Quarterly Report
Heat Source Technology Programs
April - June 1993

Los Alamos
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T. G. George

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Los Alamos
NATIONAL LABORATORY

Los Alamos, New Mexico 87545

**QUARTERLY REPORT
HEAT SOURCE TECHNOLOGY PROGRAM**

APRIL – JUNE 1993

Compiled by

T. G. George

ABSTRACT

This quarterly 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 US 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

A PAT-1 cask, allocated for shipment of a fuel sample from the former Soviet Union, was transported from LANL to EG&G Mound Applied Technologies (EG&G MAT) in November 1992. EG&G MAT then forwarded the PAT-1 cask and a 1-KW cask to the Soviet plant. In April, certification documents for the 1-KW cask were received at LANL.

In mid-May, a PAT-1 cask containing six fuel samples was shipped from a plant in the former Soviet Union to LANL. The fuel samples were analyzed to verify that the stated quantities of nuclear material were correct. All verification measurements were complete by 1 June. However, additional analytical work was delayed by a semiannual inventory of special nuclear materials (SNMs).

At the beginning of May, LANL requested that Sandia National Laboratories (SNL), New Mexico, prepare a PAT-1 container for use in shipping a fuel sample from Westinghouse Savannah River Company (WSRC) to LANL.

A shipment of recharacterization fuel was received from WSRC at the beginning of June and was placed in

storage pending completion of the SNM inventory. The amount of ^{238}Pu received in this shipment (1.2 kg) was sufficient to produce nine general-purpose heat source (GPHS) fuel pellets, assuming an overall process yield $\geq 84\%$.

II. IRIDIUM HARDWARE SHIPMENTS AND INVENTORY

A shipment of 10 GPHS weld shields (type-II) was received from Martin Marietta Energy Systems (MMES) Y-12 on 22 June.

The amount of GPHS hardware available for the Cassini mission (at LANL), as of 30 June, is shown in Table I.

Table I. LANL Inventory of Cassini GPHS Iridium Hardware

Type of Hardware	Category	Number of Items in Inventory
PICS*	Prime	25
PICS	Restricted	18
Type II Weld Shields	Prime	7

*PICS = post-impact containment shell.

II. FACILITIES

A. Launcher Relocation

During this quarter, work continued on an addition to building PF-4 to house the relocated launcher. Significant progress was made on construction of the addition, on the installation of required services, on design of an heating, ventilation, and air conditioning (HVAC) system, and on procurement of required support items. A site map that shows the location of the launcher addition may be seen in Fig. 1, and an architectural section of the completed addition is shown in Fig. 2.

1. Construction Activities

The first level of the launcher addition's interior and exterior walls was poured (to an elevation of 11 ft) at the end of the last quarter. By the end of this quarter, a second level of walls (to an elevation of 18 ft) was completed, all of the structural steel and rebar assemblies for the next two levels of the structure had been installed, and approximately 50% of the gang forms for the third concrete lift (an elevation of 30 ft) had been emplaced (Fig. 3). Seismic isolation (expansion joint) material was also installed between the third level of the launcher addition and the wall of building PF-4.

At the end of June, chemical analysis of a cement sample that had been prepared by the concrete supplier at the time of the first concrete pour revealed that the cement contained approximately 6% more lime than the maximum permitted by American Society for Testing and Materials (ASTM) specifications for portland cement. Although a nonconformance report was written, all mechanical tests of concrete actually used in the addition have exceeded specifications. In addition, existing documentation has shown that the excess lime content would have no effect on corrosion of the steel reinforcements or on aging of the concrete. Finally, the cement sample submitted for chemical analysis was not directly traceable to the concrete used in the launcher addition.

Installation of electrical services required for the launcher addition's HVAC system continued during April, but was temporarily suspended in mid-May, pending the resolution of issues associated with the integration of these services into the PF-4 central control and distribution system. At the end of June, a meeting was held between representatives from the user group, Heat Source Technology (NMT-9), the Technical Area (TA)-55 Facilities Management group (NMT-8),

Fig. 1. A site map showing the location of the launcher addition.

LANL's Facilities Engineering Division (ENG), and the building contractor to determine how the two systems would interface. All interface issues were resolved at this meeting and ENG personnel were tasked with revising design drawings for the addition. Work on installation of HVAC electrical services was expected to resume by mid-July.

