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TITLE

SUPPLEMENT A TO DESIGN OF PT-IP-263-A-FP, EVALUATION OF CHEMICALLY NICKEL PLATED FUEL ELEMENTS

AUTHOR

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and
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SUPPLEMENT A TO DESIGN OF PT-IP-263-A-FP,
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FUEL ELEMENTS

By

M. A. Clinton
And
W. H. Hodgson

August 22, 1961

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INTRODUCTION

Irradiation of the initial test in this program involving ten tubes of alternately charged nickel-plated C-64 alloy clad test elements and X-8001 alloy control elements has been successfully completed. The test indicated[1] that the nickel-plate spalling problem has been resolved, as no significant spalling or flaking was observed during the post-irradiation examination. The second test in this program will be to verify that the nickel-plate integrity problem has been solved by irradiating a pilot loading (up to 100 charges) of fuel elements which have been nickel-plated on a production basis.

OBJECTIVE

The objectives of this supplement are to present revisions in the program for evaluation of nickel-plated aluminum-jacketed fuel elements and to outline details for preparation of fuel for the remaining tests.

TEST SUMMARY

This test includes preparation and irradiation of up to 100 columns of OIIN, chemically nickel-plated, C-64 alloy jacketed fuel elements to 200 per cent of normal goal exposure to extend the evaluation of nickel-plated fuel elements on a pilot scale at DR Reactor. Up to seventy columns will be plated to a nominal thickness of 0.5 mil and up to thirty columns to a a nominal 0.2 mil thickness. Twenty measured columns, ten representing each plate thickness, will be charged to monitor the irradiation performance. Effluent samples will be obtained during the course of the test from a pair of tubes, each tube containing a measured monitor charge representing each plate thickness.

Either concurrently or following the above test, depending on the availability of nickel-plated "K" size enriched fuel elements, a 100 column test will be prepared for irradiation in a K Reactor. This test will be a pilot scale step in the evaluation of nominal 0.2 mil nickel plate and will incorporate 10 measured charges to monitor corrosion and dimensional distortion.

Following the initial test above, a 10 tube test will be prepared for irradiation in an old reactor. These 10 columns are to contain alternately charged fuel elements (a) prepared from nickel plated aluminum components and (b) nickel plated following canning (as were all previously tested nickel plated fuel elements).

BASIS AND JUSTIFICATION

The incentives and the highlights of the nickel-plate development and testing program have been covered in HW-68793.[2] The application of a thin coating

(1) HW-69285, "Post-Irradiation Examination of Chemically Nickel-Plated Fuel Elements from PT-IP-263-A (RM-414)", W. J. Gruber, 4/17/61.
(2) HW-68793, "Incentives for Nickel Plating Aluminum-Jacketed Fuel Elements", G. F. Jacky, 3/20/61.

[redacted]

of nickel on the coolant contacting surfaces of aluminum-jacketed fuel elements to provide additional corrosion resistance is attractive. Potential benefits of a nickel coating include a corrosion-resistant coating to protect against severe localized temperature conditions, reduction of mechanical damage to both fuel element jackets and process tube ribs, improved fuel element alignment (by reducing friction between fuel elements and process tube ribs) and probably lower over-all surface temperatures due to reduction in corrosion product film. Upon demonstration of improved corrosion resistance, utilization of a 0.2 mil thick plate on C-64 aluminum alloy could permit a decrease in can wall thickness and an accompanying increase in uranium volume and/or an increase in coolant flow annulus.

While major problems have included producing an adherent continuous plate of uniform thickness and evaluation of the possible reactor effluent contamination by radioactive nickel, cobalt and phosphorous, the test results to date have been encouraging and are summarized briefly below.

1. Satisfactory adhesion (probably 100 per cent) of 0.5 mil thick chemically deposited nickel plate can be achieved as demonstrated by the irradiation performance of 136 nickel-plated fuel elements from eight charges exposed to a nominal 800 MWD/T[3].

2. Reactor effluent contamination from nickel-plated fuel elements may be tolerable, based on data from four tubes irradiated to approximately 400 MWD/T at C Reactor[4]; however, these results cannot be extrapolated to full reactor usage and further testing will be required.

3. Nickel plate affords a high degree of corrosion protection in hot-spot areas.[5] Thirty-five of 136 fuel elements[6] from eight charges which were irradiated to 800 MWD/T exhibited hot-spot corrosion patterns with no evidence of apparent aluminum corrosion. This observation was supported by the fact that weight loss of the nickel-plated elements was practically nil (six to fifteen fold less than the X-8001 jacketed control elements) in the region of maximum corrosion in the reactor.

