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Monthly Progress Report
Heat Source Technology Programs

April 1994

Compiled by
T. G. George

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545

MASTER

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MONTHLY PROGRESS REPORT
HEAT SOURCE TECHNOLOGY PROGRAMS

APRIL 1994

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MONTHLY PROGRESS REPORT

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T. G. George

ABSTRACT

This monthly report describes activities performed in support of Cassini fueled-clad production and studies related to the use of $^{238}\text{PuO}_2$ in radioisotope power systems carried out for the Office of Special Applications of the U.S. Department of Energy (DOE) by Los Alamos National Laboratory (LANL). Most of the activities described are ongoing; the results and conclusions described may change as the work progresses.

I. HEAT SOURCE AND FEED POWDER SHIPMENTS

The third delivery of fuel for Cassini flight-quality applications, designated as shipment 473, was received from the Westinghouse Savannah River Company (WSRC) at the end of March. Calorimetry of containers received in this shipment was completed in the first week of April; the fuel was released for processing on 20 April.

The fourth delivery of fuel for Cassini flight-quality applications, designated as shipment 474, was received from WSRC in mid-April. Calorimetry measurements were initiated immediately, and were complete by 20 April.

LANL Authorization for five additional fuel shipments was provided to WSRC by 13 April. However, a operational "stand-down" initiated by TA-55 facility management prevented the receipt of any additional fuel shipments.

II. IRIDIUM HARDWARE SHIPMENTS AND INVENTORY

On 28 April, a quality assurance representative from Martin Marietta Energy Systems' Y-12 (MMES/Y-12) plant observed the unpacking, inspection, and storage of iridium components received in shipment 10460. The LANL inventory of GPHS hardware, as of 30 April, is shown in Table I.

Table I. LANL Inventory of GPHS Iridium Hardware

<u>Type of Hardware</u>	<u>Category</u>	<u>Number of Items in Inventory</u>
PICS*	Prime	233
PICS	Restricted Use	62
Type II Weld Shields	Prime	297

*PICS = post-impact containment shell

III. FACILITIES

A. General

On 15 April, TA-55 facility management terminated all normal operations within the Plutonium Facility (building PF-4). Activities affected by this "stand-down" included all Cassini production operations, maintenance of production equipment, heat source development activities, glovebox and new equipment installation, and most construction activities associated with the launcher addition. By 30 April, it appeared that normal operations would resume by 15 May.

B. Launcher Relocation

Work continued in April on construction of an addition to PF-4 to house the relocated launcher and on a number of related procurements. However, most construction activities associated with the launcher addition were temporarily suspended on 15 April as a result of the facility "stand-down."

1. Construction Activities

Most of the structural steel required for the main work platform inside the launcher addition was installed in early April.

The dumbwaiter was also installed, and electricians began running conduit and wiring for the lighting system.

2. Design Activities

The design of the launcher addition's fire suppression system was modified to comply with all applicable codes.

Work also continued on a concept for suspending the muzzle armor for the launcher from the ceiling of the addition. A detailed drawing of the suspension system was completed and forwarded to the architectural and engineering (A&E) contractor.

Shop drawings for the centrifugal fans that will be used in the launcher addition's heating, ventilation, and air conditioning (HVAC) system were approved by the A&E contractor. However, personnel from the Laboratory's Engineering (ENG) Division requested the drawings for additional review; this additional oversight was expected to delay the start of fan fabrication.

3. Procurements

Fabrication of the filter trains for the launcher addition's HVAC system resumed in early April. Expected delivery date for the filter trains is mid-June.

Specifications for duct expansion sections for the HVAC system were completed at the beginning of the month. By mid-month, a purchase request for the expansion sections had been forwarded to LANL's procurement organization (BUS).

Personnel from Johnson Controls International, Inc. (JCI) scheduled a receiving inspection for the dampers that will be used in the launcher addition's HVAC system.

Wiring units for the supervisory control system (SCS) for the launcher addition were delivered to the SCS vendor in early April.

