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TITLE

DESIGN OF PRODUCTION TEST IP-243-A-6
EVALUATION OF X-8001 ALLOY ALUMINUM
COMPONENTS FABRICATED FROM CAST PLAN

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March 17, 1959

DESIGN OF PRODUCTION TEST IP-243-A-6-FP, EVALUATION OF X-8001 ALLOY ALUMINUM COMPONENTS FABRICATED FROM CAST BLANKS

INTRODUCTION

Problems with segregation and non-uniform dispersion associated with X-8001 components and their possible in-reactor implications prompted FPD to investigate component fabrication techniques. As a result, it was found that segregation and dispersion problems appeared to decrease as starting ingot sizes also decreased. The ultimate in this direction was, of course, casting individual extrusion blanks for each component piece. Solid cans fabricated in this manner have shown no deleterious corrosion effects in autoclaves up to four months in 360 C water. Flow loop tests in process water at about 120 C have shown nothing untoward so far but are not complete. Metallurgically, segregation and dispersion problems normally associated with X-8001 bloom stock produced by standard fabrication techniques were absent. Costly additional scalping of the bloom stock to produce uniform alloy for present X-8001 components by standard fabrication techniques was not necessary.

In view of the potential improvement in jacket corrosion resistance resulting from the more uniform structure of the X-8001 alloy fabricated by this process, it appears expedient to evaluate the in-reactor performance. The purpose of this report is to present the design of a test for this evaluation.

OBJECTIVE

The objective of this test is to determine the quality and erosion resistance of caps and cans produced from cast X-8001 alloy blanks through fabrication and irradiation of limited quantities in accordance with the testing procedure herein defined.

SUMMARY OF TEST

Components which were fabricated from X-8001 alloy cast blanks have been subjected to rigorous out-of-reactor tests and have indicated equivalence or possible superiority to standard X-8001 alloy components. It is, therefore, proposed that; (1) six enriched charges of (0.94% U235) test material alternated with standard control material be irradiated; two to 500 MWD/T, and four to 800 MWD/T goal exposures in an old reactor, to compare corrosion resistance and (2) up to 240 charges of test enriched fuel elements be irradiated to normal variable goal exposure for enriched I & E in the same reactor, to further evaluate the performance of the components fabricated from cast blanks.

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Provided the results of this test indicate X-8001 alloy components fabricated from cast blanks are equivalent or superior to the standard Alcoa controls, they will be considered acceptable jacketing for production fuel elements.

BASIS

The early sporadic occurrence of severe groove pitting during irradiation seriously challenged the use of X-8001 nickel aluminum alloy as a fuel element cladding material. Although the actual cause of the groove pitting has not been determined[1], non-uniform dispersion of the nickel in the alloy is suspected as a contributing factor. The cause of the non-uniform nickel dispersion or segregation has been determined and virtually eliminated by additional scalping of the X-8001 alloy bloom stock before rolling and impact extrusion of components. The additional scalping has resulted in an increase in the cost of X-8001 alloy components.

Investigation of alternate component fabrication techniques has shown that nickel dispersion apparently improves as the starting X-8001 alloy ingot size is decreased. On this basis, components have been fabricated from cast blanks for HAPO evaluation.

Preliminary tests on the cast blanks and on components fabricated from cast blanks include metallography, chemical analysis, impurities distribution, grain orientation, grain size, high temperature autoclave tests in 360 C water for four months and as yet incomplete flow loop tests in process water at about 120 C. On the basis of these tests components from cast blanks were found to have more uniform nickel dispersion, appear to have improved corrosion characteristics and in other respects were not significantly different from X-8001 alloy components fabricated by standard fabrication techniques.

PROCEDURE

1. Components

   a. Cap and Cans - Fabricated from cast X-8001 blanks for six inch enriched uranium OIIE size I & E cores. Components from cast blanks must pass quality controls applied to normal components. Component Code M-2.

   b. Cores - Standard six inch length, enriched (0.94% U-235) uranium, "O" size I & E Cores, which shall meet all HAPO specifications as to physical and chemical properties and fabrication techniques.

