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HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

PRODUCTION TEST IP-2-A
ENRICHED URANIUM CONVERSION RATIO AND
STABILITY TEST

L. W. Lang

JAN 5 1957

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November 12, 1956

PRODUCTION TEST IP-2-A
ENRICHED URANIUM CONVERSION RATIO AND STABILITY TEST

OBJECTIVE

This test is one of three parts^{1,2} of the initial testing program to demonstrate enriched usage at HAPO. It proposes to irradiate two twelve-tube blocks of enriched uranium and lithium-aluminum slugs to obtain conversion ratios and preliminary information concerning slug stability.

BASIS AND JUSTIFICATION

Economic advantage and improved pile operation can be gained by using slightly enriched uranium fuel elements as a substitute for U-235 aluminum alloy elements.^{3,4} Necessary to proving the advantage, however, is the demonstration of the calculated conversion ratios and metal stability.

- 1 Lang, L. W., "Enriched Uranium Testing Program," HW-40555, 1-11-56.
- 2 Sowards, J. W. and Riley, W. C., "Design of Production Test 105-642-A-82MT, Preliminary Evaluation of E-N Loads for Combined Plutonium-Tritium Production," HW-44538-A, 8-28-56
- 3 Lang, L. W., "Analysis of Enriched Uranium Production of Tritium vs. Conventional Alloy Loading," HW-39678, 10-26-55.
- 4 Lang, L. W., "The Use of Slightly Enriched Uranium as a Substitute for C-Metal Columns," HW-36943, 8-9-55.

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This test proposes to charge twenty-four enriched uranium lithium-aluminum columns in B Pile to form two four by four squares with natural uranium columns as corners. One of the tube arrays will contain solid enriched uranium pieces and the other, half-inch cored enriched uranium fuel elements. The central tubes (~~two~~^{four}) in each square will be discharged at 62.5 MWD/tube for special processing to obtain the conversion ratios. To demonstrate the stability, the remaining ~~six~~^{eight} tubes in each square will be discharged at 125 MWD/tube or after one rupture has occurred.

PRIORITY

It will be necessary to discharge metal short of goal exposure to obtain the required location and surrounding metal conditions necessary for the enriched uranium columns. In determining the reactivity and conversion ratio from a small number of test charges as proposed here, it is necessary to isolate the enriched uranium columns as much as possible from external effects. Thus the tube array should be located outside of the rod pattern, and transients from the exposure variation of adjacent metal should be minimized.

Two ruptures may be incurred by the test if failure occurs short of 125 MWD/tube. Minimum down-time for outages is twenty-six hours. Heise readings taken during operation may inadvertently result in a pile scram. These readings are requested once a week to verify panellit pressures and bases.

COSTS

Cost Code: XXXX-5320-XXX.89

REACTIVITY LOSS: None

TIME REQUIRED

ESTIMATED LOSSES CONNECTED WITH TEST

<u>Item</u>	<u>Action</u>	<u>Manhours</u>	<u>Down-Time</u>	<u>Elevator Time</u>
I. Charging				
A. Test Metal				
1) 40 natural U charges	Valving Headers 6 men at 10 min. 8 headers	6 hours	1 hr. 20 min.	1 hr. 20 min.
2)	Set-up and charging at 6 min.	12 hours	4 hours	4 hours
3) Sequential Charges	(32) Set-up and charging 3 men at 16 min.	25 hours	8-1/2 hours	8-1/2 hours
Totals		43 hours	14 hours	14 hours

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ESTIMATED LOSSES CONNECTED WITH TEST (Continued)

<u>Item</u>	<u>Action</u>	<u>Manhours</u>	<u>Down-Time</u>	<u>Elevator Time</u>
B. Less Uranium charges that would have been replaced if no test	Valving Headers (for (36) tubes) 6 men at 10 min. 8 headers	6 hours	1 hr. 20 min.	1 hr. 20 min.
	Set-up and charging for tubes normally scheduled for discharge at 6 min.	6 hours	2 hours	2 hours
Net charges attributable to test		31 hours	10 hr. 40 min.	10 hr. 40 min.
II. Discharging				
A. 32 Sequential Charges	Valve Headers 6 men at 10 min. 5 headers	5 hours	1 hour	1 hour
	Special pick-up 2 men Tongs 6 men for valving and set-up	40.4 <u>121.4</u>	20.2	20.2
Total		166.8	21.2	21.2
B. Less Uranium charges that would have been replaced if no test 32 tubes	Valve Headers at 10 min. Set-up and charging at 6 min.	5 hours 19.8	1 hour 3.2	1 hour 3.2
Total		24.8	4.2	4.2
Net time for discharge		142.0	17.0	17.0
III. Required data taking* (3 man-hours/day)				
IV. Venturi Installation		3.0	1.0	1.0
V. Grand Total Time for Test		176	28.7 hours	28.7 hours

* Forms will be furnished for data-taking. Additional man-power will probably not be required.

