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O T T A W A April 27, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1852.

Examination of Brazed Aluminium Rods.

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(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

O T T A W A   April 27, 1945.

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ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1842.

Examination of Brazed Aluminium Rods.

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Origin of Samples and Object of Investigation:

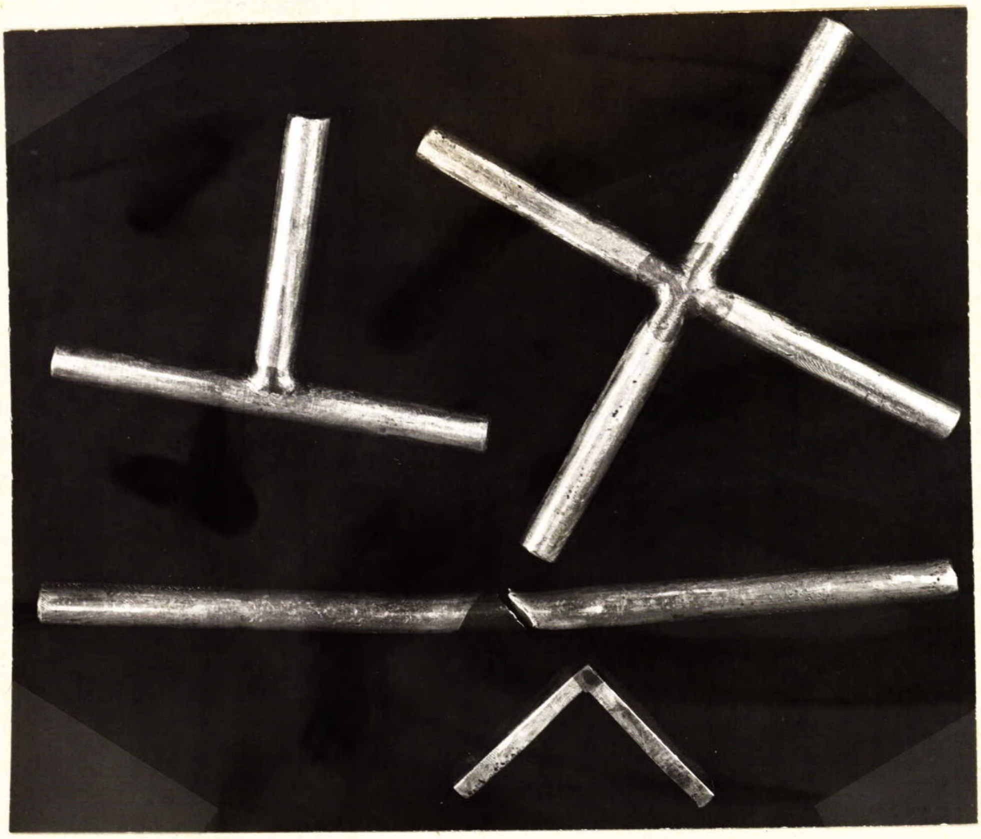
Several samples of brazed aluminium rods were received on March 2, 1945, from Air Commodore A. L. Johnson, Director of Aeronautical Inspection, for Chief of Air Staff, Department of National Defence for Air, Ottawa, Ontario, with the request (letter, File No. 832-30B-3 (AMSO DAI)) that the worth of jointing alloy be appraised and that, if possible, its composition be determined. The samples were supplied to the Toronto A.I.D. Headquarters by one Charles Lamont of Porcupine, Ontario, who claimed the joints were made by melting the end of the brazing alloy with a blow torch and directing the flow of the metal with a soldering iron.

1852
12 cc
L.P.T.

Macro-Examination:

A photograph of some of the brazes is given in Figure 1.

Figure 1.



PLEASE USE AS FILE COPY.

SOME OF THE BRAZED SAMPLES RECEIVED.

Sample second from top was broken in tension.
(Approximately ½ size).

As can be seen in the photograph, the brazing material is of a somewhat darker colour than the parent metal.

Chemical Analysis:

The composition of the brazing alloy was found by chemical methods to be as follows:

		Per Cent
Zinc	-	80.98
Aluminium	-	17.92
Copper	-	0.82
Manganese	-	0.08
Iron	-	0.07
Magnesium, Silicon, Molybdenum, Lead, Tin	-	None detected.

(Continued on next Page)

(Chemical Analysis, cont'd) -

One of the parent metal rods was found to have the following analysis:

		Per Cent
Silicon	-	0 26
Iron	-	0.08
Copper	-	0.06
Manganese	-	0.01
Magnesium	-	Faint trace.
Titanium	-	Below 0.001
Zinc, Lead	-	Faint trace.
Chromium	-	None detected.

Mechanical Tests:

A ring section broken in tension failed in the rod stock, and not in the braze, at a stress of 12,400 pounds per square inch. The rod shown in Figure 1, when pulled in tension, broke at a stress of 11,800 pounds per square inch with a shear-type failure largely through the aluminium rod but partly through the brazing metal.