2. Assembly

   All fuel elements shall be fabricated by the "F" process (Lead Dip Process For Heat Treated Uranium, HW-47029)

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1. HW-54010, "Production Test IP-124-A, Investigation of Conditions Leading To The Severe Pitting of M-388 Alloy Slug Jackets", N. R. Miller, 12-3-57, Secret

[redacted]

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3. Quality of Material

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

4. Quantity of Material

Approximately 8,000 acceptable I & E enriched fuel elements will be required for this evaluation. The bulk of this material will be lot charged to evaluate performance to goal exposure. A total of 108 acceptable pieces will be required for measured tubes to monitor corrosion of the jacketing material.

COMPARISON STANDARDS

Standard control elements will be jacketed in X-8001 alloy components fabricated by Aluminum Company of America. A total of 108 acceptable I & E enriched fuel elements will be required for standard controls.

TESTING

Pre-Irradiation Testing and Measurements

1. Pre-exposure measurements or weight, length, warp and external diameter will be required on all fuel elements for the small scale test.

2. Charging order will be stamped on all measured pieces.

Irradiation

Six charges containing alternately charged standard and test pieces will be irradiated in an old Reactor, two to 500 MWD/T and four to 800 MWD/T goal exposures for corrosion evaluation. In addition, up to 240 charges of test elements will be irradiated in the same reactor to normal variable goal for enriched I & E fuel elements.

Post Exposure Measurements

1. All fuel elements from measured charges will be visually inspected for surface conditions.

2. Post exposure measurements of length warp and diameter are required for all measured fuel elements. Weights of pieces in positions 1 through 17 in each tube are required.

3. All measured fuel elements will be weaseled to determine specific exposure and specific power.

TEST AUDIT

Notebook HW-59430 is to be used to record all data pertaining to this production test. Any unusual incidents whether or not they seem important at the time, are to be recorded in the notebook. The Appendix to this report is a guide for the preparation of the notebook.

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TEST LIMITATIONS OR HAZARDS

No unusual limitations or hazards are anticipated.

W. H. Hodgson
Process Engineering Operation
Engineering Operation
Fuels Preparation Department

R. E. Hall
Reactor Fuels Operation
Process and Reactor Development Operation
Irradiation Processing Department

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APPENDIX

DATA TO BE RECORDED IN PRODUCTION TEST NOTEBOOK

I. Fuel Element Core

A. Chemical Composition

B. Casting Data
1. Site
2. Dingot or ingot
3. Mold size
4. Mold type (temperature distribution)
5. Mold liner
6. Pickled or unpickled derbies

C. Fabrication Data
1. Site
2. Type of fabrication (rolled, extruded, etc.)
3. Attendant conditions

D. Heat Treatment
1. Site
2. Form of material when treated
3. Attendant conditions

E. Finishing Data (Machined or Centerless Ground)

F. Finished Dimensions (Pre-assembly)

G. Properties
1. Orientation data
2. Tensile data
3. Other significant properties

H. Pre-assembly treatment (including inspection)

II. Can

A. Chemical Composition

B. Fabrication Data
1. Site
2. Type of fabrication
3. Attendant conditions

C. Heat treatment

D. Finished Dimensions (Pre-assembly)

[redacted]

E. Properties
   1. Hardness
   2. Tensile Data
   3. Other

F. Pre-Assembly Treatment (Including Inspection)

III. Assembly Process

A. Process Used
B. Brief Explanation of Process
C. Attendant Conditions

IV. Post Assembly Treatment

A. Protective Coating
B. Autoclaving
C. Other Treatment
D. Inspection

V. Pre-Irradiation Examination

A. Dimensions
B. Warp

VI. Irradiation

A. Coolant Temperature
   1. Inlet
   2. Outlet

B. Panellit and crossheader pressures
C. Number of shutdowns (controlled and scram)
D. Other

VII. Post Irradiation Examination

A. Visual
B. Warp (and other profilometer data)
C. Fracture data
D. Other

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

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