Delivery date for the pressure doors was set at 27 May. Fabrication of pressure doors resumed in early April. However, the vendor modified the design of the doors to permit control by the launcher addition's SCS; the modified design must be approved by JCI.

Additional information on the load cells that will be used in the launcher was supplied to JCI so that they could complete the bill of materials for the launcher support stand. Purchase of the required materials was initiated at the beginning of the month; fabrication of some components was underway in the JCI machine shop by the end of the month.

4. Administrative Activities

Work continued on developing an operations manual for the launcher.

Personnel from the TA-55 facilities management group (NMT-8) began work on preparing for an operational readiness review (ORR) of the launcher addition. Information developed during the ORR will also be included in an updated facility safety analysis report.

Work also began on a technical analysis of the ceiling armor located above the launcher muzzle.

C. Metallography and Ceramography Glovebox Lines

All of the gloveboxes in the metallography and ceramography lines have been installed and wired for electric power. A bench-top metallographic facility for "cold" (uncontaminated) specimens was activated previously and has been used to support fueled-clad weld-process development.

On 9 November, NMT-9 requested a facility-required Safety and Technical Assessment for Readiness of Technology (START) review of the glovebox line and metallography operation. A review committee was selected and convened on 23 November. Twenty-five committee findings and a number of additional comments were provided to NMT-9 on 15 December. No operations are permitted in the glovebox line until after all of the "A"

findings identified by the START committee have been closed, and approved action plans are in place to address the "B" findings.

Work to address all of the findings and comments received from the START review committee was completed by mid-March. Approval to begin work in the hot metallography line was received from the START committee in the first week of April.

IV. GENERAL-PURPOSE HEAT SOURCE (GPHS) PROGRAM

A. Preproduction Activities

1. GPHS Fuel Powder, Pellet, and Fueled-Clad Specifications

A draft of the GPHS $^{238}\text{PuO}_2$ Fuel Pellet Specification (LANL drawing no. 26Y-318181) was distributed for review on 8 April. A final version of the specification was approved for use on 27 April.

2. Fueled-Clad Weld Development

During November, four plutonia pellets were encapsulated within clad/vent-sets. The welds on all four capsules appeared to be exemplary, and each capsule easily passed through the ring gauge. Metallographic examination of the capsule welds was postponed, pending the resumption of normal operations at the plutonium facility.

3. Fueled-Clad Ultrasonic Test (UT) Development

On 1 February, a meeting of the GPHS welding/UT working group was held in Atlanta, Georgia. Eleven action items were assigned at the meeting; six of the eleven action items were assigned to LANL. Work to close four of the action items assigned to LANL had been completed by the end of April.

4. Cold Process Verification (CPV) Tests

The CPV test series was designed to verify that the welding process for simulant-fueled ("cold") capsules had been optimized and to quantify the impact responses of the hot-pressed, and cold-pressed and sintered, urania fuel-simulants.

Most of the simulant-fueled clads required for the CPV test series were welded previously. Eight capsules were loaded with hot-pressed urania (^{235}U -depleted) fuel-simulant and seven capsules were loaded with cold-pressed urania. UT examination performed with the existing Panametrics system indicated that the welds in nearly three-quarters of the capsules (11 of 15) contained indications that exceeded the proposed UT acceptance criterion.

The postmortem examinations of capsules tested in CPV-1 and CPV-2 were completed previously. The status of ongoing postmortem examinations are given in the following sections.

a. CPV-3. On 26 February 1993, capsule SC0004, which had been loaded with cold-pressed and sintered urania fuel-simulant, was impacted against a steel plate at 55.0 ± 0.1 m/s and 1090°C . The iridium hardware used for this capsule was designated as "Prime" and was from the D2 batch. Postimpact examination revealed that although the capsule contained two small transverse cracks on the cup radii at the edges of the impact face, no

urania had been released. Details of this initial examination, as well as the metallographic examination of selected clad sections and a preliminary sieve analysis, were documented in previous monthly reports.

