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EFFECT OF INCREASED NICKEL

CONTENT IN CANNING

BATHS

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by

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INTRODUCTION

Canning bath Al-Si is supplied from two major sources, offsite vendors and from reclaimed lathe turnings generated in the 313 Building. As the production of I & E fuel elements increased, larger quantities of scrap were produced from the well-type caps and thick can bases. This scrap was reclaimed and was almost sufficient to supply all of the canning bath makeup metal until increasing amounts of X-8001 alloy aluminum components containing one per cent nickel were used. Process Specifications were changed April 2, 1958, to permit reclaiming X-8001 lathe turnings to prepare Al-Si containing up to 0.5 per cent nickel. As a result of almost complete conversion to X-8001 alloy components, it is becoming necessary to use less reclaimed metal and more virgin Al-Si from off-site to insure that the 0.5 per cent nickel limit in the canning baths is not exceeded. Consequently, the Canning Sub-Section requested that a study of the effect of increasing the nickel content of the canning baths be made. It is reported that if the maximum nickel content were increased to 0.75 per cent, all of the X-8001 scrap could be reclaimed and an estimated annual saving of \$76,000 could be expected.¹

This report describes the experimented conditions that were used to investigate the effect of using nickel concentrations greater than 0.5 per cent in the canning baths. The effect on bond quality, weld integrity, reactivity, and canning bath operation is reported.

SUMMARY AND CONCLUSIONS

Al-Si containing 1.2 per cent Ni (specification 0.5 per cent) was used in the canning bath in the 306 Pilot Plant to determine the effect of higher nickel content on bond characteristics, reactivity, weld quality of finished fuel elements, and on the operating conditions in the Al-Si furnace. The effect of high nickel on weld quality has been reported separately in HW-63138.²

1. Letter, V. H. Nelson to F. W. Grubb, "X-8001 Scrap Utilization", November 2, 1959.
2. Hanson, G. R., "The Influence of the Nickel Content of the Brazing Alloy on Fuel Element Weld Quality", HW-63138, December 21, 1959. (Confidential)

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Using Al-Si containing 1.2 per cent Ni, bonding characteristics, including braze porosity, compound layer structure and bond strength were found to be comparable to normal fuel elements canned within the nickel specification of 0.5 per cent maximum. A slight reduction in reactivity equivalent to a maximum in-hour loss in C Reactor of up to nineteen in-hours was experienced. This is not considered significant and could probably not be detected in the reactors.

Some operating difficulties were experienced in both the duplex and the canning furnace when using Al-Si containing 1.2 per cent nickel. A tendency toward channel plugging was observed, but the exact nature of the plugging and the cause of it was not investigated. However, any restriction of furnace channels would modify furnace heating patterns and contribute to reduced fuel element uniformity by producing changes in core, can-sleeve assembly, and cap heating rates, as well as influence component wetting.

Based on the adverse weld quality reported in HW-63138, the slight loss in reactivity, and the potential for furnace channel plugging observed, it is recommended that the present nickel specification of 0.5 per cent maximum remain unchanged.

DISCUSSION

It was recognized that it would be very difficult to perform an ideal experiment using increased amounts of nickel in the canning baths because of the difficulty of changing from one condition to another. Since it is possible for X-8001 alloy to contain a maximum of 1.3 per cent nickel and 1.0 per cent iron, it was decided to use about these amounts of nickel and iron for the test. The test was divided in three parts and coded as follows:

<u>Code</u>	<u>Condition</u>
RD11	Low nickel, 0.17 per cent, in both duplex and canning furnaces as control samples.
RD12	Low nickel, 0.17 per cent, in duplex furnace and high nickel, 1.2 per cent, in canning furnace.
RD13	High nickel, 1.2 per cent, in both duplex and canning furnaces.

The Manufacturing Operation prepared Al-Si containing 1.2 per cent nickel and 1.0 per cent iron for this test by dissolving nickel and iron in the 313 Building makeup furnaces. Fuel element cores used consisted of several groups of transformation rejects that were randomized and divided into three groups of three hundred cores each.

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The first part of the test, RD11, was made September 25, 1959, by dip brazing the fuel elements in Al-Si that was not contaminated with X-8001 alloy scrap. However, the Al-Si did contain 0.17 per cent nickel due to dissolution of furnace baskets. Then the canning furnace was bailed and recharged with Al-Si containing 1.2 per cent nickel on Friday, September 26, 1959, and allowed to set over the weekend. Considerable difficulty was experienced on the following Monday, September 28, 1959, when furnace operators attempted to broach the channels. Once the canning furnace channels were opened, however, little additional material was deposited. The second group of material, coded RD12, was assembled with low nickel in the duplex Al-Si and high nickel in the canning furnace on September 28, 1959. The duplex Al-Si was then bailed and replaced with high nickel content Al-Si. The following morning, September 29, 1959, the furnace channels were broached and the left-hand side of the duplex was partially plugged. After some difficulty, the channels were completely opened and the third lot of material, coded RD13, was canned.