Duct hangers for the addition's HVAC system were seismically qualified in early June, and by the end of the month installation of the hangars had begun.

2. Procurements

LANL's Materials Management Division (MAT) previously issued a purchase request (PR) for blast doors to cover both entryways from PF-4 into the launcher addition. Before bids on the PR were received, a number of potential vendors raised questions related to the technical specifications. As a result, the technical specifications were revised and a modified PR, with a 17 May bid deadline, was released at the end of April. Although the bid due date was extended to 21 May, only one bid was received. At the end of the quarter, MAT concluded a purchase agreement for procurement of the

Fig. 2. Architectural section of the completed launcher addition.

blast doors. As part of this agreement, the vendor was tasked with supervising door installation.

During April, the vendor selected for procurement and installation of the bridge crane provided shop drawings of the proposed crane. Examination of the drawings revealed that the crane's travel would not meet the requirements described in the original purchase agreement. Consequently, the vendor was asked to redesign the crane to meet the original travel requirements and to provide new shop drawings. The revised drawings were approved, and the vendor was instructed to proceed with fabrication of the crane.

Technical specifications for the filter train that will be used in the launcher addition's HVAC system were approved by the architecture and engineering (A&E)

contractor. The PR for the filter train was then forwarded to MAT for placement.

Bids from system integrators for fabrication of the Supervisory Control System (SCS) that will control launcher operations were reviewed in February. However, the original technical specification was later revised to clarify items questioned by potential vendors. As a result, the bid deadline for the modified PR was extended to 27 April. Unfortunately, the issuance of a purchase agreement was delayed by a federal audit of MAT operations.

3. Administrative Requirements

Work continued on revising launcher safe operating procedures (SOPs) and writing operator training plans.

Fig. 3. By the end of June, all of the structural steel and rebar assemblies for the third and fourth levels of the launcher addition had been installed.

B. Glovebox for GPHS Encapsulation Welding

Installation of the glovebox designed for GPHS encapsulation welding was completed in May 1992. A Safety and Technical Assessment for Readiness of Technology (START) review of the welding operation was completed in mid-September 1992 and approval

for process start-up was received on 21 September. However, because LANL may not be in compliance with current National Emission Standards for Hazardous Air Pollutants (NESHAP), a temporary limit was imposed that permitted only six fueled-clads to be welded each month.

The results of legal and managerial reviews completed in this quarter indicated that a maximum of 2.5 kg of ^{238}Pu could be processed each month without exceeding the established TA-55 baseline. On this basis of this finding, it was determined that there are no NESHAP implications for welding up to 16 fueled-clads per month.

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.

In early November 1992, work on a facility ventilation upgrade (to service open-front hoods in both lines) was stopped by the Laboratory's quality assurance (QA) organization as a result of concerns with seismic qualification and duct welding procedures. Issues associated with duct welding were resolved by early December, and the issue of seismic qualification was resolved by the end of January. Work on the ventilation upgrade resumed on 22 February, and was essentially complete by the end of June. Efforts to leak-test the duct installation were underway, and the ventilation upgrade was expected to be operational by mid-July.

D. Sieve Analysis Gloveboxes

Two gloveboxes designed to house the sieving and particle size analysis operations were previously installed and prepared for use. NMT-9 requested a START review of these gloveboxes on 9 April, and a START review team convened on 30 April. On the basis of an inspection, the START review team identified 11 findings that would have to be addressed before the gloveboxes were approved for use. By the end of June, actions had been taken to close out all findings associated with the START review.

E. Fuel-Processing Glovebox Line

In this month we concentrated on replacing the connecting rings, spools, and gaskets used to access three fuel-process gloveboxes (GB-218, GB-221, and GB-222). On 1 March 1993, a minor contamination incident was traced to degradation of the gasket between GB-221 and dropbox 7 (DB-7). Subsequent inspection of other fuel-processing gloveboxes revealed that the gaskets between GB-221 and GB-222, and between GB-218 and

DB-6, were similarly affected. All of these gaskets had been in use for the approximately 15 years that building PF-4 has been operational. In addition, gloveboxes GB-218 and GB-221 are used for ball-milling $^{238}\text{PuO}_2$ powders, which is the harshest environment present in the ^{238}Pu laboratories. As a result of these inspections, the leaking gasket on GB-221, which is normally covered by external radiation shielding, was temporarily sealed, and work on a plan to replace the gaskets and connecting hardware was initiated.

