Monthly Progress Report
Heat Source Technology Programs
June 1996

Los Alamos
NATIONAL LABORATORY

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CONTENTS

ABSTRACT	1
I. HEAT SOURCE AND FEED POWDER SHIPMENTS	1
II. IRIIDIUM HARDWARE SHIPMENTS AND INVENTORY	1
III. FACILITIES	2
A. General	2
B. Launcher Relocation	2
IV. GENERAL-PURPOSE HEAT SOURCE PROGRAM	3
A. Cassini Heat Source Production	3
B. Production Support Activities	3
1. Weld Evaluation Study	3
2. Ultrasonic Test Development	4
3. Evaluation Of Fuel Pellet GF-47	4
C. Safety Test Program	4
1. RTG/Thin-Fragment Test	4
2. Investigation of Urania/Plutonia Simulants	4
D. Research and Development	4
1. High-Silicon Fuel Characterization Study.....	4
2. Cold-Process Verification Tests	5
E. Project Management	5
V. LIGHT-WEIGHT RADIOISOTOPE HEATER UNIT PROGRAM.....	6
A. Production	6
1. Cassini	6
2. Mars Pathfinder	6
B. Safety Test Program	6
VI. 60-WATT HEAT SOURCE	6
VII. 1-kW SHIPPING CONTAINER	6
VIII. PROGRAMMATIC MEETINGS AND VISITORS.....	7

MONTHLY PROGRESS REPORT

HEAT SOURCE TECHNOLOGY PROGRAMS

June 1996

Compiled by

Timothy 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 by Los Alamos National Laboratory. 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

During the month of June, a total of 22 General-Purpose Heat Source (GPHS) capsules were shipped to EG&G Mound Applied Technologies (EG&G MAT) in Miamisburg, Ohio. Shipment of eight additional GPHS capsules was scheduled for the first half of July.

In the second half of June, a fuel shipment in thirty-one 5320 containers was received from the Westinghouse Savannah River Company (WSRC). This shipment contained approximately 4.4 kg of ^{238}Pu .

II. IRIIDIUM HARDWARE SHIPMENTS AND INVENTORY

No shipments of iridium hardware occurred this month. The Los Alamos National Laboratory (LANL) inventory of GPHS hardware, as of 30 June, is shown in Table I.

III. FACILITIES

A. General

The laboratories used for fuel processing, fuel form fabrication, and encapsulation welding were available for routine operations throughout the month. At the beginning of the month, a request was submitted to the Department of Energy/Albuquerque Operations Office for a waiver to permit continued operation of the $^{238}\text{PuO}_2$ processing laboratories during the annual facility shutdown/cleanout inventory scheduled for mid-June. The request was granted, and operations continued throughout the inventory.

Table I. LANL Inventory of GPHS Iridium Hardware as of 30 June 1996

<u>Type of Hardware</u>	<u>Category</u>	<u>Number of Items in Inventory</u>
PICS*	Prime	81
PICS	Restricted Use	27
Type II Weld Shields	Prime	118

*PICS = postimpact containment shell.

B. Launcher Relocation

A contractor operational readiness review (ORR) of the launcher facility began on 22 January. As a result of significant construction/repair issues discovered during acceptance testing, the ORR was suspended in late January. Throughout February, work focused on correcting the deficiencies identified by the ORR team. The contractor ORR team reconvened on 25 March and completed their review on 4 April. Five pre-start and five post-start findings were identified by the review team.

A DOE ORR of the launcher facility began on 30 April and continued until 4 May when the ORR team leader suspended the review pending resolution of all pre-start findings identified in the contractor ORR. The actions necessary to correct these findings were completed by LANL personnel during May, and the DOE ORR team returned to Los Alamos on 3 June.

The DOE ORR was completed on 7 June. Work on the pre-start findings identified by the ORR team was completed by 23 June, and authorization for start-up of the launcher was received from DOE/AL on 25 June. An impact test of a Light-Weight Radioisotope Heater Unit (LWRHU) was conducted in the 7-in. launcher on 28 June.

IV. GENERAL-PURPOSE HEAT SOURCE PROGRAM

A. Cassini Heat Source Production

A total of 21 GPHS fuel pellets were hot-pressed during June. In addition, 24 fuel pellets were encapsulation welded in four weld campaigns. Ultrasonic evaluation of these capsules revealed that 22 met all acceptance criteria. Although the girth welds of the two remaining capsules contained significant ultrasonic reflectors, subsequent ultrasonic analysis revealed that these reflectors were not detrimental features.

