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MONTHLY PROGRESS REPORT
HEAT SOURCE TECHNOLOGY PROGRAMS

FEBRUARY 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 second delivery of fuel for Cassini flight-quality applications, designated as shipment 470, was received from the Westinghouse Savannah River Company (WSRC) at the beginning of February. Unloading of the shipping casks and subsequent accountability measurements were delayed by the presence of swipeable surface contamination on four of the EP-61 containers. However, all of the affected containers were successfully decontaminated. By the end of the month, calorimetry measurements had been performed on two-thirds of the EP-61 containers.

Four samples of fuel received from WSRC (designated 35-1, 25-1, 29-1, and a returned sample of archive milliwatt fuel) were received at TA-55 at the beginning of the month and were shipped to the Chemistry and Materials Research (CMR) building for analysis.

II. IRIDIUM HARDWARE SHIPMENTS AND INVENTORY

On 16 February, 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 10377. The LANL inventory of GPHS hardware, as of 28 February, 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	192
PICS	Restricted Use	54
Type II Weld Shields	Prime	252

*PICS = post-impact containment shell

III. FACILITIES

A. General

During February, progress on the installation of equipment and gloveboxes required to support Cassini production continued to be delayed by the slow response of organizations responsible for work approval, scheduling, and performance.

Throughout the month, radiological control technician (RCT) coverage for $^{238}\text{PuO}_2$ operations at TA-55 was adequate for the level of activity. However, in mid-February the area work supervisor (AWS) responsible for the $^{238}\text{PuO}_2$ operations areas at TA-55 requested that RCT coverage for ongoing Cassini activities and the launcher addition be increased from 2 to 3 full-time technicians.

B. Launcher Relocation

Work continued in February on construction of an addition to PF-4 to house the relocated launcher and on a number of related procurements.

1. Construction Activities

Painting of the ceiling of the launcher addition and the greater part of the interior wall surfaces was completed. However, servicing and testing of the launcher addition's bridge crane continued to be delayed by the painting operation.

Personnel from Johnson Controls International, Inc. (JCI) continued to make progress on installation of a gas system for the launcher addition, in the PF-4 basement. Work on the gas system began in early January.

Progress was also made on fabrication of a stand for the relocated launcher. The launcher stand plate was machined, and spring housings were welded into it.

By the end of the month a preliminary schedule for completion of most construction activities had been developed. Significant schedule milestones are listed below.

1 March: complete interior painting.

15 March: complete installation of the bridge crane, service the crane, and verify function.

15 April: complete installation of the dumbwaiter and verify function.

15 April: complete installation of interior work platforms, ladders, and launcher stand.

1 May: complete installation of pressure doors.

2. Design Activities

Shop drawings for the dampers for the launcher addition's heating, ventilation, and air conditioning (HVAC) system were approved by JCI quality assurance (QA) and the architectural and engineering (A&E) contractor, and were forwarded to the vendor for fabrication.

A seismic analysis of the design of the filter train used in the launcher addition's HVAC system was rejected by the A&E contractor. Subsequently, the vendor submitted a revised seismic analysis that was approved. On 23 February, JCI authorized the vendor to begin fabrication of the filter train.

JCI also requested that the A&E contractor review and approve a revised ductwork hanger layout for the HVAC system.

3. Procurements

JCI personnel completed technical specifications for a housing to hold the high-efficiency particulate air (HEPA) filter used to exhaust air from inside the launcher room. A contract for seismic analysis of the housing design, and fabrication, was then placed with an external vendor.

4. Administrative Activities

A secretary was previously assigned to reformat the safe operating procedures (SOPs) written for operation of the relocated launcher. In this month, five SOPs and two dataforms were completed and forwarded to the TA-55 training center for editing and formatting.

A request for permission to generate mixed waste (required for removal of vacuum pumps and plumbing located on the future site of the exhaust filter train for the launcher addition) was forwarded to LANL director. Although the request was approved for plumbing containing silver solder, subsequent investigation revealed that a portion of the plumbing likely contained leaded solder. A revised mixed waste request was then resubmitted, and was approved by 23 February. However, the approval required that NMT-8 determine the qualitative composition of the lead solder before removal of the piping.

A meeting was held in Albuquerque with the vendor of the Supervisory Control System to discuss a number of items, including the software used to provide a user interface to the process logic controller (PLC), the badge readers that will control access to the launcher, and PLC wiring units.