After several meetings between personnel from NMT-9 and the Health Physics Operations group (HS-1) of LANL's Health and Safety Division (HS), a replacement plan was developed, a temporary plastic tent to minimize the spread of contamination was designed and constructed under a radiation work permit (RWP), and standard and custom parts were designed and fabricated as needed. Four practice sessions were held in the TA-55 training center practice laboratory; full-face respirators were worn during the last session. As a result of these meetings and practice sessions, an RWP with step-by-step instructions for the connecting ring changeout, which included a detailed description of anticipated radiological conditions and protective clothing requirements, was finalized.

By 19 May, the hardware used to connect GB-221 to DB-7 and to GB-222 had been replaced. No significant release of contamination occurred as a result of these replacements.

On 24 May, work began on replacing the connection between GB-218 and DB-6. During removal of the connecting ring gasket from GB-218, a portion of the gasket stuck to the box and flexed when a worker attempted to push the gasket inside the glovebox. Consequently, the replacement of this connection resulted in a contamination incident. However, by 28 May, new connection hardware was in place and decontamination of the room was in progress.

III. GENERAL-PURPOSE HEAT SOURCE

A. Preproduction Activities

1. Operational Readiness Evaluation (ORE)

A Cassini production ORE was conducted at LANL on 16–20 November 1992. Also present was a DOE Environment & Health audit/review team that acted in an oversight capacity. The ORE was closed out on 20 November, with six findings to be resolved prior to the

start of Cassini heat source production. By the end of May, the work required to close all six findings had been completed.

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

The $^{238}\text{PuO}_2$ fuel powder acceptance specification, the GPHS fuel pellet specification, and the GPHS fueled-clad specification were distributed to DOE's Office of Special Applications (DOE/OSA), EG&G MAT, General Electric Astro Space (GE-ASTRO), Oak Ridge National Laboratory (ORNL), and WSRC for review, as required by the Interface Working Agreement (IWA). Six organizations/individuals provided comments on the draft specifications by the deadline of 7 May. These comments will be addressed in subsequent specification revisions.

3. Development of Process Procedures

Two compilations of procedures, titled "Quality Assurance Procedures for Flight Quality Cassini Fueled-Clads" and "Fabrication Procedures for Flight-Quality Cassini Fueled Clads," were previously distributed on controlled-copy bases internally and externally as required by the IWA. Both compilations will be updated to reflect subsequent procedure revisions only after DOE/OSA approval.

Sets of controlled-copy compilations of the "Fabrication Procedures for Flight-Quality Cassini Fueled Clads" were distributed to members of the Cassini Process Readiness Evaluation Review, which occurred on 18-19 May.

Procedure SHS-NMT9-PP-30 ("Cassini GPHS Iridium Control Procedure") was approved for use at the local level on 7 May, and received DOE/OSA approval on 17 June. This procedure reflects recent changes to the design of the GPHS weld-shield; it replaces SHS-NMT9-PP-24 ("GPHS Clad Vent Set [CVS] Control Procedure").

4. Fueled-Clad Weld Development

Three $^{238}\text{PuO}_2$ fuel pellets were successfully encapsulated on 29 June. All three capsules were assembled with Type II (final design) weld-shields. Initial postweld examination did not reveal any weld defects or anomalies, and all of the capsules easily passed through the acceptance ring gauge. The time required to perform these three welds (which included assembly,

welding, disassembly, and required quality assurance operations) was 1 h.

The fuel pellet welded into the second capsule (FC0004) had previously fractured into three pieces. All of the weld equipment and assembly hardware performed as designed, and there were no problems positioning the three-piece pellet in the weld-shield cup.

In the next quarter, the three capsules welded on 29 June will be decontaminated, leak checked, ultrasonically tested, dimensioned, analyzed to determine the neutron emission rate, and metallographically examined to verify the presence of an acceptable weld microstructure.

