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PRODUCTION TEST IP-296-D, SWELLING TEST
 OF NATURAL AND THREE PER CENT ENRICHED
 METALLIC URANIUM

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December 10, 1959

PRODUCTION TEST IP-296-D, SWELLING TEST
OF NATURAL AND THREE PER CENT ENRICHED METALLIC URANIUM

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRODUCTION TEST IP-296-D, SWELLING TEST
OF NATURAL AND THREE PER CENT ENRICHED METALLIC URANIUM

OBJECTIVE

The objective of this production test authorization is to permit the irradiation of sixteen, 0.394 inch diameter, metallic uranium spheres at temperatures between 300 C and 800 C in the 3674 and 3865 KW front-to-rear test tubes. Eight spheres will be of natural uranium and eight of enriched (3% U-235) uranium.

SUMMARY

Temperature controlled and temperature monitored test capsules containing either four natural or four three per cent enriched uranium spheres will be irradiated. Pre- and post -irradiation examinations will be performed to determine the extent of swelling. The temperature of the spheres will be controlled at the same constant level during reactor operation and during shutdowns. Capsule exposures will vary from one to 24 months. This production test authorization will permit the irradiation of two capsules each containing four natural uranium spheres and two capsules each containing four three per cent enriched uranium spheres.

BASIS AND JUSTIFICATION⁽¹⁾

One of the most important effects of irradiation at high temperatures upon metallic uranium fuels is the change in volume or swelling. Excessive swelling of a fuel element could result in reduction of coolant flow, change in nuclear characteristics of the reactor, mechanical failures and stress corrosion failures of the fuel element jackets. These factors must be considered when determining the expected performance of a fuel element. It has not been determined whether temperature cycling at high temperatures only or temperature cycling coupled with fission burn-up is the main cause of swelling. Data concerning this relationship are needed to design metallic uranium fuel elements for use at high temperatures.

TEST DETAILS

1. Irradiation Facility

The 3674 and 3865 KW front-to-rear test holes each contain two concentric aluminum tubes. Coolant from one header flows through the annulus, coolant from another header flows through the inner tube. The I.D. of the inner tube is 2-7/8 inches. The design of the rear nozzle for each test hole will permit the discharge of the inner tube and test assembly under high radiation dose rate conditions.

2. In-Reactor Assembly

Each test capsule (see Figure 1) contains either four natural or four three per cent enriched spheres mounted concentrically in a stainless steel heater tube. The space immediately around each sphere is filled with NaK. An

(1) Program document by B. S. Kosut and R. D. Leggett, dated November 12, 1959.

expansion chamber is provided at one end of the heater tube to accommodate the expansion of the NaK. A flexible bellows in the expansion chamber lies below the NaK level and keeps the uranium spheres submerged in NaK regardless of capsule orientation. Helium gas at one atmosphere pressure occupies the space above the NaK in the expansion chamber. Thermocouple and heater wires extend through a bulkhead at the other end of the heater tube. The heater tube assembly is mounted concentrically and is enclosed in an outer stainless steel tube. Helium gas occupies the annular space between the two tubes. The temperature of the core of two of the spheres and the temperature of the NaK will be measured with thermocouples. Thermocouple and heater wire capsule entry seals are effected with swageloks and silver solder joints. An aluminum conduit extending from the capsule to the inlet nozzle cap and held in place with perforated tubular spacers will contain the heater and thermocouple leads. Perforated tubular spacers will be located downstream of the test capsule.

3. Out-of-Reactor Equipment

a. Extension Leads

The heater and thermocouple wires will be brought through the inlet nozzle cap with Conax sealing glands. The in-reactor leads, after extending a few feet through the nozzle cap will be terminated with submersion proof Amphenol connectors. Waterproof leads will extend from the Amphenol connectors to the instrument location at the top of the unit level.

b. Instrumentation

Each capsule will require a Minneapolis-Honeywell precision temperature controller, a Brown Electrovolt proportional voltage controller, a magnetic amplifier, and a 5 KVA saturable core reactor. One 12 point strip chart recorder will be used to record the temperature data from the capsules.

4. Operating Conditions

a. Test Facility

The normal flow through the test tube will be approximately 35 gpm. One orifice will be located upstream and one downstream. The diameter of the upstream orifice will be 0.281 inch, the downstream 0.309 inch. A 10-90 Panellit gage will be installed which will trip the safety circuit if the flow drops to about 30 gpm (see Figure 2).

b. Capsule

The capsule will be located at the center of the test tube. The capsule containing the three per cent enriched spheres will generate approximately 4 KW, the capsule containing the natural uranium spheres about 2 KW. It is predicted that nuclear heating alone will cause the three per cent enriched spheres to operate at less than 800 C, the natural uranium spheres at less than 400 C⁽²⁾. The normal operating temperature of the spheres during reactor

(2) Correspondence from J. Muraoka to F. Young, dated September 20, 1958.

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operation and during shutdowns will be between 300 C and 800 C depending on the heater output when the reactor is down.

5. Charging

The entire in-reactor assembly will be prefabricated and charged into the test tube as a unit from a special box supported by the work area crane. A detailed procedure will be issued before charging.

6. Discharging

The entire in-reactor assembly will be discharged into the basin by pushing on it from the front face elevator. A special pick-up of the assembly will be required. A detailed procedure will be issued before discharging.

