

Monthly Progress Report
Heat Source Technology Programs
September 1996

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MONTHLY PROGRESS REPORT

HEAT SOURCE TECHNOLOGY PROGRAMS

SEPTEMBER 1996

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

In mid-September, one General-Purpose Heat Source (GPHS) capsule was shipped to EG&G Mound Applied Technologies (EG&G MAT), in Miamisburg, Ohio. The shipment of this heat source completed the requirements for loading the three Cassini radioisotope thermoelectric generators (RTGs), and for a minimum number of spare capsules.

A shipment of 4.3 kg of ^{238}Pu was received from WSRC at the end of the month. Calorimetry of the shipment began immediately.

II. IRIIDIUM HARDWARE SHIPMENTS AND INVENTORY

No shipments of iridium hardware occurred this month. The LANL inventory of GPHS hardware, as of 30 September, is shown in Table I.

III. FACILITIES

The laboratories used for fuel processing, fuel form fabrication, and encapsulation welding were available for routine operations throughout September. Work continued to close out findings resulting from the DOE operational readiness review (ORR) of the 7-in. launcher. At the end of the month, a response to the final DOE/AL ORR report, which included a current status of all findings and estimated completion dates for open items, was forwarded to DOE/AL.

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

<u>Type of Hardware</u>	<u>Category</u>	<u>Number of Items in Inventory</u>
PICS*	Prime	76
PICS	Restricted Use	25
Type II weld shields	Prime	111

*PICS = postimpact containment shell.

IV. GENERAL-PURPOSE HEAT SOURCE (GPHS) PROGRAM

A. Cassini Heat Source Production

Although no additional fuel lots were processed during September, three GPHS pellets were hot-pressed. Seven GPHS fuel pellets were encapsulation welded on 25 September. Ultrasonic evaluation of the capsules revealed that six met the ultrasonic acceptance criteria. The weld on the remaining capsule contained a significant ultrasonic reflector, and the capsule was submitted for radiographic evaluation.

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

B. Production Support Activities: Weld Evaluation Study

Metallographic examination of example welds and unacceptable production welds continued throughout the month.

Table II. Cassini Production as of 30 September 1996

<u>Activity</u>	<u>Number of Units</u>
^{238}Pu Introduced into LANL Process Line (cumulative, kg)^a	38.6
GPHS	
Clads shipped to EG&G MAT ^b	235
Clads welded to date	284
Fuel pellets pressed to date	315
LWRHU	
Capsules shipped to KSC ^c	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 EG&G Mound Applied Technologies.

^c Kennedy Space Center.

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.

An RTG/thin-fragment test was conducted at the Sandia National Laboratories, Albuquerque (SNLA) 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.

The post-test examination and analyses of the impacted converter section and simulant-fueled capsules were documented in previous monthly reports. During September, work focused on documenting the entire RTG/thin-fragment test series in a formal topical

report. By the end of the month, an initial draft of the report had been completed and submitted to DOE/NE50 for comment.

2. Production Qualification Test Program

The purpose of the production qualification test program was to determine whether heat sources fabricated at LANL had impact properties equivalent to those of heat sources fabricated at Savannah River and evaluated during the Galileo/Ulysses test program. Four GPHS capsules fabricated at LANL in 1994 were selected for use in the first production qualification test (PQ-1).

In the PQ-1 test, a GPHS module loaded with capsules FC0018, FC0022, FC0031, and FC0038 was aged for 200 hours at a temperature of 1287°C (clad surface). The module was then thermally treated to simulate a "min. gamma" atmospheric re-entry. In an impact test conducted on 12 July, the module was launched against a steel target at 54 m/s and 919°C.

Postimpact evaluation did not reveal any evidence of a fuel release. The impacted module was relatively intact, and capsule deformations were relatively modest. The capsule strains and preliminary posttest observations have been documented in previous monthly reports.

In early August, capsules FC0018 and FC0022 were defueled. Noncontiguous areas of a thin white deposit were observed on the exterior surfaces of both fuel pellets. Similar deposits and some adjacent discoloration were observed on the clad interiors and on the weld-shields. Small sections for microprobe and SEM analyses were removed from both weld-shields. By the end of September these samples had been packaged and transported to the analytical facility at LANL's Chemistry and Materials Research (CMR) building.

D. Research and Development

1. High-Silicon Fuel Characterization (HSC) Study

The purpose of the high-silicon fuel study was to determine the effect of fuel impurities on the response of the GPHS to conditions that were 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% ²³⁹Pu) fuel and contained relatively high concentrations of silicon (905 and 1059 ppm). The GPHS capsules containing these pellets were loaded into a graphite impact shell (GIS), which was designated GIS A. This GIS 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 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 GPHS half-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 1995, 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 on 8 January 1996, 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 and 325 ppm.

2. Aqueous Processing

Dissolution and precipitation operations continued through the first half of September.

E. Project Management

Primavera updates were received from Orbital Sciences Corporation (OSC) at the beginning of September. A status report for the Cassini program was submitted to OSC on schedule.

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

A. Cassini Heat Source Production

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 September, a

final schedule for shipment of the product cans to Kennedy Space Center (KSC) had not been established.

B. Mars Pathfinder Heat Source Production

Three LWRHUs designated for the Mars Pathfinder mission were shipped to KSC in August. This shipment fulfilled the LANL commitment for the Pathfinder mission.

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. The heat source was removed from the aging furnace on 9 July, and was submitted for radiographic examination. On 26 July the heat source was returned to the furnace for an additional six months of heat treatment at 650°C.

VII. 1-kW SHIPPING CONTAINER

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

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

<u>Type of Hardware</u>	<u>Number of Items</u>
Primary containers	6
Primary lids	6
Secondary containers	3
Secondary lids	3
Product cans	31

VIII. PROGRAMMATIC MEETINGS AND VISITORS

LANL personnel supported the Cassini program monthly status meeting held at OSC, Germantown, Maryland, on 18 September 1996.