A summary of Cassini production to date is presented in Table II.

Table II. Cassini Production as of 30 June 1996

<u>Activity</u>	<u>Number of Units</u>
^{238}Pu Introduced into LANL Process Line (cumulative, kg)^a	35.8
GPHS	
Clads shipped to EG&G MAT	209
Clads welded to date	264
Fuel pellets pressed to date	298
LWRHU	
Capsules shipped to KSC ^b	0
Capsules loaded into aeroshells	180
Capsules welded to date	181
Fuel pellets pressed to date	206

^a From Program Start in January 1994.

^b Kennedy Space Center.

B. Production Support Activities

1. Weld Evaluation Study

Metallographic examination of example welds and weld blowouts continued throughout the month.

2. Ultrasonic Test Development

Work continued to develop advanced ultrasonic test (UT) techniques for accurate identification of weld defects. Ultrasonic scans of defect-containing girth welds were made using the B-scan evaluation technique, and were processed through the ICEPAK artificial intelligence system. All of the ultrasonic scans and ICEPAK data were forwarded to Martin Marietta Energy Systems Y-12 (MMES/Y-12) and WSRC for evaluation.

3. Evaluation of Fuel Pellet GF-47

LANL report number LA-13059, "General-Purpose Heat Source: Research And Development Program. Process Evaluation, Fuel Pellet GF-47," was issued at the beginning of the month. In addition to a hard copy version, the report was made available on the Internet through the LANL Research Library home page.

C. Safety Test Program

1. RTG/Thin-Fragment Test

The objective of the RTG/thin-fragment test was to provide information on the response of GPHS capsules, modules, and a loaded RTG to conditions that might be experienced as a result of potential on- or near-pad accidents resulting from launch vehicle failure.

A RTG/thin-fragment test was conducted at the Sandia National Laboratories Albuquerque rocket sled track on 26 March. In this test, a thin-fragment was accelerated down the track where it impacted a simulated RTG section that contained GPHS modules loaded with simulant-fueled (UO_2 - ^{235}U depleted) GPHS capsules. The impact velocity was measured at 306 m/s, and the temperature of the module stack within the RTG was 1090°C.

Previous monthly reports have documented the post-test examination of the impacted converter section and simulant-fueled capsules. During June, metallographic preparation and analysis of samples removed from capsule SC0126 continued. Capsule SC0126 was the only capsule that breached in the test.

2. Investigation Of Urania/Plutonia Simulants

Postmortem analysis of the HfO_2 -fueled capsule (SC0131) impacted on 17 May, at 974°C and 56.1 m/s, continued. Preliminary observations indicate that the hafnia simulant was much softer than either plutonia or urania.

D. Research and Development

1. High-Silicon Fuel Characterization Study

The purpose of the high-silicon fuel characterization (HSC) study was to determine the effect of fuel impurities on the response of the GPHS to conditions baselined during the Galileo/Ulysses test program. Four fuel pellets fabricated and encapsulated at LANL in 1993 and 1994 were selected for use in the first two half-module impact tests in this test series.

The two pellets selected for the first test, HSC-1, were fabricated from low-enrichment (<82% ^{238}Pu) fuel and contained relatively high concentrations of silicon (905 ppm and

1059 ppm). The GPHS capsules containing these pellets were loaded into a graphite impact shell (GIS), which was designated GIS A. GIS A was then paired with another GIS (designated GIS B) and was loaded into a GPHS module.

The two pellets selected for the second HSC test had calculated silicon contents of 415 ppm and 605 ppm. The GPHS capsules containing these pellets were loaded into a GIS (designated GIS D), paired with another GIS (designated GIS C), and then loaded into a GPHS module for heat treatment.

Both GPHS modules were treated in a module reduction and monitoring facility (MRMF) vacuum system. During the MRMF treatment, each module was placed in a vacuum chamber which was evacuated and then backfilled with argon. Each module was maintained at a constant temperature during the MRMF treatment. The module containing GIS A stabilized at 920°C. The module containing GIS D stabilized at 862°C. In each case the MRMF treatment continued until a fuel stoichiometry of approximately 1.98 O/Pu was achieved.