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 may be conducted 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 orders to address findings and comments received from the START review committee were initiated in early January. A target date for the completion of all required work was established as 7 February. However, by 28 February, work had been completed to close only 18 of the 25 findings received from the START committee.

IV. GENERAL-PURPOSE HEAT SOURCE (GPHS) PROGRAM

A. Preproduction Activities

1. 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 had previously been distributed to the Office of Special Applications (OSA), EG&G Mound Applied Technologies (EG&G MAT), MMES/Valley Forge (MMES/VF), Oak Ridge National Laboratory (ORNL), and WSRC for review, as required by the Interface Working Agreement (IWA). Seven organizations/individuals provided comments on the draft specifications by the deadline of 7 May.

By mid-February, significant progress had been made in revising the original draft specifications. A revised version of the GPHS $^{238}\text{PuO}_2$ Feed Powder Specification (LANL drawing no. 26Y-318180) was issued for final review and approval on 24 February.

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 startup of the hot metallography line.

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, and the participants came to agreement on the following items.

- The "top scan" UT evaluation technique is the method that will be used for Cassini, with a weld acceptance criterion of no UT indication >5.2 equivalent-mils.
- All available information indicates that the best approximation of a Galileo/Ulysses UT rating of "8" is a UT indication of 5.2 equivalent-mils.
- Additional UT development work will be conducted at WSRC and MMES/Y-12 to determine if time-of-flight signal processing, pattern recognition programs, and radiography may be used for further evaluation of capsules that do not meet the 5.2 equivalent-mil acceptance criterion.

By the end of the month, work had been initiated to close four of the six findings assigned to LANL at the 1 February meeting.

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 is 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.

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.

In this month we continued with the metallographic examination of sections removed from capsule SC0020, and with a sieve analysis of the retained and released urania fuel simulant.

c. 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. 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.

In this month we made no progress on the CPV-5 postmortem examination.

d. 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. 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.

In this month we made no progress on the CPV-6 postmortem examination.

e. CPV-7. On 13 July, 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.

In this month we made no progress on the CPV-7 postmortem examination.

f. CPV-8. On 17 November, 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.

In this month we made no progress on the CPV-8 postmortem examination.

g. CPV-9. On 24 November, 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.

In this month we made no progress on the CPV-9 postmortem examination.

h. CPV-10. On 10 December, 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.

In this month we made no progress on the CPV-10 postmortem examination.

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.

In this month we made no progress on the CPV-11 postmortem examination.

5. Production Qualification

All process operations involving fuel originally designated for the production qualification effort were suspended in January. The activities required for the production qualification effort will be rescheduled.

B. Cassini Fueled-Clad Production

1. Fuel Processing

The first delivery of fuel for Cassini flight-quality applications, designated as shipment 469, was received from WSRC in mid-December.

The second delivery of fuel for Cassini flight-quality applications, designated as shipment 470, was received from WSRC at the beginning of February. Preliminary inspection of the shipping documentation indicated that the quantity of fuel in this shipment was sufficient for approximately 7 GPHS pellets.

Processing of flight-fuel continued throughout February. By the end of the month, processing had been initiated on fuel from ten containers received in shipment 469, and over 700 grams of oxide had been processed through granule seasoning.

Duplicate samples of fuel from eight EP60 containers previously analyzed by DC-arc spectroscopy were prepared for ICP-mass spectrometric analysis for selected impurities.

2. Administrative Activities

Approval was received from the program office for use of six revised fabrication procedures and three revised data forms.

C. Safety Test Program

There was no activity during February.

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 identified a high vacuum furnace that could be temporarily modified to duplicate EG&G MAT's module reduction and monitoring facility (MRMF). A residual gas analyzer system that can be used to analyze gas within the vacuum furnace or to fill gas sampling bottles was also located, and a pressure gage that operates in the relevant range (10^{-3} to 1000 torr) was ordered.

On the basis of verbal direction from the program office, work began on 1 February to modify the vacuum furnace to serve as a substitute MRMF.

2. High-Temperature Mechanical Properties of Urania Fuel Simulant

Work continued to complete a formal report describing the mechanical properties of cold-pressed and hot-pressed and grain-stabilized urania. A preliminary version of the report was edited and returned for corrections. However, completion of the final report has been delayed by stoichiometric and metallographic analyses of samples removed from the compression test specimens and from the urania pellets impacted in CPV-1, -2, and -3.

