

Monthly Progress Report
Heat Source Technology Programs

October 1995

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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
1. Construction Activities	2
2. Administrative Activities	2
IV. GENERAL-PURPOSE HEAT SOURCE (GPHS) PROGRAM	2
A. Cassini Heat Source Production	2
B. Production Support Activities.....	3
C. Safety Test Program	3
1. End-On RTG Impact Tests.....	3
2. RTG/Thin Fragment Test	4
D. Research and Development	4
1. Cold Process Verification (CPV) Tests: CPV-12.....	4
2. High-Silicon Fuel Characterization (HSC) Study.....	4
E. Project Management	6
V. LIGHT-WEIGHT RADIOISOTOPE HEATER UNIT (LWRHU) PROGRAM... 6	
VI. 1-kW SHIPPING CONTAINER	7
VII. PROGRAMMATIC MEETINGS AND VISITORS.....	7

MONTHLY PROGRESS REPORT
HEAT SOURCE TECHNOLOGY PROGRAMS
OCTOBER 1995

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

A feed powder shipment was received from the Westinghouse Savannah River Company (WSRC) at the beginning of the month. This shipment, designated as shipment 493, consisted of 20 EP61 containers.

Two shipments of General-Purpose Heat Source (GPHS) capsules to EG&G Mound Applied Technologies (EG&G MAT) were scheduled.

II. IRIIDIUM HARDWARE SHIPMENTS AND INVENTORY

One shipment of 10 flight-quality clad/vent-sets with enlarged shield-cup vent slots, and 11 weld-shields, was received during October. The LANL inventory of GPHS hardware, as of 31 October, is shown in Table I.

Table I. LANL Inventory of GPHS Iridium Hardware as of 31 October 1995

<u>Type of Hardware</u>	<u>Category</u>	<u>Number of Items in Inventory</u>
PICS*	Prime	195
PICS	Restricted Use	39
Type II Weld Shields	Prime	275

*PICS = postimpact containment shell.

III. FACILITIES

A. General

Required maintenance to electrical breakers in the ^{238}Pu -operations areas caused intermittent power outages throughout October. These outages significantly affected calorimetry and fuel processing. However, by the end of the month, all required breaker maintenance had been completed.

Radiological control technician (RCT) coverage for $^{238}\text{PuO}_2$ activities at TA-55 was consistent, and did not impede heat source production activities.

B. Launcher Relocation

1. Construction Activities

All major construction activities were completed by 1 October. By the end of October, thickness testing of the launcher addition walls was approximately 90% complete. All connections to the supervisory control system (SCS) were installed. Evacuation horns were also installed in the launcher, and the fire alarm was tested.

2. Administrative Activities

Work on the document control system was completed, and a quality assurance review of the system was initiated in mid-October. An internal self-assessment of the 7-in. launcher was scheduled for early November.

IV. GENERAL-PURPOSE HEAT SOURCE (GPHS) PROGRAM

A. Cassini Heat Source Production

Fuel processing was impacted throughout October by intermittent power outages. At the end of the month, fuel processing was suspended pending completion and approval of a

sampling plan to evaluate the extent and severity of fuel impurities. A summary of Cassini production to date is presented in Table II.

Table II. Cassini Production as of 31 October 1995

Activity	Number of Units
^{238}Pu Introduced into LANL Process Line (cumulative, kg)^a	26.7
GPHS	
Clads shipped to EG&G MAT ^b	109
Clads welded to date	152
Fuel pellets pressed to date	209
LWRHU	
Capsules shipped to KSC ^c	0
Capsules loaded into aeroshells	84
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.

B. Production Support Activities

The ICEPAK artificial-intelligence software for interpretation of UT data was used to evaluate several GPHS capsule welds.

C. Safety Test Program

1. End-On RTG Impact Tests

a. End-On RTG Impact Test 1 (RTG-1). On 13 April, the converter section used for RTG-1 was impacted against a block of Kennedy Space Center (KSC) concrete at 57.6 m/s and 1071°C. There was no release of urania. The test components were packaged at Sandia National Laboratories, Albuquerque (SNLA) and then shipped to LANL on 21 April. Initial examination of the impacted capsules did not reveal any clad failures. Capsule strains were reported in previous reports.

