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PRODUCTION TEST IP-805

IRRADIATION OF NEPTUNIUM TARGET ELEMENTS

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PRODUCTION TEST IP-805
IRRADIATION OF NEPTUNIUM TARGET ELEMENTS

November 1, 1965

R. E. Baars
G. F. Owsley

Research and Engineering Section

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By J. E. Savely 9-22-94

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PRODUCTION TEST IP-805
IRRADIATION OF NEPTUNIUM TARGET ELEMENTS

OBJECTIVE

The objective of this production test is to obtain experimental data on plutonium 238 production in Hanford reactors.

BASIS AND JUSTIFICATION

A sustained demand for large quantities of plutonium 238, a heat generating isotope, formed by irradiation of neptunium 237, is anticipated over the next ten to fifteen years. Plutonium 238 is thus a natural candidate as an alternate product for production reactors. Detailed studies^{1,2} have been completed outlining the advantages and incentives of producing plutonium 238 at Hanford. A primary conclusion of these studies is that more efficient production is possible in Hanford's relatively low neutron fluxes. Under irradiation neptunium 237 captures a neutron, then decays to plutonium 238 by beta emission. The intermediate product, neptunium 238 has a high capture cross section; therefore in a low flux field a greater proportion decays to the desired product. More efficient utilization is an important advantage since the amount of plutonium 238 that can be produced is limited by the availability of target neptunium.

The referenced studies and conclusions drawn therefrom are based entirely on analytical calculations. Experimental data are needed to confirm the calculations and demonstrate Hanford's capability.

TEST DISCUSSION

It is proposed to irradiate 12 neptunium target elements in one of the K Reactors. Three groups of four elements each will be irradiated. Two of the groups contain 16 grams of neptunium oxide (NpO_2) per element, and one group contains 63 grams per element. Trace quantities of lithium are included as a flux monitor. The high concentration group and one low concentration group will be irradiated in one process tube for approximately 180 operating days; the other low concentration group will be irradiated in another tube for 100 operating days. Uniformity of fuel loading in the eight adjacent tubes is needed during the residence of each test column; therefore only natural uranium shall be charged into these tubes. Numbered fuel columns shall be maintained in one of the four tubes immediately adjacent to each test column for flux traverse purposes. Additionally, spline flux traverses shall be taken on each of the test columns and on two other spline tubes with fuel loading in the vicinity of the test columns.

The elements will be fabricated by compacting NpO_2 powder and aluminum (metal) powder to 95% of aluminum theoretical density in 90 mil wall thoria cans. The finished elements will be about five inches long. Considerable extra expense and delay would be necessary to provide supports on the cans; for this reason, it is proposed to irradiate the elements without supports in central zone spline (ribbed) tubes.

Some fissionable material will be produced in these elements. A maximum specific power of 15 kw/ft or less is predicted for the high concentration elements after 180 days irradiation. Although these are low density elements, high graphite

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temperatures should not occur due to the low specific power. Also, because of low heat generation sufficiently low cooling flow rates can be used that chattering of the light weight pieces should not occur.

Neptunium 237 decays by alpha emission to protactinium 233, a 0.3 Mev gamma emitter with a 27 day half-life. Thus, the target pieces will be mildly radioactive at the time of charging. It is estimated that the unshielded low concentration pieces will read about 15 mr/hr at one foot(per piece), and that the high concentration pieces will read about 60 mr/hr per piece at one foot. All twelve together would read about 120 mr/hr at one foot including self-shielding effects of the pieces grouped together³.

TEST DETAILS

1. Reactor

This test will be conducted in KW Reactor. It is highly desirable for the test to be run in one of the K Reactors since no question could arise as to uncertainty of extrapolation from small reactor results. KW Reactor was chosen because of the KER testing complex at KE.