4. Aluminum, in reactor process water, does not corrode at an accelerated rate at the site of discontinuities (pinholes or hairline cracks) in the nickel plate provided the adhesion of the plate is good; and even if a portion of the plate should slough, restriction of coolant flow passage is highly unlikely as shown by ex-reactor fuel-tube flow tests[7]; however, this may only be true for chemically deposited plate.

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(3) HW-64419 C, "PT-IP-263-A-FP, Evaluation of Chemically Nickel Plated Fuel Elements", R. E. Hall and M. A. Clinton, 4/20/60.
(4) HW-58179 C, "Irradiation Summary Report PT-IP-207-A-3-FP, Evaluation of Effluent Contamination Problems Associated with Nickel Coated Fuel Elements", R. E. Hall and R. B. Hall, 11/16/59.
(5) Op.Cit., HW-69283.
(6) Personal Communication, K. E. Fields.
(7) HW-63636, "Interim Evaluation of Nickel Plate on Aluminum-Jacketed Fuel Elements", G. F. Jacky, 2/8/60.

5. Aluminum components, plated on both external and internal surfaces, may be employed for AlSi dip canning to provide a corrosion resistant layer of nickel on both the internal and external surfaces of the aluminum jacket. The internal plate virtually eliminates AlSi penetration of the aluminum can wall during canning; hence, a more accurate pre-determination of residual can wall thickness is permitted.[8]

In conclusion, it is believed that nickel plate has a high potential for achieving the benefits cited above.

FABRICATION OF TEST MATERIAL

Nickel Plated Fuel Elements

Standard OIIN fuel elements jacketed in C-64 aluminum alloy will be utilized for the 100 column test in DR Reactor. The variables in this test will include:

1) five uranium canning lots randomly utilized;

2) two plating vendors "H" and "I". Vendor "I" will probably supply about 60 per cent of the acceptable plated elements;

3) approximately 10 plating lots (pieces plated simultaneously) per plating vendor;

4) two plating thicknesses (25 per cent of each plating lot to be 0.2 mil thick and the remainder to be 0.6 mil thick plate) will be produced.

The nickel plated fuel elements for the 100 tube pilot loading in a K Reactor will be standard KIVE geometry, jacketed in C-64 aluminum alloy. The nickel plate, produced by one vendor will be a nominal 0.2 mil thickness.

Nickel Plated Components

Special OIIIN geometry C-64 aluminum alloy cans (0.2 - 0.3 mil nickel plate thickness) and spires (0.6 - 0.8 mil nickel plate thickness) plated on internal and external surfaces are to be lead-dip canned for the plated component test. Nominal dimensions are as follows:

	Core	Can	Spire	Finished
O.D.	1.372	1.440	0.370	1.447
I.D.	0.390	1.385	0.310	0.313

Assembly

All fuel elements shall be fabricated by the F Process.[9] Supplemental procedures written for PWR-54-19 cover special steps in canning and finishing of nickel plated components for this test.

(8) Personal Communication, G. F. Jacky.
(9) HW-47029, "Process Specifications, Fuel Element Manufacturing Processes", Fuels Preparation Department.

[redacted]

Use of watermixer elements is being considered and will be used at the discretion of the Process and Reactor Development Operation representative and with the concurrence of the processing operation manager.

Quality of Material

All standard quality control measures will be applied in fabrication of fuel elements.

Quantity of Material

Numbers of acceptable fuel elements for each test are as follows:

a) Old Reactor Test: OIIN 0.6 mil plate thickness - 2260 pieces
OIIN 0.2 mil plate thickness - 980 pieces

b) K Test: KIVE 0.2 mil plate thickness - 4620 pieces

c) Plated Component Test: 0.2 mil plate thickness - 170 pieces
0.2 mil plate thickness (controls) - 170 pieces

TESTING

Pre-Irradiation Testing and Measurements

1. In addition to the ex-reactor testing described in the basis of HW-64419 A, the tests listed below will be used to insure plate integrity:
All fuel elements will be subjected to the normal F process autoclave cycle, after which a 100 per cent visual inspection will be made for plate defects. Selected pieces will be sectioned to determine the quality of the plate and condition of the nickel-aluminum bond.

2. Ten charges of each type, 0.5 mil plate and 0.2 mil plate for the DR Test, ten charges of the 0.2 mil KIVE for the K Test, and ten charges of alternated plated component and nickel plated fuel elements will be numbered for series and position. Odd numbered fuel elements in these "monitor" charges will have weight, O.D, warp and length measured and recorded. Odd numbered pieces will have I.D. measured and recorded. Where applicable, plating vendors, plating lot and plate thickness will be identified.

