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O T T A W A   October 11th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1718.

Examination of Welded and Brazed Aluminium Alloy Sheet Test Specimens.

(Copy No. 10 .)

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

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Samples and Object of Investigation:

Thirty-three brazed and welded aluminium sheet test specimens prepared by De Havilland Aircraft were received from Chief of Air Staff, Department of National Defence for Air, Ottawa, Ontario, on September 6th, 1944. The covering letter (File No. 902-38-19 (AMAE:DAI)) gave the following information as to the history of these samples:

> There are three samples of butt welds in 16, 18, 20 and 22 SWG, and three samples of butt-brazed joints on each of the same gauges. There are also three samples of lap-brazed joints in 16 SWG, having lap widths of 0.1, 0.2 and 0.3 inch. All samples are made from DTD 213 alloy.
>
> Similar tests were pulled in the laboratory of De Havilland Aircraft, and they found no appreciable difference between the strengths of any of the above lap and

(Origin of Samples and Object of Investigation, cont'd) -

butt joints. The average strengths of these joints in 16 SWG material were as follows:

Butt brazed, 1,011 lb./inch
0.1-inch lap, 1,012 "
0.2-inch lap, 998 "
0.3-inch lap, 1,008 "

The average figures, comparing the welding and the brazing in various thicknesses of material referred to above, were as follows:

Samples SWG		Strength, lb./inch Welded	Brazed
16	-	1,011	1,011
18	-	810	783
20	-	583	579
22	-	451	435

Request was made for an examination to determine the relative merits of welding and brazing.

Mechanical and Corrosion Tests:

Twenty-two specimens, two of each type, were broken in tension, the stress-strain diagrams being drawn by an automatic recorder. Eleven were pulled as received, while the other half were broken after immersion for ten days in a 3 per cent NaCl, 0.25 per cent H_2O_2 solution that was changed every second day. These corroded bars are designated C. Other abbreviations in the following list (Table I) are: G - gauge; L - lap; B - brazed; W - welded.

TABLE I.

Specimen	Ultimate Tensile Strength, p.s.i.	0.2% Proof Stress, p.s.i.	Elongation, per cent in 2 inches
16 G, 0.1"L, B	14,600	7,430	27
16 G, 0.1"L, B, C	14,700	*	17.0
16 G, 0.2"L, B	14,920	6,880	25.0
16 G, 0.2"L, B, C	14,900	*	17.0
16 G, 0.3"L, B	16,125	7,360	25.0
16 G, 0.3"L, B, C	14,900	*	24.0
16 G, B	**14,640	Not determined.	16.0
16 G, B, C	800	*	0.0
16 G, W	15,100	8,120	19.0
16 G, W, C	15,300	8,200	13.0

(Table I is continued on next page)

(Mechanical and Corrosion Tests, cont'd) -

TABLE I (cont'd).

Specimen	Ultimate Tensile Strength, p.s.i.	0.2% Proof Stress, p.s.i.	Elongation, per cent in 2 inches
18 G, B	16,100	8,400	25.5
18 G, B, C	2,400	*	2.0
18 G, W	16,600	8,800	21.0
18 G, W, C	16,800	8,400	25.5
20 G, B	15,500	7,500	19.5
20 G, B, C	Nil.	Nil.	
20 G, W	15,600	7,880	17.5
20 G, W, C	15,800	7,900	16.0
22 G, B	15,450	7,670	18.0
22 G, B, C	Nil.	Nil.	
22 G, W	15,880	7,940	13.0
22 G, W, C	16,200	8,600	18.5

* Extensometer was not attached, because of danger of breakage with joint of unknown strength.

** Broken in braze. This is the only sample which broke in the weld or braze. Some porosity was noticed.

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Eight-day "loss in weight" corrosion tests, with the same concentration of solution mentioned above, were run on rectangular samples, about 2¾ inches long and 5/8 inch wide, from the gauge length of the specimen. Results were:

TABLE II.