In this month we made no progress on the CPV-3 postmortem examination; particle size analysis of the urania fuel simulant is performed in building PF-4 and was affected by the facility "stand-down."

b. CPV-4. On 5 March, 1993, capsule SC0020, which had been loaded with cold-pressed and sintered urania fuel-simulant, was impacted against a steel plate at 55.3 ± 0.2 m/s and 1090°C. The iridium hardware used for this capsule was X- and YR-batch material (vent cup ID, X342-2; shield cup ID, YR421-1) produced for the Galileo and Ulysses missions. Postimpact examination revealed that capsule SC0020 had been breached by several cracks and that a small amount of urania had been released into the tantalum containment vessel. Details of this initial examination were documented in previous monthly reports.

Progress on the postmortem examination was affected by the facility "stand-down."

c. CPV-5. On 15 June, 1993, capsule SC0017, which had been loaded with cold-pressed and sintered urania, was impacted against a steel plate at 55.3 ± 0.1 m/s and 1090°C. The iridium hardware for this capsule was designated as "Prime" and was from the D2 batch. Postimpact examination revealed that capsule SC0017 had breached, and that a small quantity of urania had been released. Details of this initial examination were documented in previous monthly reports.

Progress on the postmortem examination was affected by the facility "stand-down."

d. CPV-6. On 29 June, 1993, capsule SC0018, which had been loaded with cold-pressed and sintered urania, was impacted against a steel plate at 55.0 ± 1.0 m/s and 1090°C. The iridium hardware used for this capsule was designated as "Prime" and was from the CR3 batch. Postimpact examination of the impacted capsule revealed that although a network of hairline axial cracks was visible on the impact face, no urania had been released. Details of this initial examination were documented in previous monthly reports.

Progress on the postmortem examination was affected by the facility "stand-down."

e. CPV-7. On 13 July, 1993, capsule SC0019, which had been loaded with cold-pressed and sintered urania, was impacted against a steel plate at 55.3 ± 0.1 m/s and 1090°C. The iridium hardware used for this capsule was X- and YR-batch material (vent cup ID, X340-4; shield cup ID, YR427-6) produced for the Galileo and Ulysses missions. Postimpact examination revealed that the capsule exhibited a centerline weld failure on the trailing face; however, no urania was released into the tantalum containment vessel. Details of this initial examination were documented in previous monthly reports.

Progress on the postmortem examination was affected by the facility "stand-down."

f. CPV-8. On 17 November, 1993, capsule SC0006, which had been loaded with a cold-pressed and sintered urania pellet, was impacted against a steel plate at 55.3 ± 0.1 m/s and 1090°C. The iridium hardware used for this capsule was designated as "Prime" and was from the CR3 batch.

Progress on the postmortem examination was affected by the facility "stand-down."

g. CPV-9. On 24 November, 1993, capsule SC0015, which had been loaded with a hot-pressed and sintered urania pellet, was impacted against a steel plate at 54.5 ± 0.1 m/s and 1090°C . The iridium hardware used for this capsule was designated as "Prime" and was from the CR3 batch.

Progress on the postmortem examination was affected by the facility "stand-down."

h. CPV-10. On 10 December, 1993, capsule SC0009, which had been loaded with a hot-pressed and sintered urania pellet, was impacted against a steel plate at 55.5 ± 0.2 m/s and 1090°C . The iridium hardware used for this capsule was designated as "Prime" and was from the CR3 batch.

Progress on the postmortem examination was affected by the facility "stand-down."

i. CPV-11. On 19 January, 1994, capsule SC0016, which had been loaded with a hot-pressed and sintered urania pellet, was impacted against a steel plate at 54.8 ± 0.1 m/s and 1090°C . The iridium hardware used for this capsule was X- and XR-batch material (vent cup ID, X312-2; shield cup ID, XR367-2) produced for the Galileo and Ulysses missions.

Progress on the postmortem examination was affected by the facility "stand-down."

