RECEIVED

NOV 10 1994

OSTI

Monthly Progress Report

Heat Source Technology Programs

June 1994

Los Alamos
NATIONAL LABORATORY

*Los Alamos National Laboratory is operated by the University of California
for the United States Department of Energy under contract W-7405-ENG-36.*

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

*This work was supported by the U.S. Department of Energy,
Office of Nuclear Energy, Radioisotope Power Systems Division.*

*The four most recent reports in this series, unclassified,
are LA-12817-PR, LA-12828-PR, LA-12840-PR, and LA-12849-PR.*

An Affirmative Action/Equal Opportunity Employer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither The Regents of the University of California, the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by The Regents of the University of California, the United States Government, or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of The Regents of the University of California, the United States Government, or any agency thereof.

LA-12873-PR
Progress Report

UC-500
Issued: October 1994

*Monthly Progress Report
Heat Source Technology Programs*

June 1994

*Compiled by
T. G. George*

Los Alamos
NATIONAL LABORATORY

Los Alamos, New Mexico 87545

MASTER

zb

MONTHLY PROGRESS REPORT

HEAT SOURCE TECHNOLOGY PROGRAMS

JUNE 1994

CONTENTS

ABSTRACT	1
I. HEAT SOURCE AND FEED POWDER SHIPMENTS	1
II. IRIIDIUM HARDWARE SHIPMENTS AND INVENTORY	1
III. FACILITIES	1
A. General	1
B. Launcher Relocation	2
1. Construction Activities	2
2. Design Activities	2
3. Procurements	2
4. Administrative Activities	2
IV. GENERAL-PURPOSE HEAT SOURCE (GPHS) PROGRAM	3
A. Preproduction Activities	3
1. GPHS Fuel Powder, Pellet, and Fueled-Clad Specifications	3
2. Fueled-Clad Weld Development	3
3. Fueled-Clad Ultrasonic Test (UT) Development	3
4. Cold Process Verification (CPV) Tests	3
B. Cassini Fueled-Clad Production	5
C. Safety Test Program	6
D. Research and Development	6
1. High-Silicon Fuel Study.....	6
2. High-Temperature Mechanical Properties of Hafnia Fuel Simulant	6
3. High-Temperature Mechanical Properties of Graphite	6
E. Project Management	6
V. LIGHT-WEIGHT RADIOISOTOPE HEATER UNIT (LWRHU) PROGRAM... 7	7
A. LWRHU Weld Development	7
B. LWRHU Production	7
C. LWRHU Safety Testing	7
VI. 60-WATT HEAT SOURCE PROGRAM	7
A. Preproduction Activities.....	7
B. Technical Support.....	7
VII. 1-kW SHIPPING CONTAINER	7
A. Container Opening Facility	7
B. Container Welding Facility	8
VIII. PROGRAMMATIC MEETINGS AND VISITORS.....	8

MONTHLY PROGRESS REPORT

HEAT SOURCE TECHNOLOGY PROGRAMS

JUNE 1994

Compiled by

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

Throughout June, an operational "stand-down" of the TA-55 Plutonium Facility (building PF-4) prevented the receipt of fuel shipments.

II. IRIIDIUM HARDWARE SHIPMENTS AND INVENTORY

On 9 June, LANL personnel unpacked, inspected, and stored iridium components received in shipment 10526. The LANL inventory of GPHS hardware, as of 30 June, is shown in Table I.

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 June, it appeared that normal operations would resume by 5 July.

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	273
PICS	Restricted Use	72
Type II Weld Shields	Prime	348

*PICS = post-impact containment shell

B. Launcher Relocation

Work continued in June 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

Electricians continued to install electrical outlets and lighting fixtures in the launcher addition throughout the month. Fabrication of duct expansion sections, the housing for an exhaust filter, and centrifugal fans also continued throughout the month.

At the beginning of the month, work was initiated to install plumbing services in the launcher room, the propulsion gas intensifier, and a chilled water system for the launcher. Sheet-metal workers also began work on fabricating a cage around the dumbwaiter passageway.

2. Design Activities

Work continued on the layout of the supervisory control system (SCS) that will be used to control launcher operations.

3. Procurements

Chilled water control valves, a roughing pump for the vacuum system, and miscellaneous plumbing hardware were ordered at the beginning of the month.

4. Administrative Activities

Work continued throughout the month on the development of Safe Operating Procedures (SOPs).

On 2 June, NMT-9 management formally requested that the NMT Division Director charter a team to perform a Level 2 START review of the launcher addition. On 15 June, NMT-9 personnel met with facility management to identify members of the review team. The first meeting of the START review team was held on 23 June.

IV. GENERAL-PURPOSE HEAT SOURCE (GPHS) PROGRAM

A. Preproduction Activities

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

A final draft of the "GPHS 238-Plutonium Dioxide Fueled Clad Specification" (LANL drawing no. 26Y-318182A) was distributed for review on 23 June.