5. Fueled-Clad Ultrasonic Test (UT) Development

On 15 April, LANL hosted a meeting of the GPHS Welding/UT Working Group. The immediate result of this meeting, which was attended by representatives from NE-53, WSRC, EG&G MAT, Martin Marietta Energy Systems (MMES), Westinghouse Advanced Energy Systems (WAES), GE-ASTRO, and Fairchild Space Company (FSC), was to reach agreement on the following points:

- That all Cassini UT development must be complete, with required equipment installed, procedures approved, and operators trained and certified, by 15 July 1993.
- That on the basis of recent UT development work conducted by WSRC, the Cassini UT procedure should consist of two scans of the girth weld (top and bottom) obtained with a 3.5-MHz transducer and the "top scan" evaluation technique.
- That after each UT standard has been supplied by Y-12, the receiver's QA organization will be responsible for maintaining the standards, replicas, and supporting documentation.
- That the results of scheduled development activities may provide evidence that the proposed UT acceptance criterion (4.8 equiv mils) should be raised or lowered.
- That the second-generation UT standards should be modified to include 3-, 5-, and 7-mil-deep slots just above the weld, a 5-mil-deep slot at the weld centerline, and a 5-mil-deep slot just below the weld. All of the slots will be 75 mils long and 4 mils wide.
- That all subsequent development work would focus on adapting the "top scan" evaluation technique for Cassini UT.

- That the optimum Cassini UT system would be configured to provide calibration, part inspection, and engineering information reports and would digitize and store all scan data. Each report would consist of the following information:

Calibration Report

Slot calibration information and data file ID numbers
Standard ID
Inspection date
Operator

Part Inspection Report

Part ID
ID number for Calibration Report data file
Data file IDs for top and bottom scans
System component information and IDs
Inspection date
Operator
Determination that part is ACCEPTABLE or NONCONFORMING

Engineering Report

Part ID
Histograms of top and bottom scans in equiv mils format

A detailed plan and schedule were also developed to ensure that a viable UT system is in place and operational by 15 July 1993.

In early June, MMES-Y12 personnel indicated that major modifications to the Cassini-UT inspection system software were complete and that a plan had been developed for required hardware modifications. On 9 June, MMES-Y12 personnel trained a LANL UT technician on implementation and use of the modified UT inspection system.

6. 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 uranium fuel-simulants.

All simulant-fueled clads required for the CPV test series were welded previously. Eight capsules were loaded with hot-pressed uranium (^{235}U -depleted) fuel-simulant and seven capsules were loaded with cold-pressed uranium. UT examination performed with the

existing Panametrics system indicated that the welds in nearly three-quarters of the capsules (11 of 15) contained reflectors that exceeded the proposed 4.8 equiv mils acceptance criterion.

a. CPV-1. On 28 September 1992, the first impact in the CPV series was completed. In this test (CPV-1), capsule SC0011, which had been loaded with a hot-pressed uranium pellet, was impacted against a steel plate at 55.0 ± 1.0 m/s and 1092°C . The iridium hardware used for this capsule was Z-batch material produced for the Galileo and Ulysses missions. Postimpact examination of capsule SC0011 revealed that the clad had breached as a result of a fuel fragment push-through; details of the clad failure were reported in a "Quick-Look" report issued on 26 October 1992.

In this quarter we made significant progress on the CPV-1 postmortem examination. Examinations of seven metallographic sections previously cut from the impacted clad were completed. The results of these examinations confirmed that the primary breach (which occurred in the girth weld) had not resulted from a weld defect. The weld microstructure was generally fine-grained, and the breaching crack did not occur along the weld centerline (Fig. 4).

Another feature revealed by metallographic examination was the presence of a large offset (Fig. 5) between the vent and shield cup walls at a radial location of 144 deg (from the weld start). Although the outer surfaces of the cups were flush, the inner surfaces were offset by 0.125 mm (0.005 in.). In this cross section, the apparent thicknesses of the vent and weld shield cups (at the weld) were 0.845 mm (0.033 in.) and 0.720 mm (0.028 in.); the current Y-12/MMES specification for maximum wall thickness in this region is 0.73 mm (0.029 in.). Interestingly, the anomalous wall thickness did not appear to have prevented full weld penetration or adversely affected the resulting weld microstructure (Fig. 6).