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TEST DETAILS

Charging Details

The sixteen-tube squares will be selected at B-Pile that appear to be the best compromise between desirable location with respect to minimizing flux perturbations and discharging metal near goal exposure. The row of natural uranium tubes surrounding should be charged with green uranium to minimize the reactivity transients outside the tube arrays. The corners of the sixteen-tube square will likewise be charged with green uranium. The enriched uranium columns in one square will be made up of six-slug enriched uranium segments alternated with a four-inch lithium-aluminum slug as shown in Table 1. The second array of tubes will be charged with half-in cored enriched uranium fuel elements and lithium-aluminum elements. The tensile strength of lithium-aluminum alloy is approximately twice that of ordinary aluminum, and the hardness is roughly 2.5 times that of aluminum.⁵

The outer eight tubes will be irradiated to 125 MWD/tube unless a rupture occurs in any tube prior to this. If a rupture occurs at exposures greater than 45 MWD/tube all metal of that type - the rupture and eleven tubes containing similar metal will be discharged upon rupture verification. This schedule is also shown in Table 2.

Dual panellit gauges may be required for all tubes in the test containing enriched uranium. Special calibrated venturis will be installed in eight tubes. No tubes with corrosion indexes of over 40 will be charged with enriched uranium. The specific power of the enriched uranium pieces will be approximately twenty percent higher than natural uranium irradiated in the same flux. Tube powers, however, will be slightly less than surrounding natural uranium columns due to the interspersation of the lithium-aluminum slugs and shortening of the columns.

Graphite temperatures may be slightly elevated in the center of the tube arrays. If this is the case, specifications will be relaxed sufficiently to allow this area to operate as high as 50° above maximum graphite temperatures outside the array without changing gas composition.

Metal Handling

Because the uncontrolled use of 0.94% U-235 (E-slugs) could cause a critical mass problem, the following handling procedures will be followed:

- 1) Pre-irradiation handling and storage: The 100 hole shipping containers may be stored in a single layer without regard to distance between containers. Alternatively, they may be stacked in rows with not more than three containers in any stack and with at least one foot separating the rows. No limit is necessary on space between containers in a given row. In neither case will any other fissionable material be stored within six feet of the E-slugs.
- 2) Discharge: Not more than 800 E-slugs shall be allowed in the discharge chute at any one time. If any natural uranium is also present, this number shall apply to the sum of 6" E-slugs and 8" natural uranium slugs. If the number of E-slugs does not exceed 400, any number of natural uranium slugs may also be present.
- 3) Post irradiation storage: As many as 280 irradiated slugs may be stored in a storage basket so long as the uranium in that basket is not allowed within one foot of any other fissionable material. During the pick-up the limits of 2) will apply.

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Table 4

Row/Column

66 67 68 69 70 71

CHARGING PATTERN FOR TEST MATERIAL

23	U	U	U	U	U	U
22	U	U	A	B	U	U
21	U	A	B	A	B	U
20	U	B	A	B	A	U
19	U	U	B	A	U	U
18	U	U	U	U	U	U

Tubes will be charged in two four by four squares as shown above.

B. INDIVIDUAL TUBE MAKE-UP

U (48 tubes) Reg. Dummy Pattern	A (6 tubes) 11 - 8" Perfs. 7 - 8" SA	B (6 tubes) 11 - 8" Perfs. 7 - 8" SA	C (6 tubes) 11 - 8" 7 - 8" SA	D (6 tubes) 11 - 8" 7 - 8" SA
30 - 8" Nat. U (Slugs in corner charges individually identified)	2 - E Solid 1 - N 6 - E Solid 1 - N 6 - E Solid 1 - N 6 - E 1 - N 6 - E 1 - N 4 - E	4 - E Solid 1 - N 6 - E Solid 1 - N 6 - E Solid 1 - N 6 - E 1 - N 6 - E 1 - N 2 - E	2 - E Cored 1 - N 6 - E Cored 1 - N 7 - E Cored 1 - N 6 - E 1 - N 6 - E 1 - N 4 - E	4 - E Cored 1 - N 6 - E Cored 1 - N 7 - E 1 - N 6 - E 1 - N 6 - E 1 - N 2 - E

E - Cored 1/2" Cored, 6-inch slugs .94 percent U-235
 E - Solid 6-inch slugs .94 percent U-235
 N - Std. Lithium-aluminum alloy pieces
 U - 8" - natural uranium

The central four tubes in each array will have a nominal goal exposure of 62.5 MWD/tube. A special pick-up will be required for the eight central tubes after irradiation, and tube identities should be maintained. All of the metal in an array will be discharged if a rupture should occur between 45 MWD/tube and 62.5 MWD/tube. Should a rupture occur in a central tube at less than 45 MWD/tube, the metal should be replaced with natural uranium and operation should be continued until the remaining three central tubes reached 45 MWD/tube, at which time all would be discharged.