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 9 June, a LANL team was formed to investigate the use of radiography to inspect welds rejected by the UT evaluation technique.

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." However, because sieving of the fuel simulant is performed in another facility, we were able to complete this activity. The results of a sieve analysis of the simulant retained in capsule SC0020 are presented in Table II. Because only a small amount of material was released from capsule SC0020 (0.103 g), it was not submitted for sieve analysis.

Table II. Sieve Analysis of Simulant Retained in SC0020

Particle Size (μm)	Weight Fraction*
+5600 to 1000	0.3850
+2000 to 5600	0.2439
+ 850 to 2000	0.2669
+ 425 to 850	0.0366
+ 180 to 425	0.0357
+ 125 to 180	0.0065
+ 75 to 125	0.0071
+ 45 to 75	0.0055
≤ 45	<u>0.0128</u>
Total:	1.0000

* Weight fractions are calculated on the basis of the simulant retained in capsule SC0020 (146.7213 g).

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." However, sieving of the fuel simulant is performed in another facility, and we were able to make some progress on this activity.

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." However, sieving of the fuel simulant is performed in another facility, and we were able to make some progress on this activity.

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." However, sieving of the fuel simulant is performed in another facility, and we were able to make some progress on this activity.

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. All additional work on fueled-clad production was suspended on 15 April, as a result of the facility "stand-down."

C. Safety Test Program

In this month, we developed a schedule for the rocket-sled tests that will be conducted at Sandia National Laboratory (SNLA) and for design, fabrication, and delivery of components that will be used in these tests.

After a careful review of the hardware designs used for the Galileo/Ulysses Safety Verification Test (SVT) series, we made a decision to use these designs with minimal modification. By the end of the month, fabrication of stands to support the furnaces used in the end-on and side-on impact tests had been initiated, work was proceeding on a number of rocket-sled design concepts, and an inventory of graphite components at LANL was underway.

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).

2. High-Temperature Mechanical Properties of Hafnia Fuel Simulant

We continued to evaluate hafnia as a potential simulant for plutonia. Although previous test results indicated that the hafnia was much stronger than plutonia, a review of the literature revealed that hafnia undergoes a crystallographic transformation from a monoclinic to tetragonal structure at elevated temperature and that repeated cycling through this transformation could significantly reduce the material strength.

In this month, we submitted a hafnia sample for differential thermal analysis (DTA) at temperatures up to 1500°C. No evidence of crystallographic transformations were observed in this experiment. As a result, we believe that the failure of our previous attempt to weaken hafnia by cycling through the monoclinic to tetragonal transformation was a result of not going to a sufficiently high temperature. In the next month, we plan to use the furnace designed for testing graphite tensile specimens to heat treat the hafnia.

3. High-Temperature Mechanical Properties of Graphite

In this month, we concentrated our efforts on building a vacuum system for operating the high-temperature furnace. Previously, we used a single system to operate both this furnace and the furnace used for compression testing. This became a major inconvenience because the vacuum system had to be relocated each time a different furnace was used, and we consequently decided it was necessary to assemble a second vacuum system. Work on this second vacuum system was nearly complete by the end of the month.

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.

C. LWRHU Safety Testing

Two LWRHU capsules containing UO_2 pellets were welded in the second half of the month. Both ends of the capsules were fabricated with "closure-end" caps because "vent-end" caps were not available. Unfortunately, on 22 June EG&G MAT personnel indicated that the use of capsules with two closure-end caps would not be acceptable for LWRHU vibration tests. Additional hardware with suitable end caps was requested from EG&G MAT.

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

Thirteen capsules fueled with cold-pressed urania pellets were shipped to EG&G MAT in the second half of the month.

VII. 1-kW SHIPPING CONTAINER

A. Container Opening Facility

The container opening facility is operational.

B. Container Welding Facility

Work on the design of a system to load the 1-kW shipping container onto an automated weld fixture was completed. Fabrication began on a sliding tray for the glovebox airlock, a cart to transport shipping containers, and lifting yokes to raise the shipping container to the glovebox airlock.

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 completed, the welder was reconfigured to fit in the welding glovebox, and work on weld qualification was initiated.

Design and analysis of the helium leak-check fixture was completed in early June. By the end of the month, fabrication of the fixture was underway.

VIII. PROGRAMMATIC MEETINGS AND VISITORS

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

On 7 June, one LANL staff member attended the 60-watt monthly meeting held at EG&G MAT in Miamisburg, Ohio.

A WSRC weld engineer visited LANL on 21–23 June and worked on LWRHU and 1-kW weld development.

On 30 June, Earl Wahlquist from DOE/NE toured the $^{238}\text{PuO}_2$ processing areas at TA-55.

Three LANL staff members attended the Cassini program quarterly review held on 30 June in Germantown, Maryland.