Sieve analysis of the uranium fuel-simulant retained in capsule SC0011 was completed by 30 April. The results of this analysis are shown in Table II. Particle size analyses of the subsieve portion of the retained fuel simulant and of the simulant released into the tantalum impact can were delayed by a START review of the sieve analysis gloveboxes (see Section IIID).

Fig. 4. The primary breach in capsule SC0011 did not occur along the weld centerline; etched, 50 $\times$.

Fig. 5. A large offset was observed between the vent and shield cup walls of capsule SC0011 at a radial location of 144 deg; as polished, 32 $\times$.

Fig. 6. The offset between the vent and weld-shield cups in capsule SC0011 did not appear to have prevented full weld penetration or adversely affected the resulting weld microstructure; etched, 50 $\times$.

Table II. Sieve Analysis of Retained Urania Fuel-Simulant

Particle Size (mm)	Weight Fraction ^a	
	SC0011	SC0008 ^b
+ 5600	0.3766	0.5293
+ 2000 to 6300	0.3310	0.2947
+ 850 to 2000	0.1823	0.0354
+ 425 to 850	0.0108	0.1131
+ 180 to 425	0.0495	0.0135
+ 125 to 180	0.0225	0.0019
+ 75 to 125	0.0026	0.0016
+ 45 to 75	0.0017	0.0016
≤ 45	<u>0.0228</u>	<u>0.0089</u>
Totals:	0.9997	1.0000

^aWeight fractions are calculated on the bases of the total weight of urania recovered.

^bNo urania fuel-simulant was released from capsule SC0008.

b. CPV-2. On 4 December 1992, capsule SC0008, which had been loaded with a hot-pressed urania pellet, 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 D2 batch. Postimpact examination revealed that although the capsule had two small transverse cracks on the cup radii at the edges of the impact face, no urania was released; details of the initial examination were reported in a "Quick-Look" report issued on 1 February 1993.

In this quarter we continued to make progress on the CPV-2 postmortem examination. Five metallographic specimens were cut from the impacted clad and the fuel retained in the capsule was submitted for sieve analysis (Table II).

c. 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 capsule SC0004 had apparently been breached by two small transverse cracks on the cup radii at the edges of the impact face. The impact face of the capsule was centered approximately 120 deg. from the weld start (0 deg. reference location). No urania was observed in the tantalum containment vessel, and subsequent alpha counting verified that no

uranium had been released. Overall capsule deformation was moderate; the capsule strains are listed in Table III.

There was no detectable deformation of the steel target plate.

Table III. CPV-3 and CPV-4 Capsule Strains

	Minimum (%)		Maximum (%)	
	CPV-3	CPV-4	CPV-3	CPV-4
Axial (length):	+8.4	-0.9	+14.3	+16.1
Diametral:				
Vent Cup	-12.8	-8.9	+6.9	+6.6
Weld	-13.5	-8.9	+9.3	+8.3
Weld-Shield Cup	-13.6	-10.8	+7.6	+5.7

The hairline cracks on the cup radii at the edges of the impact face (Fig. 7) appeared to be similar to cracks observed in other capsules impacted at this velocity, and should be considered typical. Both cracks had an apparent length of 4.5 mm (0.177 in.).

After macroscopic examination, capsule SC0004 was opened by a cut along the edge of the grit-blast on the weld-shield cup. Examination of the opened capsule revealed that the fractures in the fuel-simulant tended to radiate from the point of initial impact (Fig. 8).

d. CPV-4. On 5 March, 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 (Fig. 9); the capsule impact face was centered at the weld start (0 deg. reference location). The primary breach was an axial crack located approximately 120 deg. from the weld start that extended from the shield cup, through the weld, and into the vent cup. Smaller axial weld cracks also occurred at 170, 180, and 225 deg. At approximately 180 deg, a network of hairline (generally axial) cracks extended from the edge of the grit blast line to the vent cup radius. Small transverse cracks were also visible on the cup radii, at the edges of the impact face. Overall capsule deformation was significantly less than that observed in previous CPV impact tests; the capsule strains are listed in Table III. A small amount of urania was released into the tantalum containment vessel.

(a)

(b)

(c)

(d)

(e)

(f)

Fig. 7. Although two small transverse cracks were observed on the impact face of capsule SC0004, no urania was released into the tantalum containment vessel: (a) impact face, (b) profile, (c) trailing face, (d) opposite profile, (e) vent end, (f) blind end; all at 2.2 $\times$.