B. Cassini Fueled-Clad Production

All of the remaining fuel received in shipments 469 and 470 was processed to granules in the first week of April. By 15 April, 19 GPHS pellets had been hot-pressed, and 17 of the pressed pellets had been sintered.

In early April, impurity analyses of fuel samples from all of the containers received in the first shipment of flight-quality Cassini fuel (shipment 469) were completed, as well as analyses of the seasoned granules produced from each of these fuel lots. A compilation of as-received and granule impurity analyses for the fuel received in shipment 469 is presented in Table II. The analytical results indicated that LANL processing operations had significantly increased the silicon and aluminum contents of the as-received fuel.

C. Safety Test Program

The LANL engineer responsible for coordinating the radioisotope thermoelectric generator (RTG) end-on and fragment impact tests began working with personnel from Sandia National Laboratory (SNLA) to determine the dimensions and positioning of various test components. By the end of the month, information on sizing concrete targets for the end-on RTG impacts had been provided by SNLA, and preliminary action had been taken to reserve a "window" for both sets of RTG impact tests at SNLA's rocket sled facility, in the August to October time frame.

D. Research and Development

1. High-Silicon Fuel Study

In response to a request from the program office, and to resolve questions concerning the behavior of fuel with a high silicon content, we previously modified a high-vacuum furnace to duplicate EG&G Mound Applied Technologies' module reduction and monitoring facility (MRMF).

Table II. Nonactinide Cation Impurities Detected in Shipment 469 Fuel

WSRC SN No. ^a	LANL Lot No.	Impurity Amounts (ppm/sample of plutonia fuel)																			
		Ag	Al	B	Be	Bi	Ca	Cd	Cr	Cu	Fe	Mg	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Zn
1465	301																				
as-received		<DL ^b	<DL	<DL	<DL	<DL	130-1300	<DL	40	20	110	40	5	<DL	<DL	85	<24	25	150	<DL	25
		<DL	<DL	<DL	<DL	<DL	130-1300	<DL	30	20	100	50	5	<DL	<DL	80	NS ^c	25	110	<DL	25
granules ^d		<DL	175	<DL	<DL	<DL	20	<DL	150	20	410	<DL	3	<DL	<DL	32	NS	<DL	360	<DL	50
		<DL	155	<DL	<DL	<DL	20	<DL	140	20	390	<DL	3	<DL	<DL	33	NS	<DL	310	<DL	50