Sample	Weight Before Corrosion, in grams	Weight After Corrosion, in grams	Difference, in grams	Percentage Loss in Weight
16 G, W	5.8262	5.8067	0.0195	0.33
16 G, B	5.6099	5.4892	0.1207	2.2
18 G, W	4.4759	4.4374	0.0385	0.86
18 G, B	4.4876	4.3355	0.1521	3.4
20 G, W	2.9704	2.9327	0.0377	1.3
20 G, B	3.3793	3.2682	0.1111	3.3
22 G, W	2.5119	2.4948	0.0171	0.68
22 G, B	2.6488	2.6040	0.0448	1.7
16 G, 0.1"L, B	5.9356	5.8767	0.0589	0.99
16 G, 0.2"L, B	6.1844	6.1035	0.0809	1.3
16 G, 0.3"L, B	6.6010	6.5155	0.0855	1.3

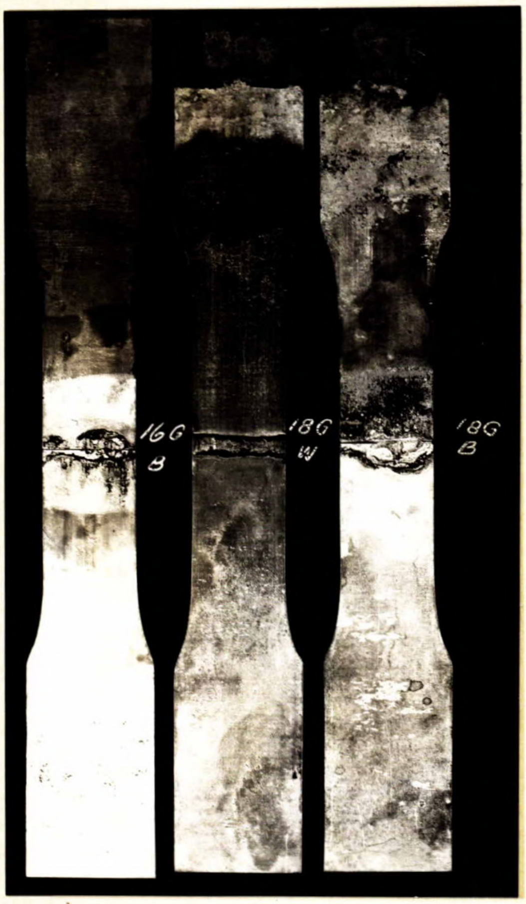
Macro-Examination:

During and after corrosion it was clear that the brazes were being attacked much more vigorously than the welds. Figure 1 shows the comparative behaviour of two butt brazes and a butt weld. Note that the brazing material is almost

(Macro-Examination, cont'd) -

completely gone, leaving the butting ends of the sheets plainly visible, while the weld appears practically untouched.

Figure 1.



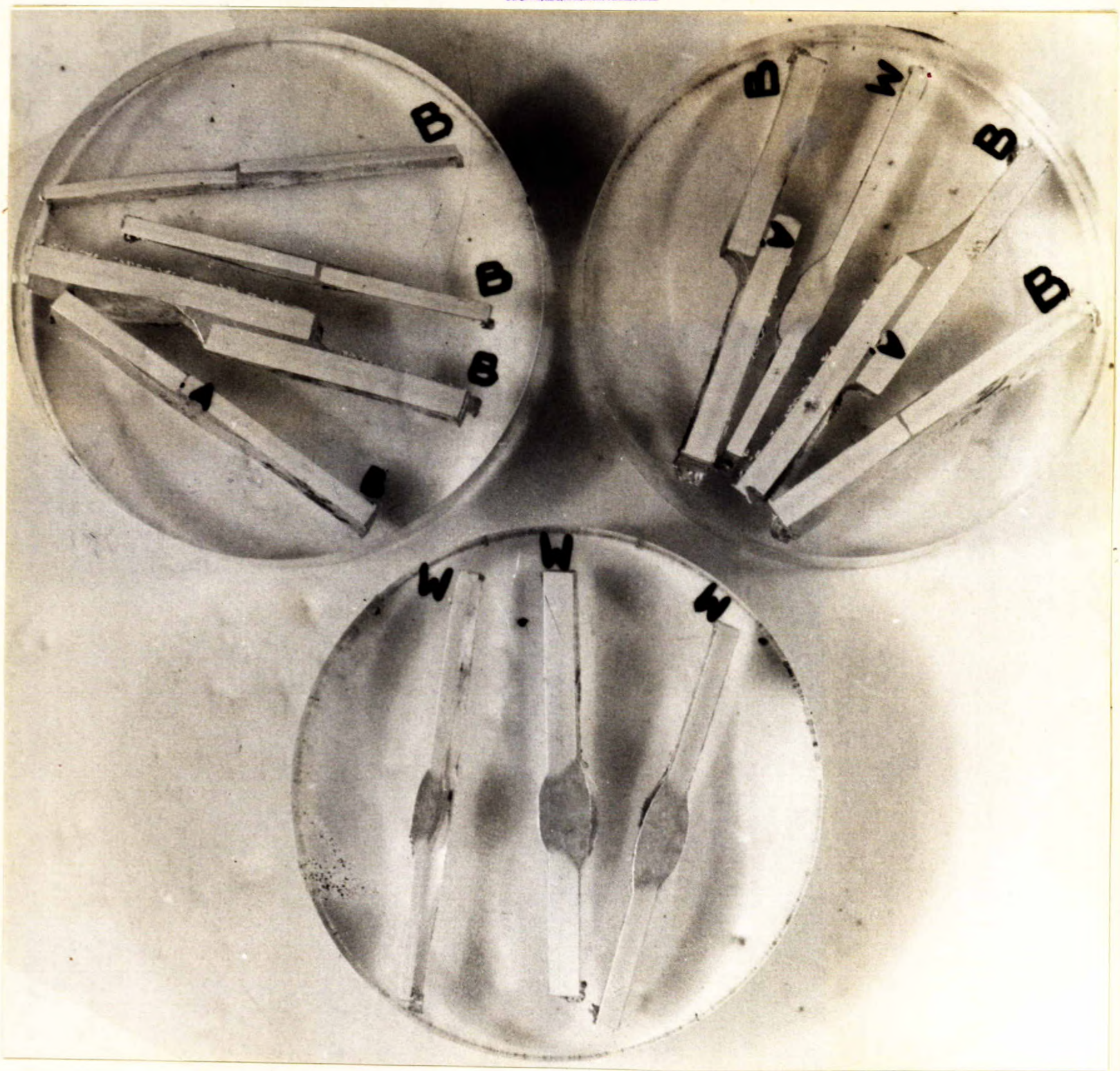
(Approximately 1/2 actual size).