HAZARDS

The prime hazard involved in the irradiation is the failure of the capsule to act as a barrier between cooling water and the NaK. The NaK and uranium are contained in two sealed concentric stainless steel tubes. The thermocouple and heater wire entries to the uranium and NaK are each triple sealed, twice with swageloks and once with silver solder. It is considered that these features of capsule design reduce to a low level the possibility of any water penetration to the NaK. Furthermore, out-of-reactor tests(3) have shown that the NaK water reaction is not serious. Eight NaK filled capsules were deliberately failed in 98 C water in the 314 Building flow tubes. After running for two hours the NaK had been completely flushed from the capsules. There was no distortion and no serious corrosion on any of the capsules. Escape of NaK to the coolant should also cause no hazard from the NaK-water reaction. Definite indications of a failure would result from high activity readings on the reactor gamma monitor from the uranium fission products and Na-24. The water from the two test tubes is monitored by the reactor gamma monitor independently of headers 36 and 38. If high activity occurs simultaneously from the test tube water and the header water it should be assumed that a capsule has failed. The reactor should be shutdown and the capsule discharged.

RESPONSIBILITIES

Physical Metallurgy Operation, Hanford Laboratories Operation, will:

1. Design, fabricate and perform pre-irradiation testing of the in-reactor assembly.
2. Provide all instrumentation.
3. Issue technical operating instructions for the capsule and data sheets.
4. Analyze recorded data.
5. Issue technical reports.

(3) HW-56588, "Results of NaK Capsule Failures in Hot Water Flow Tube,"
J. W. Weber, June 30, 1958.

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Irradiation Testing Operation, Irradiation Processing Department, will:

1. Provide extension leads.
2. Charge and discharge the in-reactor assembly.
3. Collect operating data.
4. Operate the test equipment and controls.

Process and Reactor Development Operation, Irradiation Processing Department, will make recommendations concerning the application of the test results.

KW Processing Operation, Irradiation Processing Department, will be responsible for operational safety and production continuity of the reactor.

RK Marshall
Irradiation Testing
RESEARCH AND ENGINEERING OPERATION

RK Marshall:mc

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APPROVAL:

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<u>R. L. Dickeman</u>	R. L. Dickeman MANAGER, MANUFACTURING

FEB 19 1960

Date of issue _____

WGT GRAMS	QTY. EACH	%	DESCRIPTION	MAT'L	DWG NO
TOTAL			ASSEMBLY		
345.3	345.3	1	2 INNER TUBE	304 SST	
203.8	203.8	1	3 N ₂ K EXPANSION CHAMBER	304 SST	
143.0	143.0	1	4 END CAP	304 SST	
73.4	73.4	1	5 END CAP		
140.0	140.0	1	6 ADAPTER TUBE		
141.4	141.4	1	7 END CAP		
18.0	3.0/FT.	1	8 THERMOCOUPLE (SEE NOTE NO 5)	TA TIP	H-31307/1
		1	9 THERMOCOUPLE		/2
		1	10 THERMOCOUPLE		/3
		1	11 THERMOCOUPLE		/4
210.0	1.26R/IN.	1	12 HEATER ELEMENT	KANTHAL	H-31307/5
328.3	328.3	1	13 ADAPTER TUBE	304L SST	
44.0	8.5	8	14 SWAGELOK REDUCER	316 SST	
33.0	6.5	6	15 RIS	304 SST	
		1	16 SWAGELOK REDUCER	316 SST	
554.7	554.7	1	17 OUTER TUBE 1/4 O.D. X .060 WALL 1/4 X 1/4	304L SST	
269.8	269.8	1	18 INNER SPACER	2 x 2	
19.6	9.8	2	19 TEST SPECIMEN (UNDRILLED)	URANIUM	
19.4	9.7	2	20 TEST SPECIMEN (DRILLED)	URANIUM	
2.0	.5	4	21 CYLINDERS 1/4 O.D. X .002 WALL	TANTALUM	
63.1	63.1	1	22 BELLOWS TUBE ASSY	304 SST	
6.1	6.1	1	23 SPACER RING (OUTER)		
9.8	9.8	1	24 SPACER RING (INNER 2 PIKE)		
9.3	9.3	1	25 SPACER RING		
67.0	67.0	1	26 ADAPTER TUBE CAP		
24.7	24.7	1	27 HEATER RETAINER		

GENERAL NOTES

- ALL PARTS (UNLESS OTHERWISE NOTED) SHALL CONFORM TO THE FOLLOWING:
- TOLERANCES: FRACTIONAL 2 DECIMAL ± .001 ANGULAR ± 0°30'
- PARTS TO SHOW GOOD WORKMANSHIP, FREE FROM BURRS, UNMARRIED AND CLEAN.
- BREAK ALL CORNERS.
- ALL MACHINED SURFACES V (ASA B46.1-1958)
- ALL MATERIAL TO BE AS SPECIFIED, OR EQUAL QUALITY.

- SWAGELOK REDUCER 1/4 ODT TO 1/8 ODT SWAGELOK CATALOG B-256-A, PAGE 12 CAT NO 100-R-2-316
- SWAGELOK REDUCER 3/8 ODT TO 1/8 ODT SWAGELOK CATALOG B-256-A PAGE 12 CAT NO 100-R-3-316
- TO BE FURNISHED BY CUSTOMER.

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1 CHANGED TITLE		LLKING	
2 REDRAWN DUE TO GENERAL CHANGE		11-4-59	
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CLASSIFICATION		REV. NO.	DATE
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H-3-13075		1	1
SCALE: NONE		BY	DATE
DRAWN R.C. DATE 11-2-58		1	11-2-58
CHECKED K.C. DATE 11-2-58		1	11-2-58
DESIGNED J.E. DATE 11-2-58		1	11-2-58
U. S. ATOMIC ENERGY COMMISSION			
HANFORD ATOMIC PRODUCTS OPERATION			
GENERAL ELECTRIC			
SWELLING BEHAVIOR - CAPSULE			
H-3-13075			

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Figure 2

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