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SUBJECT: Dynamic Corrosion Screening Tests on Inconel Copy 13 of 27 copies. Series A.
and Nickel in $\text{NaCl-MgCl}_2\text{-UCl}_3$ Bath.

EXTERNAL TRANSMITTAL
AUTHORIZED

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SUMMARY

Nickel is more susceptible to mass transfer in a 100-hr non-isothermal dynamic corrosion system than is Inconel when exposed to a $\text{NaCl-MgCl}_2\text{-UCl}_3$ (50.0-33.3-16.0 mole %) bath at a hot zone temperature of 1800°F. No nickel mass transfer was observed in a 500-hr test at 1350°F, but Inconel showed some attack under these conditions. Inconel mass transfer was observed in both tests, being more severe at the higher temperature. On the bases of these preliminary tests, it appears that nickel is a more satisfactory container than Inconel for the chloride bath at temperatures in the region of 1350°F. The chromium is more susceptible to selective leaching from Inconel at 1800°F during a short 100-hr test (0.26% Cr in bath) than in a 500-hr test (< 0.001% Cr in bath) at a lower temperature (1350°F).

INTRODUCTION

At the request of a group from ORSORT working on a "Fused Salt Fast Breeder" project, dynamic seesaw corrosion screening tests, under non-isothermal conditions, were conducted on Inconel and nickel using a $\text{NaCl-MgCl}_2\text{-UCl}_3$ bath as a fluid fuel.

PROCEDURE

Tubing, 1/2-in OD x 0.035-in. wall thickness, was used for the test containers. These were filled to 35% of their volumes with the $\text{NaCl-MgCl}_2\text{-UCl}_3$ (50.0-33.3-16.7 mole %) bath in an inert atmosphere dry box. Capsules were then evacuated and sealed by heliarc welding.

Four tests were conducted in the seesaw furnace apparatus at a tilting rate of one cycle per minute with hot zones at 1350°F, with the exceptions cited. A nickel capsule and an Inconel capsule were tested for 100 hr in the same furnace. The failure of the temperature controller of this furnace caused the hot zone to rise to 1800°F. The tests were operated at this higher temperature with a temperature gradient between the hot and cold zones of 320°F. The other two tests of 500-hr duration were made with a nickel capsule and Inconel capsule in a second seesaw furnace with a hot zone temperature of 1350°F and a temperature gradient of 280°F between the hot and cold zones.

At the completion of the tests, the baths were allowed to solidify in the hot zone of the capsules in order to keep any mass transfer crystals which might have deposited in the cold zone free from solidified bath material. In this manner, crystals were easily photographed or collected for analysis.

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Sections from the hot and cold zones of each capsule were metallographically examined after test for any evidence of attack.

RESULTS

Results of corrosion tests at a hot zone temperature of 1800°F for 100 hr:

Mass transfer was found in both the nickel and Inconel capsules in the 1800°F tests, the nickel capsule exhibiting a much larger amount. (See Figs. 1, 2, and 3, Y-19642, Y-19663, Y-19664). The crystals from the Inconel container were analyzed spectrographically and found to contain 62% Ni - 8.5% Cr - 1.74% Fe (wt %).

Metallographic examination of the hot zones of each capsule showed a slight amount of surface roughening. Capsule wall thickness measurements indicated a uniform removal of the container material from the hot zones of each capsule.

Results of corrosion tests at a hot zone temperature of 1300°F for 500 hr:

No evidence of mass transfer was found in the nickel container. Metallographic examination of the hot zone portion of the nickel container showed small subsurface voids to a maximum depth of 0.5 mil.

A slight amount (a smaller quantity than shown in Fig. 3) of mass-transfer crystals was observed in the cold portion of the Inconel capsule. These crystals analyzed 85.2% Ni - 13.6% Fe - 1.2% Cr (wt %).

Metallographic examination of the hot zone portion of the Inconel capsule showed a scattered, subsurface void type of attack to a maximum depth of 4 mils, shown in Fig. 4 (Y-19922).

Chemical analyses of the baths before and after tests are listed below:

TABLE I
ANALYSIS OF CHLORIDE BATHS BEFORE AND AFTER TESTS
(Weight Percentages)

	Mg	U	Cl	Na	Ni	Fe	Cr
Before Test	9.23	27.34	52.24	11.49	--	--	--
After 100-hr test in Ni at 1800°F	8.11	22.8	55.4	12.5	0.0075	--	--
After 100-hr test in Inconel at 1800°F	7.6	20.9	55.9	13.6	< 0.001	< 0.001	0.26
After 500-hr test in Ni at 1350°F	8.7	22.4	52.4	12.3	0.009	--	--
After 500-hr test in Inconel at 1350°F	9.23	21.3	52.3	14.3	0.009	0.017	0.001

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Fig. 1 (Y-19642) Cross Sectional View of Cold Zone of Nickel Capsule
Containing NaCl-MgCl₂-UCl₃ (50.0-33.3-16.7 mole %) Bath Seesaw
Tested for 100 Hr at 1800°F Hot Zone Temperature.

Unclassified: ~~See [redacted] Caption.~~

Fig. 2 (Y-19663) Longitudinal Portion of Cold Zone from Nickel Capsule
Containing $\text{NaCl-MgCl}_2\text{-UCl}_3$ Bath and Seesaw Tested for 100 Hr at
1800°F Hot Zone Temperature. Unclassified: ~~Secret with Caption.~~

Fig. 3 (Y-19664) Longitudinal Portion of Cold Zone from Inconel Capsule
Containing $\text{NaCl-MgCl}_2\text{-UCl}_3$ Bath and Seesaw Tested for 100 Hr at
1800°F Hot Zone Temperature. Unclassified: ~~See Y-19664-1~~

Fig. 4 (Y-19922) Hot Zone (1350°F) of Inconel Capsule after Seesaw Test with $\text{NaCl-MgCl}_2\text{-UCl}_3$ Bath. Duration of test was 500 hr. The subsurface void type of attack was quite scattered and found to a maximum depth of 4 mils. Etchant: Copper Regia. Unclassified: [REDACTED].

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The uranium content of each bath decreased a slight amount during the tests. This can be attributed to the alloying of uranium with the container material. After removing any UCl_3 from the hot and cold zones of the Inconel capsule undergoing the 1800°F test, millings 5 mils deep were taken from the inner wall. Millings from the hot zone contained 0.019% uranium whereas those from the cold zone contained 0.015% uranium. This corresponds to 140 ppm of uranium per square inch of container material covered by the bath.

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