CORRODED BRAZES AND WELD.

Sections from one of each type of weld and braze were examined, before corrosion, for porosity. Pores were seen in three of the brazes (see Figure 2) but none was noticed in the other eight samples.

(Macro-Examination, cont'd) -

Figure 2.



Approximately X2, etched with Keller's reagent.

CROSS-SECTIONS OF WELDS AND BRAZES.

Note pores at A. Welds and brazes are marked with W's and B's respectively.

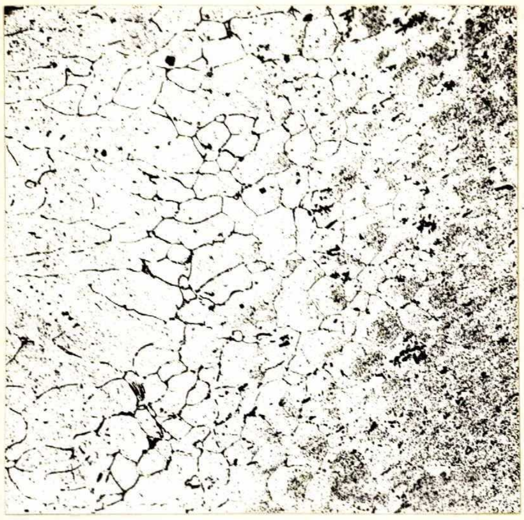
Micro-Examination:

The specimens used for macro-examination were polished and etched for microscopic study. Photomicrographs of a weld and a braze, the latter showing porosity, are given in Figures 3 and 4.

(Continued on next page).

(Micro-Examination, cont'd) -

Figure 3.



X100, Keller's etch.

FUSION LINE OF SHEET
AND WELD METAL.

Sheet at right.

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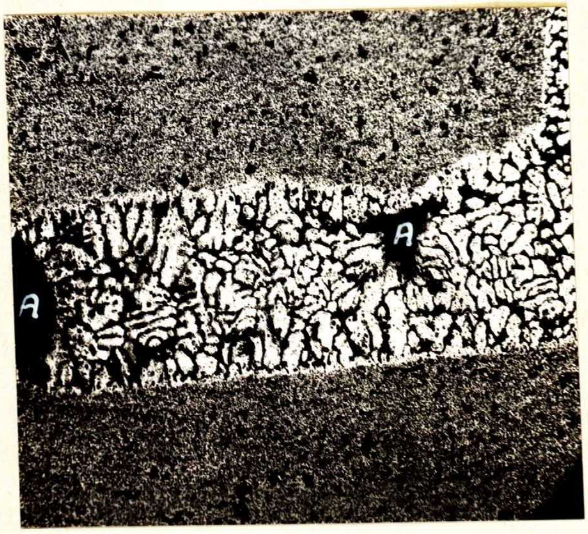
Figure 4.