3. High-Temperature Mechanical Properties of Graphite

In this month we focused our efforts on testing Fine-Weave Pierced-Fabric (FWPF) graphite samples obtained from GPHS graphite impact shells (GISs). The first experiment was conducted at 1000°C. Although the furnace performed as designed, the 2-D graphite test clevises used to load the test specimen failed prematurely. The clevis failure resulted from an alignment error during machining that resulted in an 85% reduction in strength.

By the end of the month an order was placed for new test clevises. The clevises will be made from 3-D graphite and will be cut in the correct orientation. When the new clevises have been machined, the graphite testing will resume.

An upgrade of the furnace controller and power supply was also completed. The last step in preparing the furnace for very high-temperature operation will be to install voltage and current meters to permit continuous monitoring of the power supply output.

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 FSC (the operator of the program PMS) on schedule.

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

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

LWRHU Fuel powder, pellet, and fueled capsule specifications were issued in January.

B. LWRHU Weld Development

Metallographic evaluation of welds on stainless steel LWRHU components was completed by 16 February, and the next phase of cold weld development was scheduled for the first week in March.

C. LWRHU Production

Fuel lots 272 and 274, sufficient to fabricate 112 pellets, were selected for LWRHU production. Fuel lot 272 slightly exceeded the permissible nickel content (105 ppm actual; 100 ppm specification limit), and fuel lot 274 exceeded the permissible silicon content (220 ppm actual; 200 ppm specification limit). However, blending the two lots will produce a mixture that is within specifications. Nonconformance reports were issued for both lots, with a proposed corrective action to combine the lots to produce a mixture that meets

LWRHU impurity specifications. The nonconformance reports and proposed corrective action were submitted for review by the material review board (MRB).

In February 48 LWRHU fuel pellets were hot pressed. The first two hot-press runs yielded as-pressed pellets with lengths of 10.0 to 10.1 mm. After sintering, the pellet lengths ranged from 9.0 to 10.0 mm. The nominal pellet length was approximately 9.4 mm. For the third hot-press run, the die assembly was shortened by 0.5 mm. The as-pressed pellets from this run had lengths of 9.9 to 10.1 mm. After sintering, the pellet lengths ranged from 9.8 to 10.0 mm.

A die assembly with the same dimensions as the assemblies used for the first two pressings was used for the fourth hot-press run. However, the load on the hot-press die was increased to the same pressure used for hot pressing GPHS pellets. The resulting as-pressed pellets had lengths that ranged from 9.9 to 10.1 mm.

Seventy-five percent of the LWRHU primary shipping containers were vacuum outgassed by the end of February.

VI. 60-WATT HEAT SOURCE PROGRAM

A. Preproduction Activities

1. Equipment and Facilities

In this month, installation of the hot isostatic press (HIP) continued to be delayed by other facility priorities. Although installation work was suspended between 12 January and 21 February, work resumed on 22 February and was expected to be complete by mid-March.

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.

2. Administrative Activities

Comments on the draft IWA were provided to DOE/NE-53 and Teledyne Brown Engineering on 23 February.

3. Procurement Activities

A budgetary quotation of \$100K was received from a furnace manufacturer to provide two furnaces suitable for the proposed 60-watt heat source life tests.

B. Technical Support

Neutron and gamma dose rates from FC0007 and FC0008, and isotopic analyses for the fuel lots used to fabricate the fuel pellets, were provided to the program office.

Cold-pressed urania pellet no. 22 was encapsulated, helium leak checked, weighed, dimensioned, and ultrasonic tested. HIPing of the capsule was expected to be complete by the first week of March.

VII. 1-KW SHIPPING CONTAINER

A. Container Opening Facility

Soft-jaws for the headstock and tailstock on a lathe for opening the 1-kW container were fabricated. A rail and trolley system for the hood used for opening the container was also fabricated, and design work on modifications to the hood door was completed. A request for installation of the rail and trolley system was submitted to the facility management group.

Tests on opening simulated 1-kW containers continued throughout the month.

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.

VIII. PROGRAMMATIC MEETINGS AND VISITORS

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

On 1 February, two LANL staff members attended a meeting of the GPHS Welding/UT Working Group in Atlanta, Georgia.

Two DOE employees from the Office of Nuclear Safety toured the $^{238}\text{PuO}_2$ processing area during the first week of February.

A 60-watt heat source program meeting was held at LANL on 8 February. Personnel from Westinghouse, Lamb associates, DOE/NE-53, and Teledyne Brown Engineering attended the meeting.

On 16 February, a Quality Assurance representative from MMES/Y-12 observed the unpacking, inspection, and storage of iridium components.

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