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RECORD CENTER FILE

RICHLAND, WASHINGTON HANFORD AREA OPERATION

SPECIAL REVIEW

FINAL DETERMINATION

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March 22, 1954

PRODUCTION TEST NO. 105-519-SI
IRRADIATION SERVICE REQUEST NO. HAP0 108

STUDIES OF URANIUM CRYSTAL STRUCTURE DAMAGE
USING LOW IRRADIATION TEMPERATURES

OBJECTIVE

The purpose of this production test is to gain information regarding the nature of pile radiation damage to uranium crystal structures. Low temperature irradiations are to be used.

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BASIS AND JUSTIFICATION

Studies of the behavior of uranium metal as a fuel element have been hampered by the lack of understanding of the nature of radiation damage to the crystal structures. With the aid of the double crystal x-ray spectrometer, samples from irradiated fuel elements which had received total exposure of 150 MWD/T and 1,000 MWD/T were studied and gross radiation damage was not present. (1)

Although these findings are of a preliminary nature, they are well in agreement with theoretical calculations by Seitz⁽²⁾ in which he predicts that the equilibrium concentration of displaced atoms at temperatures above 200 C would be extremely low. Assuming this to be the case, most of the crystallographic imperfection induced by pile radiations must have been annealed out of the metal studied.

On the basis of this work it would seem quite likely that some fundamental facts about the nature of radiation damage could be learned by keeping the temperature low. This production test is designed so as to give information regarding the crystal structure damage where the uranium temperature during irradiation and post-irradiation operations is kept below 35 C.

SCHEDULE

1. Starting Date

The material should be charged as soon as possible after the approval of this production test.

2. Duration

A total of fourteen separate exposures are authorized. The first three exposures will be for one, six, and twenty-four hours. The lengths of the balance of exposures will be determined from the results of the first three. However, none will exceed thirty days.

3. Area

100 B

COSTS

1. Cost Code

xxxx-5903-108

2. Reactivity Loss

There will be a reactivity loss of one to two inhours if heavy metal must be discharged from the fringe process tube selected for this experiment.

3. Reactor Section

Shutdown time: Six hours on the front and rear elevator are authorized for installation and removal of the poison column control facility nozzles.

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Manpower: Maintenance--Forty-eight hours are required for the installation and removal of the poison column control facility nozzles. Operations--Four manhours are required for each charge-discharge of the facility. The total time required is dependent on how well the exposures can be dovetailed, and on the data desired for each exposure.

DESCRIPTIVE DETAILS

1. Assemblies

Each assembly which is to be irradiated will consist of two canned wafers of uranium and an (Al-Co) alloy flux monitor, all three key-slotted into a perforated dummy slug. (See Figures 1 and 2).

The wafers will be canned according to the following process:

- a. The uranium wafers, 15 to 17 grams each, are machined from powder metallurgy slugs and the aluminum tubing (2S) is carefully cleaned and dried.
- b. The uranium is anodized according to technique developed by G. A. Last⁽³⁾ and one face is polished.
- c. The uranium is placed inside the aluminum tubing which is then forced down until a good mechanical bond is formed all around with the exception of the one polished face.
- d. The two ends of the tubing are welded shut.
- e. The canned specimens are annealed at 250 C for three hours.
- f. Each assembly is numbered on the outside of the aluminum directly above the anodized uranium surface, as will be explained later during the discussion of the charging plan.
- g. The canned wafers are subjected to standard production autoclave testing, and the welds are radiographed.

Although the assemblies will not be the same size and shape as normal slugs, there is no serious erosion or cavitation problem anticipated as the assemblies will be in the reactor relatively short periods of time. Furthermore, since the uranium is machined from powder metallurgy material, it can be expected to exhibit greater dimensional stability than the uranium used in normal production fuel elements.

The flux monitors consist of thin wafers of aluminum-cobalt alloy canned in the same manner as the uranium wafers.