One T-joint was boiled in water for about 6 hours and subsequently slowly bent. A break occurred at the joint and a considerable area of the abutting surfaces was found to be poorly bonded. A photograph of this is given in Figure 2.

Figure 2.

JOINT BROKEN BY BENDING.

(Approximately twice actual size).

(Mechanical Tests;cont'd) -

The Vickers hardness (10-kilogram load) of the brazing metal was found to be about 120 V.P.N. and that of the parent metal about 27.5 V.P.N.

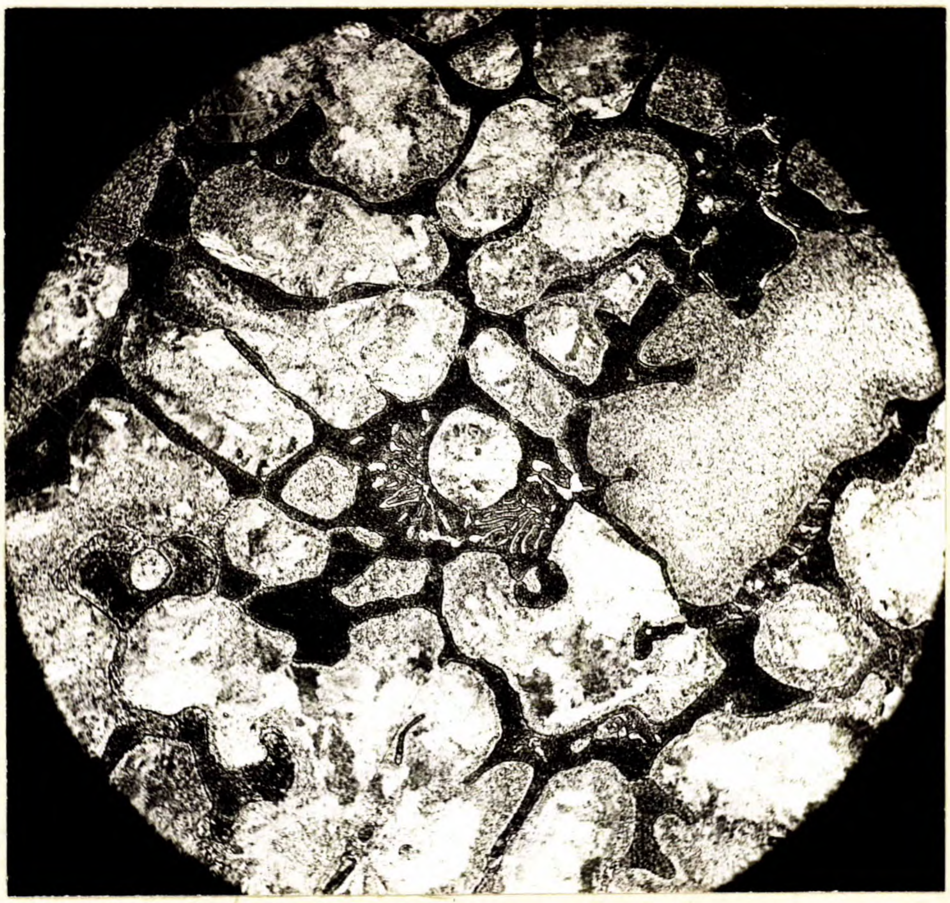
Corrosion Test:

After a 14-day, intermittent-type corrosion test in 5 per cent salt water at a temperature of 32° C. (90° F.), the brazed joints were found to be not seriously attacked.

Microscopic Examination:

The microstructure of the brazing material is given, at 500 diameters, in Figure 3. The structure of this zinc-aluminium alloy consists largely of alpha cores surrounded by beta envelopes in which are located areas of the beta-gamma eutectic.

Figure 3.



X500, etched in
dilute nitric acid.

BRAZING METAL.

(Microscopic Examination, cont'd) -

Very little diffusion was noticed at the brazing alloy-aluminium rod interface.

Abstract From the Literature:

A summary of brazing practice (particularly of the German) with zinc and high-zinc alloys, together with a discussion of the characteristics of those alloys, is given in V. Fuss's book, "Metallography of Aluminum and Its Alloys" (Sherwood Press, Cleveland, Ohio, 1936). The following passages are taken from pages 161 and 162 of that text and deal with a different technique for zinc-soldering aluminium, but many of the statements bear directly on the type of braze used in the present case:

> The aluminium-zinc system is industrially important in consideration of the problem of hard soldering aluminium. Zinc diffuses very rapidly in solid aluminium even at relatively low temperatures. Zinc and certain zinc-rich alloys are among the best solders for aluminium. Pure zinc used with a flux was judged to be the best solder for aluminium among many offered in a prize competition held by the German Metallurgical Society in 1923. The 75:25 zinc-cadmium alloy was considered next best.
>
> Röhrig and Borchert have discussed the diffusion of zinc along aluminium grain boundaries and Von Schwarz has dealt with the grain-boundary diffusion of metals in general. The former investigators soldered aluminium sheet by the following method: A powdered mixture of zinc oxide and ammonium chloride was placed along the edges of the pieces to be soldered, and heated until reduction of the zinc oxide began. The reduced zinc is dissolved by the aluminium, or the zinc itself dissolves the aluminium. In any case the resulting seam consists of a zinc-rich aluminium-zinc alloy. Figure 143a (in original) shows the microstructure of the soldered joint as made. The structure has the appearance of an alloy containing 84 to 95 per cent zinc. It consists of primary beta (dark) embedded in the beta plus gamma eutectic. One conclusion to be reached is that the temperature of the reaction was at least 380° C. (the eutectic equilibrium temperature). Diffusion along the aluminium grain boundaries did not occur because heating was discontinued as soon as the reduction started. The uniformity of juncture between the solder and sheet edges may be noted. The black rims consist largely of beta. On heating, zinc diffuses from the zinc-rich seam along the aluminium grain boundaries, and then the aluminium in the immediate vicinity of the solder is converted into an aluminium-zinc alloy. As the heating is continued the volume impregnated with zinc becomes greater. As the temperature is increased aluminium grains are converted completely into an aluminium-zinc alloy, and the diffusion

(Abstract From The Literature, cont'd) -

at the grain boundaries continues. The progress of diffusion on heating at 200° C. for 3, 24, and 81 hours is shown in Figures 143b, 143c, and 143d, respectively.

Soldered joints made as above described are strong and mechanically useful. But these joints contain beta which decomposes spontaneously. Therefore, the danger of breakdown exists. Moreover, their resistance to corrosion is poor. By heating in a succession of stages, however, first at just below 380° C., then up to 450° C., and finally above the latter temperature, the entire quantity of solder can be converted into alpha solid solution. The behaviour of zinc-rich binary alloys, e.g., zinc cadmium or zinc-tin, in soldering aluminium is similar to that of zinc. It is important to point out that some alloy solders (too lean in zinc) may form binary or ternary eutectics with aluminium which melt at rather low temperatures. Then, on heating the joint in stages these eutectics may melt and not be eliminated by diffusion. Soldered aluminium joints can be made more easily by applying aluminium-rich aluminium-zinc alloy instead of zinc. That is, hard in contrast to soft soldering is done. The desired diffusion along grain boundaries can then be effected at higher temperatures, and the seam accordingly does not contain the injurious beta constituent.

Numerous complex aluminium-zinc base alloys are suitable for hard soldering. The solders are made by adding to binary aluminium-zinc alloys metals which form solid solutions with aluminium, including beryllium, copper, lithium, manganese, silicon, and silver.

Discussion of Results:

The brazing metal is a zinc-rich aluminium alloy. The zinc-aluminium system has a eutectic at about 95 per cent zinc that melts at 380° C. (716° F.). The range of melting of an alloy of the composition used in these joints would be about 445° C. (833° F.) to 475° C. (887° F.). Pure zinc would melt at 419° C. (786° F.). The lack of very noticeable diffusion at the braze-parent metal interface leads to the supposition that the composition given for the braze material is close to that of the brazing alloy used. However, some increase in the aluminium content may have occurred. The stock rods are commercially pure aluminium.

Mechanical tests show that the joints when properly bonded have good strength. The angle of the bevel on the rods (about 45°) was responsible for the shear-type fracture in

(Discussion of Results, cont'd) -

the tensile test. The partially poor bonding of the braze tested by bending was probably caused by failure to scrape or flux off all the oxide.

The good resistance to corrosion of these brazes does not confirm the quoted German statement that brazes of this type are poor in this respect. It is possible, however, that when they used in conjunction with other aluminium alloys the corrosion resistance would not be as good.

The beta phase present in the braze is subject to spontaneous decomposition, and this decomposition is accompanied by a contraction of volume that amounts, in a 78:22 zinc-aluminium alloy, to about 0.3 per cent[1]. This action may continue over a period of months. By studying the spontaneous evolution of heat which accompanies this decomposition it has been found that copper, which is present in this alloy in some quantity, slightly retards the onset of the phenomenon but does not affect the total amount of heat evolved[2]. The copper in this alloy, then, would not be expected to affect to a practical extent the amount of volume contraction that may occur.

Summary:

When properly bonded these joints have good strength and are also quite corrosion-resistant. One instance of faulty bonding was found. To determine the seriousness of the volume contraction that occurs in the brazes (when they are not specially heat-treated to eliminate the beta phase), further tests would be required with the joints preferably being made

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(1) Fuss, V.: "Metallography of Aluminum and Its Alloys" (Sherwood Press, Cleveland, Ohio, 1936), pp. 158-9.

(2) ibid., p. 159.

(Summary, cont'd) -

on an assembly reinforced to the desired degree of rigidity in order that the danger of breakdown, warping or dimensional changes may be checked. Accelerated ageing and steam tests, as requested in zinc-base die-casting alloy specifications, would probably yield a quick answer on the assembly.

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