The pieces were then faced and welded as usual. After the normal weld inspection, the pieces were tested for bond integrity on the ultrasonic bond tester. The external bond probe was equipped with a lithium-sulfate crystal to provide greater sensitivity to fractures and discontinuities in the bond. Total external bond counts were taken and found to be lower for the high-nickel groups. Results are shown in Table I.

TABLE I

EFFECT OF NICKEL CONCENTRATION ON TOTAL EXTERNAL BOND COUNT

<u>Treatment</u>	<u>Average Log (X+1)</u>	<u>Antilog in Counts</u>	<u>Difference in Counts</u>
RD11	1.335	20.6	Control
RD12	1.258	17.1	-3.5
RD13	1.211	15.3	-5.3

For all practical purposes, increasing the nickel content of the canning baths will not degrade fuel element quality on the basis of total external bond count. In fact, increased nickel may even reduce external braze porosity. The day-to-day effect of canning variables is always present and may have influenced the above results.³

3. Letter, J. L. Jaech to W. F. Stevenson, "Effects of Nickel Concentration on Total Bond Counts", January 7, 1960.

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With the exception of a few fuel elements for others tests, all pieces from each of the test groups were turned over to G. R. Hanson for weld evaluation. In brief, the higher nickel content of the Al-Si increased both the weld reject rate and the incidence of non-mixing in the weld beads. The poor silicon mixing in the weld bead also covered defects in the weld, making them more difficult to see.⁴

A total of 120 fuel elements from this test were autoclaved. It was noted that the oxide film on the weld bead became darker, charcoal gray, at the highest nickel level.

Five fuel elements from each of the test groups were sectioned for compound layer evaluation. There was essentially no difference in the resulting bonding layers; however, it was noted at the higher nickel levels that the UAl_3 -type compound tended to be somewhat softer than usual. No actual hardness measurements were made, but after polishing, the interface between the UAl_3 -type compound and the uranium had a pillow-shaped edge rather than the jagged edge, which is typical of the usual UAl_3 -type compound layer. This slight difference in compound layers does not appear to be detrimental.

Bond strength measurements by the stud-pulling method for each of the groups were made. The average bond strength of two measurements taken at the center of each of thirty pieces from the three test groups is shown below.

TABLE II

AVERAGE BOND STRENGTH

	<u>Tensile Strength in lb/in²</u>	<u>Difference lb/in²</u>
RD11	13,100	Control
RD12	11,900	-1,200
RD13	13,800	+ 700

It will be noted that the pieces canned in Al-Si containing the high level of nickel had the highest bond strength and the pieces brazed with low-nickel duplex Al-Si and assembled in high-nickel canning furnace Al-Si had the lowest bond strength. These differences, however, are not significant.⁵

4. op. cit., Hanson, G. R., page 2.

5. Letter, K. B. Stewart to W. F. Stevenson, January 4, 1960.

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Since nickel has a high neutron cross-section, increased amounts of it in Al-Si reduces the reactivity of fuel elements. A total of 44 fuel elements from each of the test groups was sent to the 305 Test Reactor for reactivity measurements. Table III shows a decrease in reactivity as the nickel content of the canning bath is increased. The discrepancy in reactivity values of RD12 (high nickel in canning bath only) and RD13 (high nickel in both baths) could not be found. It is concluded, however, that increasing the nickel content of the canning baths would cause a slight reduction in fuel element reactivity.

TABLE III

EFFECT OF NICKEL IN AL-SI UPON FUEL ELEMENT REACTIVITY

AS MEASURED BY THE 305 TEST REACTOR

Average Reactivity Measured in In-Hours*

<u>Treatment</u>	<u>ΔIn-Hours</u>	<u>Reactivity Loss Fully Loaded C Reactor (in hours)</u>	<u>Difference</u>
RD11	-0.892	4	Control
RD12	-0.956	23	-19
RD13	-0.918	12	- 8

* Calculated by C. E. Fitch

For reactor operating purposes, this slight loss in reactivity is not a problem; however, any loss in reactivity means a loss in net plutonium production.

C. A. Strand

C. A. Strand, Engineer
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