1634	302																				
as-received		<DL	15	<DL	<DL	<DL	250-2500	<DL	60	10	180	25	20	<DL	<DL	50	<24	25	220	<DL	<DL
		<DL	20	<DL	<DL	<DL	250-2500	<DL	55	15	170	25	15	<DL	<DL	50	NS	25	210	<DL	<DL
granules		<DL	90	<DL	<DL	<DL	<DL	<DL	300	10	630	<DL	20	<DL	<DL	78	NS	<DL	600	50	<DL
		<DL	120	<DL	<DL	<DL	<DL	<DL	410	10	920	<DL	20	<DL	<DL	120	NS	<DL	1000	50	<DL
1314	303																				
as-received		<DL	140	<DL	<DL	<DL	250-2500	<DL	90	15	210	50	15	<DL	<DL	130	<24	50	140	<DL	5
	1	93	<DL	<DL	<DL	<DL	250-2500	<DL	86	15	200	50	15	<DL	<DL	88	NS	50	150	<DL	5
granules		<DL	9	<DL	<DL	<DL	250	<DL	55	15	140	10	15	50	<DL	45	NS	25	160	<DL	10
		<DL	75	<DL	<DL	<DL	125-1250	<DL	77	25	200	15	20	50	<DL	55	NS	75	180	<DL	20
1405	304																				
as-received		<DL	67	<DL	<DL	<DL	250-2500	<DL	100	25	220	30	25	<DL	<DL	130	NS	200	220	<DL	<DL
		<DL	73	<DL	<DL	<DL	250-2500	<DL	96	50	220	30	25	<DL	<DL	130	NS	200	210	<DL	<DL
granules		<DL	110	<DL	<DL	<DL	200	<DL	160	15	540	15	20	<DL	<DL	37	NS	<DL	550	<DL	15
		<DL	110	<DL	<DL	<DL	200	<DL	200	15	760	15	20	<DL	<DL	55	NS	<DL	760	<DL	15
1289	305																				
as-received		<DL	<DL	<DL	<DL	<DL	125-1250	<DL	120	25-250	340	30	50	30	<DL	75	<23	100	160	<DL	5
granules		<DL	<DL	<DL	<DL	<DL	25	<DL	45	20	150	5	5	<DL	<DL	35	NS	100	110	<DL	<DL
		<DL	<DL	<DL	<DL	<DL	25	<DL	50	20	150	6	5	<DL	<DL	35	NS	100	150	<DL	<DL
1340	306																				
as-received		<DL	<DL	<DL	<DL	1	125-1250	<DL	35	25	70	30	20	<DL	<DL	35	<25	50	130	<DL	5
granules		<DL	160	<DL	<DL	<DL	10	<DL	180	3	450	<DL	5	<DL	<DL	48	NS	10	340	<DL	20
		<DL	135	<DL	<DL	<DL	10	<DL	200	3	470	<DL	5	<DL	<DL	52	NS	20	450	<DL	20
1300	307																				
as-received		<DL	25	<DL	<DL	1	250-2500	<DL	75	20	170	100	15	<DL	<DL	130	NS	50	120	<DL	<DL
		<DL	45	<DL	<DL	<DL	250-2500	<DL	70	50	150	100	10	<DL	<DL	100	NS	50	120	<DL	<DL
granules		1	200	<DL	<DL	<DL	7	<DL	150	30	410	<DL	2	<DL	<DL	38	NS	5	370	<DL	5
		<DL	190	<DL	<DL	<DL	7	<DL	140	30	380	<DL	2	<DL	<DL	28	NS	5	320	<DL	5
1407	308																				
as-received		<DL	20	<DL	<DL	2	125-1250	<DL	75	25-250	170	100	50	20	<DL	75	<24	125-1250	150	<DL	15
granules		<DL	310	<DL	<DL	<DL	10	<DL	700	20	1600	<DL	5	<DL	50	240	NS	30	960	<DL	60
		<DL	235	<DL	<DL	<DL	10	<DL	700	20	1400	<DL	5	<DL	50	220	NS	30	820	<DL	60