2. Heat Transfer

Calculations by members of the Heat Transfer Group predict that the uranium temperature will never exceed the adjacent process water temperatures by more than 10 C in a thermal neutron flux of 4.2×10^{12} .⁽⁴⁾

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3. Pile Facilities Required

A fringe tube (orifice zone 11) fitted with the poison column control facility is needed for this experiment. (5)

4. Charging Plan

The 28 special perfs will be supplied numbered on the outside consecutively from 1 to 28. Special perfs 1 and 2 will be used for the first exposure; 3 and 4 for the second exposure; etc. The even numbered perfs are to be charged downstream, and the numbered end of each perf is to be downstream.

The charging pattern is as follows:

- a. Normal downstream dummy pattern.
- b. 17 8" perfs and 1 5" perf.
- c. Even numbered sample.
- d. 1 8" perf
- e. Odd numbered sample.

5. Disposition of Material after Discharge

The samples are to be picked up on discharge and will be transferred to L. D. Turner, Radiometallurgy Sub-Unit, for post-irradiation examination.

6. Exposure History Requested

- a. The tube number of the pile in which the material was irradiated.
- b. Exposure time: The exposure time will be measured as accurately as possible by Special Irradiations personnel.
- c. Process water temperatures: The exit water temperature of the sample tube, the average exit water temperature of the surrounding tubes, and the inlet water temperature will be recorded by Operations personnel. Frequency of readings will vary with each run. Instructions and data sheets will be provided for each run by the Special Irradiations Sub-Unit.

RESPONSIBILITY

The Reactor Section, Operations Sub-Section, will be responsible for all scheduling and for the operational safety and production continuity of the pile. R. E. Adams, Pile Technology Sub-Section, will be responsible for the Technical Section interests in the 100 areas. W. V. Cummings, Metallurgy Unit, Applied Research Sub-Section, who requires that this information be obtained will be responsible for reports which will be issued relative to

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these irradiations. Arrangements for examination of the irradiated specimens will be made with L. D. Turner, Radiometallurgy Sub-Unit, Applied Research Sub-Section.

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Special Irradiations Sub-Unit
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ENGINEERING DEPARTMENT

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- (1) Cummings, W. V., Hurst, R. P., A Preliminary X-Ray Diffraction Study of Irradiation Damage to Uranium, HW-29507, September 9, 1953 (SECRET).
- (2) Seitz, Frederick, The Influence of Fission Radiations on Solid Materials, Journal of Metallurgy and Ceramics, TID-69, July 1948 (SECRET), p. 142.
- (3) Last, G. A., Canning of Uranium by Mechanically Bonding the Jacket to the Slugs, HW-27700, April 10, 1953 (SECRET).
- (4) McNutt, C. R., Maximum Temperatures in Thin Rectangular Uranium Wafers, HW-30451, December 1953 (SECRET).
- (5) Schilling, R. D., Production Test 105-4-MR, Evaluation of Poison Column Control Facilities, HW-25702, May 15, 1953 (SECRET).

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APPENDIX

Loading Pattern

From several experimental plans available for resolving the questions regarding the nature of irradiation damage to uranium crystal structures, D. W. Gayler of the Statistics Unit chose the following as the most desirable considering both the statistical and practical aspects of this production test.

1. Each wafer is stamped with a letter A, B, C, D, or E corresponding to the slugs 923-1, 923-2, 923-3, 432-4-G, 451-5-G, respectively, from which it was machined. In addition, each wafer is further identified according to the pile position and exposure by a second number.
2. The flux monitors are stamped with the numbers M-1 through M-14 and the weight of each is recorded in the secret notebook of R. P. Hurst.
3. These assemblies are to be irradiated in the pile as shown in Figure 2. It is important that the same tube and two tube positions be used for each exposure level.

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CANNED ASSEMBLY

CANNED SAMPLE

FIGURE 1

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SAMPLE LOADING PLAN

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