corrosion or entrapped flux.

Discussion:

The chemical analysis of the tank material indicates that it conforms to the Alcoa Specification 52S. The microscopic examination reveals that the material is not heat treated and that there is no evidence of intercrystalline corrosion. Material

(Discussion, cont'd) -

of this specification is one of the best from the point of view of corrosion resistance and a recommendation of change to a different specification is, therefore, unwarranted.

A visual examination reveals that the outsides of the tanks show no evidence of corrosion and that corrosion has taken place from the inside towards the outside. In every case the corrosion is localized around welds joining fittings to the tank or in areas into which welding flux might be expected to drop due to the positioning for welding. It was observed that in many cases corrosion on a vertical surface had resulted in a dribbling action, as might be expected of a liquid drop of flux gradually working its way downward under the influence of gravity. This had resulted, in some cases, in a groove eaten along the tank wall for as much as one inch. All tanks in areas inaccessible to welding flux show no evidence of corrosion.

The detection of fluorine in the analysis of corrosion products and in badly corroded areas is highly significant. The welding fluxes used on these materials consist entirely of fluorides and chlorides. The presence of chlorine, to which other investigators have called attention, might conceivably be due to a Friedel-Craft reaction between the de-icing fluid and a cleaning compound. However, this reaction cannot explain the presence of fluorine, which is certainly not present either in de-icing fluids or in tank cleaning compounds. It is our opinion that the fluorine can only come from the welding flux. This is supported additionally by the fact that corrosion has taken place only where splatter of welding flux might be expected. A Friedel-Craft reaction resulting in free hydrochloric acid would have resulted in pitting corrosion all over the tank, and this has not occurred.

An examination of sections of the welds shows no

(Discussion, cont'd) -

corrosion or entrapped flux, indicating a good welding technique and skilled operators.

The widespread appearance of the corrosion in different parts of the world could easily be accounted for by the rapid ferrying of some aircraft to combat areas and the delays encountered by others. If it is assumed that corrosion will produce perforation 100 days after welding it can readily be seen that the hundredth day may find the aircraft close to or remote from the manufacturer, depending upon weather conditions and/or the urgency of requests for aircraft in particular combat areas.

In summary, it would appear that the corrosion of the de-icer tanks is due to splattering of welding fluxes which have not subsequently been removed by a cleaning operation.

CONCLUSIONS:

1. The material from which these tanks are made conforms to the Alcoa 52S specification. This aluminium alloy material is one of the best available from the point of view of corrosion resistance.

2. Microscopic examination reveals that there is no intercrystalline corrosion and that the material is not in the heat-treated condition.

3. Corrosion is due to splattered welding flux on the inside of the tanks which has not been removed after welding by a cleaning procedure.

4. The welding technique has been good and indicates the use of skilled welders.

Recommendations:

1. All suspected tanks should be examined by means of a periscope for evidence of corrosion.

2. If the above inspection shows evidence of corrosion the tanks should be subjected to a pressure test. In the event that corrosion has proceeded to the near perforation point, a pressure test will probably cause leakage. Should this occur, the tank, of course, should be scrapped.

3. In the event that the pressure test on a tank showing evidence of corrosion does not cause a leak, the following procedure is recommended:

(a) Fill tank with 10 per cent sulphuric acid and let stand for 30 minutes.

(b) Wash three times with boiling water.

(c) Check for effectiveness by putting 100 c.c. of distilled water into tank, swill around, and drain into beaker. Add a few drops to 5 per cent silver nitrate solution and acidify with nitric acid. A white precipitate indicates incomplete flux removal. If there is no precipitate, cleaning has been effective.

In our opinion it should be left to the discretion of the inspector as to whether or not a tank showing evidence of corrosion is to be scrapped or remain in service.

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Figure 1.

GENERAL SHAPE OF WINDSHIELD DE-ICER TANK
FROM LIBERATOR BOMBER A.L. 593.

Figure 2.

BOTTOM OF LIBERATOR WINDSHIELD DE-ICER TANK.

Note circular bottom welded to tank completely eaten away.

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Figure 3.

LIBERATOR WINDSHIELD DE-ICER TANK.

Arrow points to yellow corrosion product. This corrosion product contains 0.027 per cent fluorine.

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Figure 4.

GENERAL SHAPE OF DAKOTA III, F.L. 530,
PROPELLER DE-ICER TANK.