^a The WSRC SN number indicates the ID number of the shipping container used to transport the fuel to Los Alamos.

^b Below the detection limit.

^c Not submitted for this analysis.

^d Analyses were performed on samples of fuel that had been processed to seasoned granules.

Table II. Nonactinide Cation Impurities Detected In Shipment 469 Fuel
(Continued)

WSRC SN No.	LANL Lot No.	Impurity Amounts (ppm/sample of plutonia fuel)																			
		Ag	Al	B	Be	Bi	Ca	Cd	Cr	Cu	Fe	Mg	Mn	Mo	Na	Ni	P	Pb	Si	Sn	Zn
1400	309																				
	as-received	<DL	55	<DL	<DL	<DL	250-2500	<DL	100	15	200	50	20	<DL	<DL	80	NS	100	170	<DL	50
	1	20	<DL	<DL	<DL	<DL	250-2500	<DL	100	50	200	100	40	<DL	<DL	100	NS	75	170	<DL	50
	granules	<DL	10	<DL	<DL	<DL	200	<DL	83	50	260	20	25	50	<DL	50	NS	70	320	<DL	15
		<DL	10	<DL	<DL	<DL	250	<DL	82	50	230	20	25	50	<DL	70	NS	50	320	<DL	10
1409	310																				
	as-received	<DL	26	<DL	<DL	<DL	250-2500	<DL	75	3	160	20	20	<DL	<DL	120	NS	150	170	<DL	<DL
		<DL	36	<DL	<DL	<DL	250-2500	<DL	68	3	140	20	15	<DL	<DL	100	NS	200	160	<DL	<DL
	granules	<DL	110	<DL	<DL	<DL	20	<DL	78	100	200	<DL	5	25	<DL	81	NS	40	480	<DL	10
		<DL	90	<DL	<DL	<DL	20	<DL	60	100	240	<DL	5	25	<DL	57	NS	40	280	<DL	10
1391	311																				
	as-received	<DL	<DL	<DL	<DL	1	125-1250	<DL	55	25	120	50	50	30	<DL	35	<23	100	90	<DL	10
	granules	<DL	57	<DL	<DL	<DL	250	<DL	70	25-250	260	50	25	<DL	<DL	17	NS	50	200	<DL	125-1250
		<DL	60	<DL	<DL	<DL	250	<DL	80	25-250	290	50	25	<DL	<DL	23	NS	50	280	<DL	125-1250
1304	312																				
	as-received	<DL	<DL	<DL	<DL	1	125-1250	<DL	65	200-2000	200	75	75	<DL	<DL	55	<24	10	130	<DL	10
		<DL	<DL	<DL	<DL	1	125-1250	<DL	40	200-2000	130	75	75	<DL	<DL	35	NS	10	120	<DL	10
	granules	<DL	140	<DL	<DL	<DL	<DL	<DL	90	3	300	<DL	3	<DL	<DL	24	NS	10	400	<DL	10
		<DL	155	<DL	<DL	<DL	<DL	<DL	120	3	300	<DL	3	<DL	<DL	25	NS	10	390	<DL	10
1401	313																				
	as-received	<DL	30	<DL	<DL	<DL	250-2500	<DL	130	50-500	200	100-1000	35	<DL	<DL	150	NS	150	170	<DL	15
		<DL	140	<DL	<DL	<DL	250-2500	<DL	140	50-500	240	100-1000	25	<DL	<DL	140	NS	150	180	<DL	15
	granules	<DL	30	<DL	<DL	<DL	200	<DL	120	25-250	280	30	25	<DL	<DL	85	NS	75	200	<DL	5
		<DL	25	<DL	<DL	<DL	125-1250	<DL	130	25-250	260	50	25	30	<DL	90	NS	125-1250	160	<DL	5
		<DL	155	<DL	<DL	<DL	10	<DL	180	50	290	<DL	3	<DL	<DL	93	NS	25	240	<DL	20
		<DL	120	<DL	<DL	<DL	10	<DL	240	50	410	<DL	3	<DL	<DL	120	NS	25	370	<DL	20
1434	314																				
	as-received	<DL	25	<DL	<DL	1	250-2500	<DL	85	5	170	100	20	<DL	<DL	140	NS	100	120	<DL	<DL
		<DL	30	<DL	<DL	<DL	250-2500	<DL	80	3	160	100	15	<DL	<DL	120	NS	150	130	<DL	<DL
	granules	<DL	40	<DL	<DL	<DL	3	<DL	98	10	180	<DL	15	20	<DL	82	NS	25	200	<DL	<DL
		<DL	45	<DL	<DL	<DL	3	<DL	110	10	200	<DL	15	20	<DL	90	NS	25	240	<DL	<DL

2. High-Temperature Mechanical Properties of Urania Fuel Simulant

Stoichiometric analysis on depleted urania specimens from several sources were obtained in early April. Analyses were performed on compression specimens before and after mechanical testing, and on samples removed from fuel pellets impacted in CPV tests one, two, and three. The results of these analyses are summarized in Tables III and IV. For all of the data listed in both tables, the accuracy of the measurement is $x = \pm 0.003$, where x is the oxygen composition $^{238}\text{UO}_x$.