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Table 2

DISCHARGE SCHEDULE FOR TEST

Prior Conditions of Test

- 1) Natural uranium corners and surrounding tubes discharge exposure 500 MWD/T.
- 2) The performance of natural uranium columns is not a test criteria.
- 3) The discharge of one array is not dependent upon the other.

<u>Condition</u> <u>(Applies to Either Array)</u>		<u>Action</u>
1) A rupture occurs in an enriched uranium charge at an exposure.		
A. Less than 45 MWD/T		1) Discharge rupture and replace with solid uranium.
		2) Discharge all tubes containing enriched uranium slugs at 45 MWD/tube.
B. Between 45 and 62.5 MWD/tube.		Discharge all metal.
C. Between 62.5 and 125 MWD/tube.		1) The four central tubes have been discharged at 62.5 MWD/tube.
		2) Discharge the remaining enriched uranium columns.
2) Metal reaches 62.5 MWD/tube without incident		Discharge central four tubes.
3) Metal reaches 125 MWD/tube without incident		Discharge all remaining PT metal.

DATA DESIRED

1. Length and diameter measurements prior to irradiation. Length, diameter, and warp measurements after irradiation.
2. Irradiation Data
 - a. Weekly - Heise gauge readings and Panellit readings on all 72 tubes and headers involved.
 - b. Once-a-day Panellit pressures and Brown temperatures for all 72 tubes and headers involved. Pile inlet temperature and power at the time above readings are taken.
 - c. Once-a-shift Panellit pressures and Brown temperatures for the central four tubes in each array plus header pressures.

- d. Time of start-down and shut-down noted.
 - e. Brown temperature and Panellit readings plus header pressures at 1-2-4-8 hour interval after start-up. Pile inlet temperature and power when these readings are taken.
 - f. Heise readings taken as soon as possible after a Panellit base has been changed on any of the tubes involved in the test.
3. Weasel data as required or specified.
 4. Isotope analysis for Pu to be made at HAPO and tritium analysis of lithium-aluminum to be secured at SR.

FUEL COMPONENTS

1. Enriched Uranium Slugs
 - a. Caps - HW material 303; for eight-inch "F" process canned slugs.
 - b. Cans - HW material 302, Type I, with length machined to accommodate the six-inch uranium core.
 - c. End Plugs - Aluminum end plugs for use with nominal half-inch cored slugs.
 - d. Cores - Enriched uranium, 0.94% U-235, six-inches in length, O.D. 1.36", both solid cores and cores with half-inch drilled central holes will be used.
2. Lithium-Aluminum Alloy Slugs
 - a. Caps - HW material 303.
 - b. Insert Wafer - HW material 305 for "C" process canning.
 - c. Cans - HW material 302, Type 6, "B" and "C" process - four inch.
 - d. Cores - Lithium-aluminum alloy, 3.5% Li by weight, 3.80 inches in length, O.D. 1.364 inch.
3. Natural Uranium Slugs - Regular eight-inch natural uranium fuel elements.

Assembly Process

All enriched uranium slugs shall be canned by the "F" process (Lead Dip Process for Beta Treated Uranium, HW-29341).

All lithium-aluminum alloy slugs will be canned by the "C" process (Cold Canning Process, HW-30146).

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Quantity of Material

Enriched Uranium

Solid Slugs, "E" - 372 pieces, plus 20 extra.

One-half inch cored slugs, Cored "E" - 372 pieces, plus 20 extra.

Lithium-Aluminum Alloy

"N" Slugs - 60 pieces, plus 5 extra.

Natural Uranium

Eight-inch Regular Production Slugs - 254 pieces, plus 10 extra.

RESPONSIBILITYResearch and Engineering OperationProcess Technology Operation

Coordination of charging detail and data collection.

Process and Reactor Development Operation

1. J. H. Brown - Analysis of data and reporting of pile physics results.
2. L. W. Lang - Over-all control, inter-department liaison, technical aspects of irradiation and issuing of reports pertinent to Process Economics and Development.

B and C Reactor Operation

1. Charge-discharge operations.
2. Operational safety and production continuity of the piles.

Production Operation

Scheduling and maintenance of records for tubes containing test material.

Reactor Specialist
Research and Engineering Operation
IRRADIATION PROCESSING DEPARTMENT

LW Lang:mf

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