Fig. 8. Fractures in the SC0004 fuel-simulant tended to radiate from the point of initial impact; 1.5x.

The axial crack at 120 deg. (Fig. 10) had an apparent length of 10.4 mm (0.409 in.) and a maximum width of 0.65 mm (0.026 in.). The extent of localized clad deformation suggested that the crack had resulted from the differential displacement of a sharp fuel-simulant fragment.

The thin axial weld cracks at 170, 180, and 225 deg. were all contained within the weld metal. The cracks at 170 and 180 deg. were 1.3-mm (0.051-in.) long, and the crack at 225° had a length of 2.3 mm (0.091 in.). The network of hairline cracks on the vent cup at 180 deg. (Fig. 11), had an apparent length of 10.0 mm (0.394 in.) and appeared to be related to severe localized deformation caused by the displacement of a sharp urania fragment.

The transverse cracks on the impact face of the vent and shield cup radii appeared to be similar to cracks observed in other capsules impacted at this velocity, and should be considered typical. The crack in the vent cup radius appeared to be 11.0-mm (0.433-in.) long, and the crack on the shield cup radius had a length of 5.5 mm (0.217 in.).

There was no detectable deformation of the steel target plate.

e. CPV-5. On 15 June, 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.

f. CPV-6. On 29 June, 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.

g. CPV-7. Capsule SC0019, loaded with cold-pressed and sintered urania, was selected for use in CPV-7. 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.

7. Production Qualification

On 18-19 May, the Cassini Process Readiness Evaluation Team conducted a preliminary review of LANL operations. Previously, LANL had completed a review of the 14 April draft readiness plan for the Production Qualification Program and had forwarded a copy of this review to the leader of the Process Readiness Evaluation Team.

A shipment of recharacterization fuel was received from WSRC at the beginning of June and was placed in storage pending completion of the SNM inventory (expected by 6 July). The amount of ^{238}Pu received in this shipment (1.2 kg) is sufficient to produce nine GPHS fuel pellets, assuming an overall process yield $\geq 84\%$.

B. Cassini Fueled-Clad Production

There was no activity during this quarter.

C. Cassini Safety Test Program

There was no activity during this quarter.

D. Research and Development

1. High-Temperature Mechanical Properties of Urania Fuel Simulant

There was no activity during this quarter.

2. High-Temperature Mechanical Properties of Graphite

There was no activity during this quarter.

E. Project Management

All required weekly status reports were delivered on schedule. The Program Project Management System (PMS) monthly status reports (which included a data disk) were also delivered to FSC (the operator of the Program PMS) on schedule.

(a)

(b)

(c)

(d)

(e)

(f)

Fig. 9. Capsule SC0020 was breached by several cracks: (a) impact face, (b) profile, (c) trailing face, (d) opposite profile, (e) vent end, (f) blind end; all at 2.2 $\times$.

Fig. 10. The primary breach in capsule SC0020 was an axial crack that extended from the shield cup, through the weld, and into the vent cup; 3x.

Fig. 11. A network of hairline cracks on the vent cup appeared to be related to the differential displacement of a sharp urania fragment; 3x.

IV. LIGHT-WEIGHT RADIOISOTOPE HEATER UNIT (LWRHU)

A. LWRHU Fuel Powder, Pellet, and Fueled-Capsule Specifications

A draft version of the LWRHU product index was previously distributed to DOE/OSA, EG&G MAT, GE-ASTRO, ORNL, and WSRC for approval, comment, or information as described in the IWA. A final version of the LWRHU product index was not released.

B. LWRHU Weld Development

Installation of a plexiglass welding chamber designed for "cold" weld process development continued throughout the quarter. All installation activities were expected to be complete by 15 July.

C. LWRHU Production

Installation of a vacuum furnace for high-temperature outgassing of assembled LWRHUs was completed in April. The furnace was brought on-line in June, and will be first used for outgassing of vibration test assemblies.

Fabrication of urania (^{235}U -depleted) fuel-simulant pellets for two LWRHU vibration tests and for weld development was initiated at the end of May. The urania pellets were expected to be complete by mid July.

END

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