Table III. Oxygen Stoichiometry of Depleted Urania Samples

<u>Condition</u>	<u>Test Temperature (°C)</u>	<u>Experimental Strain Rate ($\dot{\epsilon}$, s^{-1})</u>	<u>Stoichiometry, x, for $^{238}\text{UO}_x$</u>
cold-pressed and sintered, starting material	-	-	2.010
hot-pressed, pellet edge, starting material	-	-	1.994
hot-pressed, pellet core, starting material	-	-	1.991
cold-pressed	900	2.5×10^{-4}	1.993
cold-pressed	1400	2.5×10^{-4}	1.989
hot-pressed	900	2.5×10^{-4}	1.997
hot-pressed	1300	0.1	2.001

All of the measurements indicate that the composition of the depleted urania samples was extremely close to stoichiometric. There did appear to be slight variations that may have resulted from the initial processing. The compression experiments do reduce the specimens from their initial composition but the amount of reduction is only 0.25%, with the single exception of the specimen tested at the highest temperature and the slowest strain-rate; in this case the reduction was 0.5%. Some reduction in the composition of the urania is expected because of the graphite platens and graphite furnace elements used to perform the compression tests. However, these reductions in stoichiometry do not appear to be any larger than the initial fluctuations in specimen composition due to processing variables, and they were only three times larger than the error of the stoichiometric measurement itself. We examined the literature, and from these data we believe that the slight reductions from exact stoichiometry did not influence the mechanical properties results.

Table IV. Fuel Pellet Stoichiometry

<u>Specimen</u>	<u>Stoichiometry, x, for $^{238}\text{UO}_x$</u>
CPV-1	1.996
CPV-2	1.993
CPV-3	2.000

The compositions of the CPV pellets were almost stoichiometric. We believe that the impact test in no way altered their composition. The results of these measurements thus confirm that the processing of the depleted urania pellets produces a stoichiometric material and that the testing, either for properties measurements or engineering systems simulation, does not alter this composition in any significant manner.

3. High-Temperature Mechanical Properties of Hafnia Fuel Simulant

Three lots of hafnia (HfO_2) compression specimens were received in early April. There were 8 pellets in each of the three lots. The lots of hafnia each had a different density: 83%, 90%, and 96% of theoretical. Our preliminary experiments were designed to evaluate the 90% and 96% dense-material, at a nominal strain rate of $\dot{\epsilon} = 2.5 \times 10^{-4} \text{ s}^{-1}$. We found that the hafnia was remarkably strong; while performing these experiments the alumina loading platens frequently fractured. There were indications of platen fracture in almost all of the tests, and an important question is whether or not the specimen fracture was induced by a cracking platen.

Our results indicated that the 90% dense hafnia was 50% to 100% stronger than $^{238}\text{PuO}_2$ below 1300°C . The hafnia did not yield but rather loaded directly to fracture. During these experiments there were sudden small incremental jumps in testing-machine cross-head displacement. We interpreted these jumps to be the result of platen fracture rather than specimen yielding or specimen deformation.

The 96% dense hafnia was exceedingly strong below 1350°C . During these experiments we reached the capacity of our testing machine without fracturing the specimens. There is a deformation mechanism that becomes active at elevated temperature, in this case at $\approx 1350^\circ\text{C}$. We observed yield at 50MPa and then rapid work hardening in the specimen tested at 1400°C .

These initial hafnia experiments indicate that hafnia is not as good a simulant for $^{238}\text{PuO}_2$ as depleted urania. The urania has strength and deformation behavior comparable to plutonia. Hafnia, on the other hand, appears to be stronger than plutonia and will have less mass together with its higher strength.

4. High-Temperature Mechanical Properties of Graphite

Work in this month focused on developing techniques for testing graphite rings (cut from GPHS graphite impact shells [GISs]) at elevated temperature. We designed graphite clevises and half-moons to load the ring specimens of GIS material. In our initial

experiments at 1000°C we fractured both the clevises and the half moons. Although we were able to finally fracture the specimens, even after these parts broke, we were left with an artificially low fracture-stress; this was a result of bending moments in the specimen that resulted when the half-moons failed.

Both the clevises and half-moons were produced from 3-D fine weave pierced fabric (FWPF) graphite. We intend to perform experiments to quantify the strength of the FWPF material as a function of orientation. Coupons with pin loading holes have been prepared to simulate the clevises, and steel rings have been made to load the half-moons. The dimensions of the steel rings will be sized to match the stiffness of the GIS specimens.