In September, postmortem examination of the test components continued. Capsule SC0076, which had been located at the blind end of the graphite impact shell (GIS) in the

"A" GIS cavity, and experienced more deformation than any of the other RTG-1 capsules, was selected for particle size analysis. In October, we completed a particle size analysis of the SC0076 fuel simulant; the results are presented in Table III.

b. End-On RTG Impact Test 2 (RTG-2). On 24 May, the converter section used for RTG-2 was impacted against a 3 ft X 4 ft X 1.5 ft block of KSC concrete at 77.1 m/s and 1090°C. Posttest observations at the test site revealed considerable damage to the converter. The converter end cap had been removed and several of the end bolts embedded into the impact face of the concrete block. Four modules were ejected from the converter, and four GPHS capsules (SC0091, SC0092, SC0096, SC0107) were released. The vent end of one capsule (SC0092) was severely damaged; approximately one quarter of the vent cup had been removed and the uranium pellet was clearly visible.

Macroscopic examination of the impacted capsules verified that three of the four capsules released from their graphite impact shells (GISs) had breached. Additional observations, as well as the capsule strains, were reported in previous monthly reports.

In October, we completed particle size analyses of the fuel simulant removed from capsules SC0096 and SC0107; the results of these analyses are presented in Table III.

2. 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 engineering test in which an aluminum cylinder impacted an aluminum sheet was performed at Sandia National Laboratories (SNL) on 5 October. Preliminary observations indicated that the RTG-simulant was completely severed by the fragment, as predicted by a LANL hydrocode.

In mid-October, work began on a second engineering test in which the positions of the aluminum sheet and cylinder would be reversed, with the sheet accelerated into a stationary cylinder. The LANL/SNL team prepared a proposal for the test, and submitted it to DOE at the end of the month.

D. Research and Development

1. Cold Process Verification (CPV) Tests: CPV-12

Postmortem examination of components tested in CPV-12 were completed in September.

2. 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 heat source 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% ²³⁸Pu) fuel and contained relatively high concentrations of silicon (>1000 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) furnace system. During the MRMF treatment each module was placed in a vacuum furnace 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, and 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.

Table III. Particle Size Analyses of Simulant-Fueled Capsules

<u>Particle Size (µm)</u>	<u>Weight Fraction Of Recovered Fuel Simulant</u>		
	<u>SC0076</u>	<u>SC0096</u>	<u>SC0107</u>
+ 5600	0.4929	0.5296	0.8111
+ 2000 to 5600	0.3074	0.3215	0.1435
+ 850 to 2000	0.1256	0.1033	0.0318
+ 425 to 850	0.0408	0.0257	0.0077
+ 180 to 425	0.0196	0.0122	0.0033
+ 125 to 180	0.0036	0.0027	0.0004
+ 75 to 125	0.0037	0.0016	0.0004
+ 45 to 75	0.0023	0.0012	0.0008
+ 30 to 45	0.0007	0.0006	0.0002
+ 20 to 30	0.0010	0.0004	0.0002
+ 10 to 20	0.0016	0.0005	0.0003
+ 9 to 10	0.0001	0.0000	0.0000
+ 8 to 9	0.0001	0.0000	0.0000
+ 7 to 8	0.0001	0.0000	0.0000
+ 6 to 7	0.0001	0.0000	0.0000
+ 5 to 6	0.0001	0.0001	0.0000
+ 4 to 5	0.0001	0.0001	0.0001
+ 3 to 4	0.0002	0.0003	0.0002
+ 2 to 3	0.0000	0.0001	0.0000
+ 1 to 2	0.0000	0.0001	0.0000
+ 0 to 1	0.0000	0.0000	0.0000
 Total ≤10 µm:	 0.0008	 0.0007	 0.0003

After MRMF treatment, each module was soaked at 1074°C 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 continued heat treatment at 1074°C, to give a total aging treatment of 270 days. GIS B was scheduled for removal from the aging furnace on 1 November 1995. GIS C was scheduled to be removed from the furnace on 3 January 1996.

E. Project Management

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

Safe operating procedure SHS-NMT9-PP-11-R03, "Helium Leak Check of GPHS Fueled Clads," was revised according to comments received from Cassini program participants. Signed document review requests and completed change request forms were forwarded to EG&G MAT.

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

By 31 October, a total of 181 LWRHU capsules had been welded. Eighty-four heat sources had been loaded into aeroshells and 97 capsules were either awaiting or finished with NDT/characterization.

Table IV. LANL Inventory of 1-kW Hardware as of 31 October 1995

<u>Type of Hardware</u>	<u>Number of Items</u>
Support blocks	11
Support cups	132
Product can spacers	24
Graphite filler blocks	9
Primary containers	18
Primary lids	18
Secondary containers	10
Secondary lids	10
Product cans	64

VI. 1-kW SHIPPING CONTAINER

The LANL inventory of 1-kW hardware, as of 31 October, is shown in Table IV.

VII. PROGRAMMATIC MEETINGS AND VISITORS

DOE and WATBA personnel were on-site throughout the month for quality assurance meetings and routine surveillance.