Figure 5.

WELD AND AREA OF CORROSION OF DAKOTA PROPELLER DE-ICER TANK.

Note the localization of corrosion in the vicinity of the weld.

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Figure 6.

WELD AND AREA OF CORROSION OF DAKOTA PROPELLER DE-ICER TANK.

Note the localization of corrosion in the vicinity of the weld.

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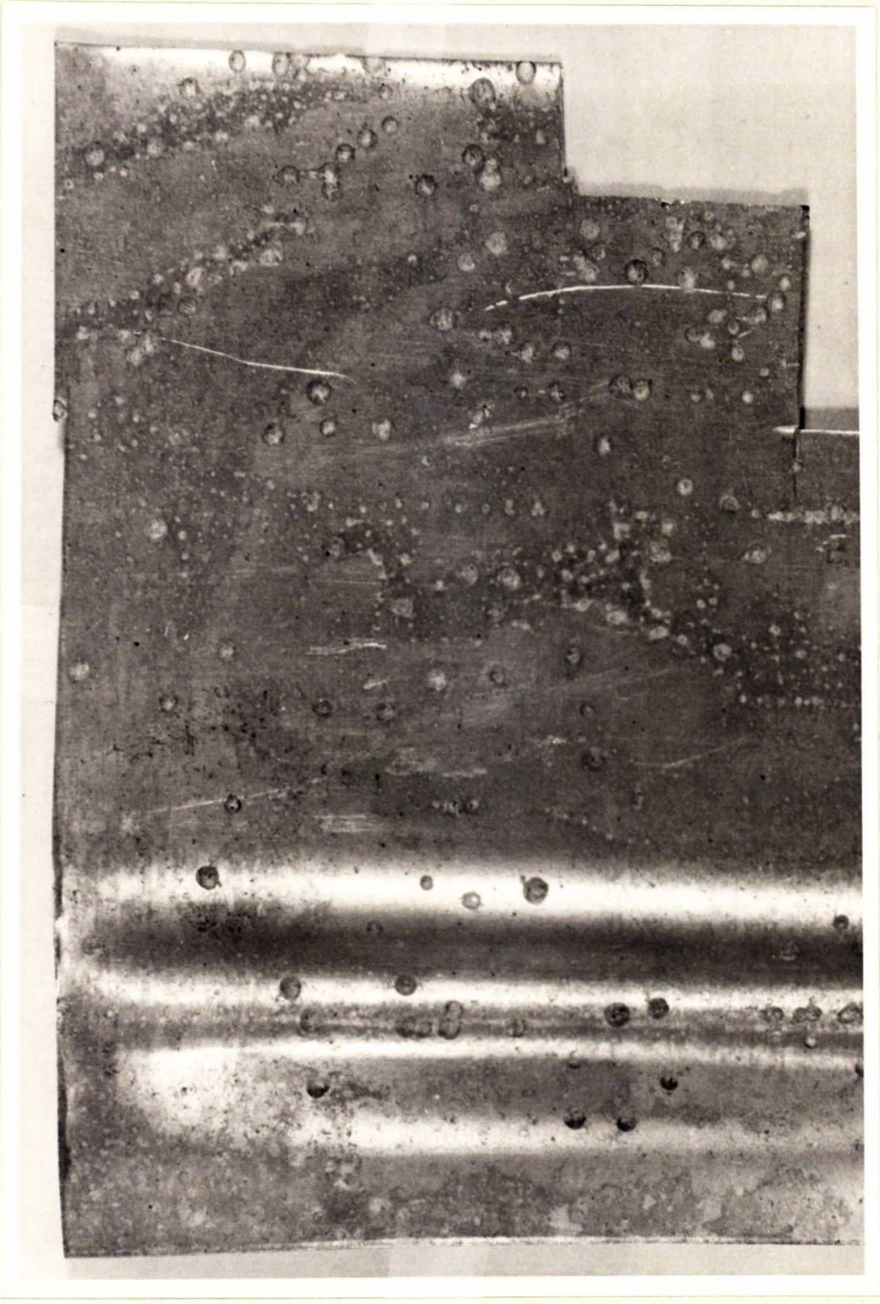
Figure 7.



CORRODED SECTION OF MITCHELL BOMBER
WING DE-ICER TANK.

Note local attack, characteristic of all tanks examined. Arrows point to corroded grooves in metal.

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