Our experiments to date show that we can get sufficient strength from the graphite clevises to be able to perform the experiments. However, we found that there was no orientation of FWPF material that gave sufficient strength in the half-moons to be able test the GIS rings to failure.

We will pursue the following approach to finish these experiments. First, clevises, half-moons, and loading pins are being built from tungsten-zirconia-molybdenum (TZM) and thoriated tungsten. The metal fixtures will easily be strong enough to perform experiments up to moderate temperatures. The TZM is useful between room temperature and 1200°C and the thoriated tungsten between 1200°C and 2000°C. We will need to perform experiments above 2000°C, and for this we will still need to use the graphite fixturing. For this purpose we redesigned the half-moons to include an integral loading pin. The fractures that occurred in the half-moons were a result of the loading-pin hole. We believe that making the half-moon and loading pin as one piece will alleviate this fracture problem.

E. Project Management

All required weekly status reports were delivered on schedule. The program Project Management System (PMS) monthly status report (which included a data disk) was also delivered to Fairchild Space Company (the operator of the program PMS) on schedule.

V. LIGHT-WEIGHT RADIOISOTOPE HEATER UNIT (LWRHU) PROGRAM

A. LWRHU Weld Development

There was no activity this reporting period.

B. LWRHU Production

Fuel lot 286 was processed to low-fired granules, and fuel lot 285 (low-fired) was approved for use in fabrication of LWRHU pellets. If fuel lot 286 is approved for use, sufficient granules exist to meet the LWRHU production requirements for the Cassini mission.

VI. 60-WATT HEAT SOURCE PROGRAM

A. Preproduction Activities

In this month, installation of the hot isostatic press (HIP) was suspended as part of the facility stand-down.

When the HIP unit has been connected to all building services, a factory representative will be scheduled to start up the unit and install a gas-reclaim feature. After the unit has been demonstrated as operational, a facility START review will be requested. The START review must be closed out before any programmatic activities can be performed. In the interim, arrangements have been made with another LANL group for HIPing simulant-fueled clads.

B. Technical Support

Five cold-pressed urania pellets were encapsulated. Capsules SC0025 and SC0026 were helium leak-checked, weighed, dimensioned, and ultrasonic tested. Both capsules were HIPed by 20 April.

After capsule SC0024 had been HIPed, it was submitted for ultrasonic examination. However, the asymmetric capsule deformation prevented meaningful ultrasonic examination.

VII. 1-KW SHIPPING CONTAINER

A. Container Opening Facility

The container opening facility is operational.

B. Container Welding Facility

Work on a conceptual design for a system to load the 1-kW shipping container onto an automated weld fixture continued throughout the month.

Performance testing of the weld system conducted in early April, verified that it had been damaged during relocation at LANL. Repair of damaged components by factory personnel was scheduled.

VIII. PROGRAMMATIC MEETINGS AND VISITORS

Members of a mentor team selected by DOE headquarters were present on-site throughout the month.

In the first week of April members of the Defense Nuclear Facilities Safety Board (DNFSB) evaluated TA-55 formality of operations, personnel training and qualification, glovebox glove and gasket inspection programs, and deliberate operations.

In the second week of April, representatives from DOE Environment and Health (DOE/EH) evaluated TA-55 formality of operations, personnel training and qualification, glovebox glove and gasket inspection programs, and deliberate operations.

Representatives from Westinghouse Nuclear & Advanced Technologies Division (WNATD) were on-site 18 April.

On 28 April, a Quality Assurance representative from MMES/Y-12 observed the unpacking, inspection, and storage of iridium components received in shipment 10460.

On 26 April, Tara O'Toole and several DOE/EH personnel visited TA-55.

On 27-28 April, two LANL staff members supported Cassini and 60-watt monthly meetings at Germantown, Maryland.

**DATE
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10/18/94

END