2. Neptunium Elements

a. Fabrication

As previously described, the neptunium elements will be fabricated by compacting a mixture of NpO_2 and aluminum powders in standard 90 mil wall thoria cans. The compaction will be carried to 95% of theoretical density, with the compacted mass similar in appearance to a solid aluminum cylinder. Following compaction, the cans are cut to length, end caps inserted and the weld closure completed.

b. Dimensions

The pieces will conform to standard thoria diametral dimensions for K size ribbed tubes, and will be five-inches long with an active length of four inches.⁴

c. Columns

One test column will consist of two groups of four elements each. The groups will be separated by aluminum dummies fabricated as noted below and approximately centered in the tube. Additional aluminum dummies will be included as required for a column length equal to the standard 38-piece thoria charge. The standard downstream dummy pattern for a 38-piece thoria charge will be used, and the standard upstream spline perf charge will be used. The second test column will be essentially the same except it will contain only one group of four elements. Detailed charging orders will be provided for each column by the test authors. The neptunium elements and aluminum dummies will be identified as to

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position number within the fuel column and a series number will identify each column. The identifying letters and numbers will be stamped on the downstream end of the elements and dummies.

d. Pre-Irradiation Measurements

The neptunium elements will be measured at the standard O.D. locations before charging.

3. Aluminum Dummies

The aluminum dummies will be formed by filling standard thoria cans (1.480 inches O.D.) with surplus end caps, and then welding an end cap in place. The test author will supply the aluminum dummies.

4. Fuel Elements

At least one numbered column of standard K5W fuel elements shall be irradiated in one of the four process tubes adjacent to each test column during its residence. The elements in these columns shall be identified as to position number within the column and a series number will identify each column. The identifying letters and numbers will be stamped on the downstream end of the elements. Other pre-irradiation measurements will be made as per Production Test IP-216 practices.

5. Process Tubes

The test columns shall be charged into standard ribbed, aluminum spline tubes in the central zone. Tubes on the far side of the reactor are preferred to minimize special pick-up problems. The nearest rod bank or test hole shall be at least 1-1/2 lattice units away. Only natural uranium shall be charged in the eight tubes surrounding each test column.

6. Irradiation

a. Charging

The aluminum dummies in the test columns may be machine charged if desired. The test elements will be individually charged. As previously noted, the neptunium elements are radioactive. Standard spline caps and thoria rear caps* for the ribbed tubes will be used. The caps will be painted pink for identification, and identification tags used.

b. Data

Flow and outlet temperature data shall be taken daily (or less often with concurrence of the test author) by Processing on the four tubes immediately adjacent to the test columns, and the test columns. Forms for recording the data will be supplied by the test author. Spline traverses shall be taken approximately once per month on each test column and on two other columns in the immediate vicinity as directed by the Process Physicist. if spline data is

* As per design change 951

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not satisfactory in the Process Physicist's opinion, the traverses will be rerun.

c. Orificing and Panellit Requirements

The proper orificing and Panellit requirements for the test columns will be specified by the Process Engineer. One of the two arrangements now used on thoria tubes should be satisfactory. The primary concern is that the flow rate should not exceed approximately 30 gpm so as to avoid chattering of the light-weight pieces.

d. Goal Exposure

The column containing only four low concentration neptunium elements shall be discharged after accumulating 100 ± 15 days operation. The column containing eight test elements shall be discharged after accumulating 180 ± 15 days operation. The numbered fuel columns required adjacent to each test column will be discharged at normal goal exposure, except that the numbered fuel column in residence when the associated test column is discharged shall also be discharged whether normal goal exposure has been achieved or not. Goal exposure for either the test columns or the numbered fuel columns may be changed by the test author with the concurrence of the Manager, KW Processing.

e. Discharge

Both test columns and numbered fuel element columns shall be given special pickup upon discharge. Numbered fuel columns may be stored as many as four (columns) to a bucket.

