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SUBJECT: Comparison of the Corrosion Resistance
of Some High-Nickel Content Brazing
Alloys to Fuel Compositions 44 and 107

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Summary

Non-chromium bearing brazing alloys containing large percentages of nickel (89 to 93 wt%) show good corrosion resistance to the NaF-KF-LiF-UF₄ (11.2-41.0-45.3-2.5 mole %, fuel 107) mixture at 1500°F under seesaw-test conditions. Corrosive action by fuel 107 was greater than that by NaF-ZrF₄-UF₄ (53.5-40.0-6.5 mole %, fuel 44) mixture on nickel-base brazing alloys tested.

Introduction

With increased emphasis on the use of the NaF-KF-LiF-UF₄ (11.2-41.0-45.3-2.5 mole %, fuel 107) mixture, some brazing alloys which have shown promising corrosion resistance to NaF-ZrF₄-UF₄ (53.5-40.0-6.5 mole %, fuel 44) have been tested in fuel 107. These alloys and their compositions, along with the suggested brazing temperatures in dry hydrogen, are given in Table I.

Either the pure alloy "button" or a brazed Inconel tube-to-header joint was used for test specimens. When the button-type specimen was used, a nickel capsule was employed because of its relative inertness to the fuel mixtures. An ideal two-component system is essentially achieved with this setup. Inconel capsules were used in tests when corrosion specimens were of the tube-to-header type.

Procedure

Test containers (3/4-in.O.D. x 0.035-in. wall) measuring approximately 16-in. long were loaded and filled with the bath to one-third their volumes under a purified argon atmosphere. They were then evacuated and sealed by heliarc welding. Seesaw tests were conducted at 1500°F hot-zone temperature at one cycle per minute for 100 hours.

Upon completion of the tests, specimens were stripped off the bath and examined metallographically. Resistance to corrosion was determined by the condition of the exposed surface of the alloy as far as porosity and leaching is concerned and weight changes accompanying the specimens of each test.

Results

The Coast Metals No. 52 and both Handy-Harmon alloys show about the same surface condition after testing, with the exception of the No. 52 alloy which

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TABLE I

BRAZING ALLOYS CORROSION TESTED IN BATH 107

<u>Alloy</u>	<u>Nominal Composition (Wt%)</u>	<u>Brazing Temperature (°F)</u>
Coast Metals No. 52	89Ni-5Si-4B-2Fe	1840
Coast Metals No. 53	81Ni-8Cr-4Si-4B-3Fe	1950
Handy-Harmon No. 91	91.25Ni-4.5Si-2.9B	1820
Handy-Harmon No. 93	93.25Ni-3.5Si-1.9B	1930

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developed slightly larger porous areas just beneath the surface. See Fig. 1 (Y-22835) and Fig. 2 (Y-23064, Y-22836). Microspark-spectrographic examination and analyses of millings taken from the depleted edge of these alloys after test indicate that boron and silicon are being selectively leached from the surface. The compositions of these two constituents at the edge of the alloy were approximately one-third of that found in the interior of the button after exposure. This condition is advantageous provided these minor constituents in the amounts leached can be tolerated in the bath since an extremely nickel-rich phase, both ductile and corrosion resistant, is left.

The listings in Table II show comparative corrosion resistance to these high-content-nickel-brazing alloys to the fuel mixtures. The 107 bath is the more corrosive to all the alloys, in some cases by two or three fold. The chromium containing Coast Metals 53 alloy showed severe corrosion. It was found that some micro-cracks in this alloy provided a path for the corroding medium. The chances of this crevice corrosion (Fig. 3, Y-23748) is possibly increased due to the low surface tension of the fuel 107. (3.0 centipoise as compared to 5.7 centipoise for fuel 44 at 700°C).

The tests in which a brazed Inconel tube-to-header joint was used for test specimens shows the same magnitude of corrosion but not as severe, since the attack is not concentrated on the brazing alloy alone but also on the Inconel capsule and tube-to-header specimen.

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TABLE II

COMPARISON OF RESULTS OF SEESAW CORROSION TESTS
ON BRAZING ALLOY BUTTONS TESTED IN BATH NO. 44 AND BATH NO. 107

Alloy and Nominal Composition	Metallographic Examination and Weight Change			
	Bath No. 44		Bath No. 107	
	Surface Condition	Wt. Loss (%)	Surface Condition	Wt. Loss (%)
Coast Metals No. 52 (89Ni-5Si-4B-2Fe)	Depleted to 3 mils. Non-uniform stringers to < 0.5 mil.	0.11	Relatively large voids at surface. Depleted to about 2-3 mils.	0.22
Coast Metals No. 53 (81Ni-8Cr-4B-4Si-3Fe)	Intermittent stringers 1 mil deep. Surface leached to 1 mil.	0.13	Heavy subsurface void formation to depth of 10 mils. Alloy leached to same depth.	0.85
Handy-Harmon No. 91 (91.25Ni-4.5Si-2.9B)	Surface leached to 1/2 mil deep. No subsurface voids observed.	0.07	Depleted to 3 mil in depth. scattered subsurface voids in this depleted region.	0.24
Handy-Harmon No. 93 (93.25Ni-3.5Si-3.9B)	Surface leached to 1 mil. No sub- surface voids observed.	0.03	Depleted region to 4 mils with accompanying sub- surface voids.	0.29

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Fig. 1 (Y-22835) Coast Metals No. 52 Brazing Alloy after Exposure to Fuel No. 107 for 100 Hr at 1500°F. Note the relatively heavy subsurface void formation as compared to the Handy-Harmon Alloys. Etchant - 10% Oxalic Acid.

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(a) Y-23064

(b) Y-22836

Fig. 2 Brazing Alloys (a, Y-23064) Handy-Harmon No. 91 and (b, Y-22836) Handy-Harmon No. 93 after Exposure to Fuel No. 107 for 100 Hr at 1500°F. Etchant - 10% Oxalic Acid.

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Fig. 3 (Y-23748) Micro-crack in Coast Metals No. 53 (81Ni-8Cr-4Si-4B-3Fe) after Seesaw Test in Fuel No. 107 for 100 Hr at 1500°F Hot-Zone Temperature. Etchant - 10% Oxalic Acid.

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