After MRMF treatment, each module was soaked at 1074°C (module surface temperature) in a vacuum for an extended time period; this treatment temperature was calculated to give a fuel temperature of 1461°C. After the aging treatment, the modules were removed from the aging furnaces and GIS A and GIS D were loaded into half GPHS modules for impact testing. Both impact tests (HSC-1 and HSC-2) were performed in mid-1995; the results of these tests have been presented in previous monthly reports.

The remaining two GISs (GIS B and GIS C) were reinserted in the aging furnace and heat treatment continued at 1074°C. GIS B was removed from the aging furnace during the first week of November, after a total of 235 days at temperature. The GIS was then placed in a helium-atmosphere glovebox for storage. GIS C was removed from the furnace in early 1996 (8 January), after a total of 262 days at temperature. After removal from the aging furnace, GIS C was placed in storage with GIS B. The fuel capsules in GIS B had silicon contents of 1127 and 776 ppm; the GIS C capsules had silicon contents of 336 ppm and 325 ppm.

2. Cold-Process Verification Tests

Publication of a report documenting the results of the cold-process verification (CPV) test series was expected by early July

E. Project Management

OSC provided project management updates using the Primavera software. A status report for the Cassini program was submitted to OSC on schedule.

Work continued throughout the month to develop cost and schedule numbers for four scenarios of a Pluto mission. These estimates were expected to be submitted to OSC, in the form of Primavera files, in early July.

V. LIGHT-WEIGHT RADIOISOTOPE HEATER UNIT PROGRAM

A. Production

1. Cassini

A total of 180 LWRHU capsules were previously loaded into aeroshells, welded into product cans, and transferred to the PF-4 vault for storage. By the end of June, a final schedule for shipment of the product cans to Kennedy Space Center (KSC) had not been established.

2. Mars Pathfinder

Three LWRHUs designated for the Mars Pathfinder mission were previously packaged into a product container and transferred to the PF-4 vault. They were scheduled for shipment to KSC in early September.

B. Safety Test Program

On 28 June, an LWRHU heat source was impacted against a steel target plate at 53.5 m/s. The test was conducted at ambient temperature in the 7-in. launcher. Postmortem examination of the impacted heat source was expected to begin in the first week of July.

VI. 60-WATT HEAT SOURCE

Heat source 16-040 (containing capsule FC0029) was placed in an aging furnace under vacuum at 650°C on 14 December and reached thermal equilibrium on 15 December. As of 30 June, the scheduled date for termination of the aging treatment was 9 July 1996.

Heat source 16-041 (containing capsule FC0017) was placed in an aging furnace under vacuum at 830°C on 14 December and reached thermal equilibrium on 15 December. The aging treatment was terminated in early March after a total of 71 days at 830°C. Defueling and examination of the unit began on 17 April. Initial observation and measurement indicated that the shield cup of the capsule had bulged. There were also indications of anomalous oxidation on several of the molybdenum components removed from the aging furnace.

Capsule FC0017 was defueled in May. The initial results of the postmortem examination have been documented in a previous report. In June we conducted a flow test of the capsule vent, inspected the clad interior, and obtained samples of the fuel pellet for chemical analysis. The results of the flow test indicated that the capsule vent had not been completely opened. Inspection of the interior of the weld-shield cup revealed a number of small cracks that apparently provided a pathway for pressure release, albeit after the internal pressure had caused modest clad deformation.

VII. 1-kW SHIPPING CONTAINER

The LANL inventory of 1-kW hardware, as of 30 June, is shown in Table III.

Table III. LANL Inventory of 1-kW Hardware as of 30 June 1996

<u>Type of Hardware</u>	<u>Number of Items</u>
Primary containers	8
Primary lids	8
Secondary containers	2
Secondary lids	2
Product cans	31

VIII. PROGRAMMATIC MEETINGS AND VISITORS

A DOE team was present on-site for four days beginning 3 June to complete the ORR of the launcher facility.

Representatives of the LANL technical staff attended the 60-Watt and Cassini status meetings held at OSC on 10 and 11 June.

Westinghouse Advanced Technology Business Area personnel were on-site throughout the month to observe Cassini production operations.

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It is available to the public from the National Technical Information Service, US Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22616.