Strength tests will be performed on elements fabricated in like manner to the NpO_2 elements, but with no NpO_2 , to determine allowable discharge forces. Until these results are available, discharge force should be considered as limited to no more than 7000 pounds.

f. Operating Limits

Operating limits as specified for thoria tubes in Process Standard M 20.05 shall be observed on the test columns. During shutdown, flow may be removed from the test columns indefinitely as soon as graphite temperatures have reached 100 C or less, if the need arises.

g. Reactivity Effect

It is estimated that two spike enriched columns will be required per test column to compensate for reactivity loss. The process physicist shall be responsible for specifying amount and location of additional enrichment.

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HAZARDS

Neptunium is an element of similar though somewhat lesser biological hazard than plutonium. In this particular case it is present in the oxide form in a solid compact and completely encased in an aluminum can. The compact is coherent and a structural member, and no dusting problem is anticipated if a can should break open during discharge, or during discharge of a ruptured piece. No other significant hazards are known to be associated with these elements.

PROCESS STANDARDS⁵

The charging of neptunium oxide elements and of aluminum dummies fabricated as detailed herein is authorized. The Process Standards are affected in no other way by this test.

GENERAL

Schedule

The test shall be charged at the same outage as the removal of the core thorium loading, or as soon thereafter as possible. This authorization expires on January 1, 1968.

Post-Irradiation Examination

The neptunium elements will be examined visually and the O.D. measured in the standard locations in the C Irradiated Fuel Examination Facility. Further investigations will be performed by Battelle-Northwest, but are beyond the scope of this authorization.

For the purposes of this test, only weasel data are needed from the numbered fuel columns. However, these columns will have been given pre-irradiation measurements as for PT-216 fuel. Thus, the fuel will be given standard PT-216 measurements in the C Irradiated Fuel Examination Facility. Weasel data shall be reported directly to the test author; other data shall be processed in the usual fashion for PT-216 data.

COSTS

Outage Time

Estimated outage time costs are as follows:

Charge-Discharge (2 test columns, 5 numbered fuel columns)	4 hours

Special Pickup (7 columns)	3 hours

TOTAL	7 hours

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Lost Production

It is estimated that the equivalent of approximately 200 MWD production will be lost due to maintenance of enriched columns for reactivity compensation. No loss is predicted from diversion of the two test columns on the presumption of anticipated administrative power level limits.

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Process and Reactor Development
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RE Baars/GF Owsley:md

Issue Date 2/9/66

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RESPONSIBILITIES

Research and Engineering Section

Process and Reactor Development Subsection shall be responsible for over-all coordination of the test; for arranging for neptunium elements, aluminum dummies, and numbered fuel columns; for selection of test columns; for covering test installation, for arranging for post-irradiation analysis of the neptunium pieces after measurements; and for analysis of data and issuance of a final report.

Milner

Process Technology Subsection shall be responsible for issuing proper orificing for the neptunium columns, for loading adjustments as required by the test, for scheduling spline flux traverses and judging adequacy of spline flux traverse data, for forwarding operating data to Process and Reactor Development, and for assistance in coordinating the test and selection of test channels.

A. M. Bond

Testing Subsection shall be responsible for post-irradiation measurements on the neptunium elements and the numbered fuel columns, and for conducting spline traverses as requested by the Process Physicist.

C. G. Lewis

Manufacturing Section

Production Subsection shall be responsible for maintaining and reporting exposure levels on the four tubes immediately surrounding each test column, and for scheduling charge-discharge of the numbered fuel columns and the test columns.

R. J. Hunter

KW Processing shall be responsible for charge-discharge and special pick-up of the numbered fuel columns and the test columns, for recording test data as required, for concurrence in the tubes selected for the test, and for over-all operating efficiency and safety.

W. R. K.

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REFERENCES

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2. McCurry, J.W., Pu-238 Unit Costs, RL-REA-2149, May 26, 1965, (Secret).
3. Personal Communications, F. E. Owens to R. E. Baars, October, 1965.
4. Letter, W. K. Alexander to R. W. Stewart, Neptunium Irradiation Elements, July 29, 1965.
5. Process Standards - Reactor, HW-46000 K, (Secret).

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