Irradiation Tests

This design outlines the intent and extent of three parts of this irradiation of nickel plated fuel elements. These tests may be irradiated concurrently or sequentially as acceptable test material is made available.

1. Pilot Evaluation in DR Reactor

Charge up to 70 columns of heat treated (300 C for 5-6 hours) 0.5 mil nickel-plated, C-64 jacketed OIIN I&E fuel elements and up to 30 columns of heat-treated (300 C for 5-6 hours) 0.1 to 0.2 mil nickel plated C-64 jacketed OIIN I&E fuel elements to be irradiated for two cycles to achieve goal exposure. Ten charges each of the 0.5 mil and 0.2 mil nickel plate will be weighed and measured and will require special charging and pickup. Water sampling equipment is required to monitor effluent and measure contamination due to the nickel plate.

It is not the intent of this test to take ruptures. However, if two ruptures should occur in nickel plated columns, the remaining columns in the test may be discharged prior to the scheduled goal, provided all monitor columns can be specially picked up.

2. <u>Pilot Evaluation in K Reactors</u>

   Charge up to 100 columns of heat treated (300 C for 5-6 hours) 0.1 to 0.2 mil nickel plated, C-64 jacketed, KIVE I&E fuel elements to be irradiated to normal exposure goals. Ten charges of the 100 will be weighed and measured and will require special charging and pickup.

3. <u>Preliminary Evaluation of Nickel Plated Components</u>

   Ten measured columns containing alternated fuel having nickel plated components and C-64 jacketed fuel plated after canning will be irradiated to normal exposure goals in an old reactor.

POST IRRADIATION EXAMINATION

1. Measured charges are to be visually examined in C Basin Metal Examination Facilities, for surface phenomenon prior to and following cleaning and a record of all unusual conditions and changes in appearance noted. Those pieces which exhibit unusual surface conditions are to be photographed.

2. All pre-measured fuel elements will be measured for weight, diameter and warp in order to determine the tube filling capacity of each piece.

3. Selected fuel elements representing the best and worst appearance may be sent to Radiometallurgy for more complete examination and metallography.

TEST AUDIT

All data pertaining to the preparation of this test are to be recorded in a PT notebook for this test. Any unusual incidents, whether or not they seem important at the time, are to be recorded in the notebook. The appendix of this report contains a list of items to be used as a guide for preparation of the notebook.

[redacted]

TEST LIMITATIONS AND HAZARDS

No unusual limitations or hazards are anticipated.

W. H. Hodgson, Engineer
AlSi Product Engineering
Engineering Section
Fuels Preparation Department

M. A. Clinton, Engineer
Reactor Fuels Unit
Research and Engineering Section
Irradiation Processing Department

WHH:MAC:dl

[redacted]

APPENDIX

Data to be recorded in Production Test Notebook:

I. Fuel Element Core

  A. Lot Numbers

    1. Ingot Numbers and Chemical Analysis
    2. Unusual Treatment

  B. Finished Dimensions (Pre-Assembly)

II. Aluminum Components

  A. Lot Numbers

    1. Alloy Type
    2. Unusual Treatment

  B. Finished Dimensions (Pre-Assembly)

  C. Pre-Assembly Treatment (Cutoff, Sizing, Inspection, Nickel Plating - vendor, thickness, etc.)

III. Pre-Assembly Treatment of Cores

  A. UT-2 Record Data

  B. SORT-Record Data

  C. Surface Tester-Record Data

  D. Measure Length, O.D., I.D., and Warp

IV. Assembly Process

  A. Process Used

  B. Brief Explanation of Each Process

  C. Attendant Conditions

  D. Total Bond Count

V. Post-Assembly Treatment

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A. Support Attachment

B. Nickel Plating

C. Autoclaving

D. Other Treatment

E. Inspection

VI. Pre-Irradiation Examination and Measurements

A. Dimensions, Length, O.D., I.D.

B. Warp

C. Weight

VII. Irradiation

A. Coolant Temperature

1. Inlet
2. Outlet

B. Panellit and Crossheader Pressures

C. Number of Shutdowns (Controlled and Scram)

D. Other

VIII. Post-Irradiation Examination

A. Visual

B. Warp (And Other Profilometer Data)

C. Total Bond Count

IX. Log - Running account with dates recording the progress of the PT, unusual incidents (such as slight change in process during assembly), and other deviations whether or not they seem pertinent at the time of occurrence.

[redacted]

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