X100, Keller's etch.

CROSS-SECTION OF
BRAZED JOINT.

Dark areas at A are voids. Black network is a dark etching constituent, and not voids.

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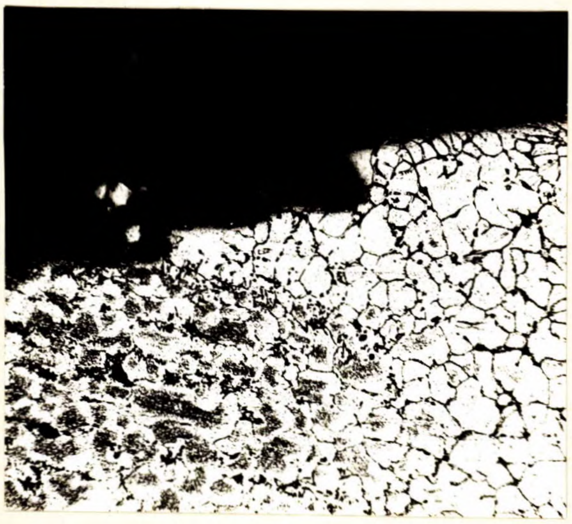
(Continued on next page)

(Micro-Examination, cont'd) -

After corrosion, sections were taken from representative welds and brazes and prepared for metallographic examination. In the welds a rather slight galvanic-type corrosion was found at the fusion line of weld metal and sheet (see Figure 5). The attack seemed to be of a pitting nature. The dark etching constituent of the brazes was selectively attacked, thus undermining the matrix (see Figure 6).

Figure 5.

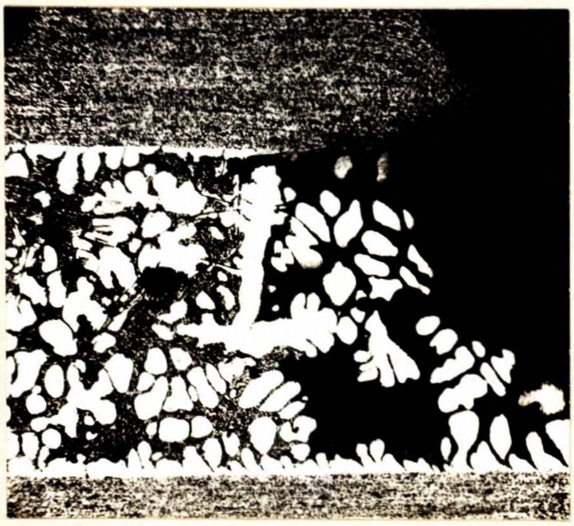


X100, Keller's etch.

CROSS-SECTION OF CORRODED WELD SPECIMEN.

Note pitting-type corrosion at fusion line. Sheet at left.

Figure 6.



X100, Keller's etch.

CROSS-SECTION OF CORRODED BRAZED SPECIMEN.

Note selective attack on dark etching constituent.

Discussion of Results:

Since all but one of the test specimens broke outside the welds and brazes in the tension tests before corrosion, there is no significant difference in strength. The uncorroded specimen which broke in a butt braze did so because that joint was somewhat porous and had very little reinforcement. It was quite noticeable, moreover, that in these bars the brazes had more porosity than the welds, no pores being found in the latter. Certainly, though, this is not fundamental, because the degree of porosity in either welding or brazing is a matter of technique and thus can be controlled.

Mechanical testing after corrosion and "loss in weight" corrosion tests demonstrate conclusively that these brazes (of unknown alloy) are very much more susceptible to corrosion than the examined welds. It is known, however, that there are other brazing alloys which would probably be more suitable and whose corrosion resistance might compare favourably with the welds. In these corrosion tests, the welds suffered no noticeable loss in strength.

Conclusions:

For applications where there is no likelihood of significant corrosion, this brazing alloy would make as strong a joint in this sheet as would welding, provided butt brazes, in particular, were reinforced somewhat to insure against lowering of properties by porosity. Under corrosive conditions, however, brazes with this alloy would be very much inferior to the examined welds.

If brazing is to be used for fabrication of parts subject to corrosion, it is suggested that a more corrosion-resistant alloy be tested. If this were done and a technique developed or a different brazing method adopted to reduce porosity, brazing might well replace welding for some applications.

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