LA-9980-PR

Progress Report

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Space Nuclear Safety Program

August 1983

MASTER

Los Alamos

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This work was supported by the US Department of Energy, Office of Special Nuclear Projects.

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**LA-9980-PR
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**UC-33a
Issued: January 1984**

Space Nuclear Safety Program

August 1983

Compiled by
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SPACE NUCLEAR SAFETY PROGRAM

August 1983

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ABSTRACT

This technical monthly report covers studies related to the use of $^{238}\text{PuO}_2$ in radioisotope power systems carried out for the Office of Special Nuclear Projects of the US Department of Energy by Los Alamos National Laboratory. Most of the studies discussed here are ongoing. Results and conclusions described may change as the work continues.

I. GENERAL-PURPOSE HEAT SOURCE

A. Nominal Impact Test (D. Pavone)

The scheduled 38-day, 1287°C aging of the impact assembly (pellets HF-438 and HF-450) was completed and it was subjected to the standard orbital-decay reentry heating simulation. Radiography results showed that pellet HF-438 was cracked diagonally after the heat treatment; reentry heating did not degrade it further. Pellet HF-450 was intact after reentry heating. The partial module will be assembled and impacted at 54 mps and 975°C.

B. Safety Verification Tests

1. SVT-3 (D. Pavone). The third sample in the Safety Verification impact series (SVT-3) is being held at 1287°C for 2160 h to simulate the failure of the Centaur Rocket to fire during the Galileo mission. After aging, the sample will be exposed to a simulation of reentry heating and impacted.

On September 1, 1983, the total aging time reached 1120 h. During this time, the helium release rate dropped to 75% of the helium generation rate nine times, indicating that one of the vents was plugged. The vent plugging history is given in Table I.

The frequency of plugging increased with time of exposure, but the duration decreased as the aging progressed. There have been no plugging incidents since 689 h.

2. SVT-4 (D. Pavone). The fourth sample in the Safety Verification impact series (SVT-4) was shipped to Los Alamos as a complete module. The impact assemblies were removed, radiographed, and put in the aging furnace. No abnormalities were visible in the aeroshell or the impact shells; as expected, the radiographs showed all fuel pellets to be broken. This sample will be aged at

TABLE I. Vent Plugging in SVT-3

Elapsed Exposure Time (h)	Duration of Plugging (h)
144	40
277	60
273	44
543	14
623	18
637	9
644	1.5
684	2.3
689	0.7

1287°C for 2160 h. On September 1, 1983, the aging time reached 337 h with no instances of vent plugging.

3. Fragment Impact (R. Tate). Initial calibration tests for the rocket-sled-driven, large-fragment impacts have been completed. They showed that the desired test velocity, 914 mps (3000 fps), could be reached and the fragment could be released from the sled on time and in the correct position. The catch tube did not retain all the fragments of the dummy modules used in the calibration runs; some of the fragments apparently never entered the catch tube. After the test films are examined, the catch tube will be redesigned.

II. LIGHT-WEIGHT RADIOISOTOPE HEATER UNIT (LWRHU)

A. Seawater Exposures (C. Land and J. Patterson)

Two LWRHUs were exposed to seawater as part of the safety verification testing program at Los Alamos. One, examined this month, was held at ambient pressure and the other was held at the pressure of the deep ocean (10 000 psi).

LWRHU RHU-10-15 was immersed in aerated, circulating artificial seawater at 10°C for 640 days. During the immersion, the water was sampled weekly and analyzed for plutonium. The plutonium contents were <0.2 ng/l (the absolute detection limit) during the first 6 weeks, but then rose to 0.3 to 1.6 ng/l for most of the remaining exposure time. The measured concentrations varied periodically. The last three measurements were 2.0, 2.0, and 2.5 ng/l. Three days after the LWRHU was removed, the concentration was still 2.3 ng/l, or 92 ng in the 40-l volume of the aquarium.

The closure end of the recovered LWRHU is shown in Fig. 1. Sea salt is visible around the joint where the water initially retained in the graphite shell evaporated. There was no evidence that any graphite component was affected by the exposure.

The graphite was removed from the LWRHU and burned and the ash was analyzed for plutonium. Radiochemical analysis showed 31.8 µg total plutonium, over 300 times the amount left in the water.

The fuel capsule was cut open along a circumferential path one-third of the way from the vent and the smaller piece was removed to expose the fuel pellet (Fig. 2). The salt deposit on the end of the pellet proves that seawater had been in the capsule during the test.

Fig. 1. Except for the dried salt deposit, the RHU-10-15 aeroshell appeared unaffected by the ambient pressure seawater exposure (2X).

The fuel pellet was subjected to a size analysis (Table II). As expected, it was broken, as are most pellets after the capsules are welded. Most of the fuel was in large pieces; 98% did not pass through the 421-µm sieve. A sample of the fuel pellet was prepared ceramographically and examined. The pellet structure was uniform (Fig. 3) and showed neither evidence of reaction with the seawater nor deposits in the pores (Fig. 4).

The capsule pieces, Fig. 5, were sectioned longitudinally and prepared metallographically. There was no evidence of a reaction between the seawater and the capsule. All four weld sections were completely fused.

Fig. 2. Salt on the RHU-10-15 fuel pellet proves that seawater entered the capsule during the ambient-pressure test (2X).

TABLE II. Particle Size Distribution of Fuel from RHU-10-15 After 640-Day Seawater Exposure

Particle Size (μm)	Weight Fraction
+2000	0.4476
+841	0.2525
+421	0.0941
+177	0.0861
+125	0.0173
+74	0.0245
+45	0.0143
+30	0.0117
+20	0.0110
+10	0.0222
-10	0.0189

Fig. 3. Fuel from RHU-10-15 was apparently unaffected by seawater exposure (10X).

B. Specification (R. Tate)

Our review of the Interagency Specification for the LWRHU prepared by the Jet Propulsion Laboratory (JPL) showed several areas that require clarification. We will study additional documents that were referenced in the Specification as part of this review.

C. Test Objects (R. Tate)

Two dummy LWRHUs were fabricated from the standard composite graphite and sent to JPL. The models, made to the Flight Specification dimensions, will be used by JPL to check the sizes of the LWRHU holders on the Galileo Orbiter and Probe.

Fig. 4. There was no evidence of reaction between the fuel and the seawater in which it was immersed (250X).

(a)

(b)

Fig. 5. The capsule from RHU-10-15 was unaffected by exposure to ambient-pressure seawater (~8X): (a) vent-end; (b) closure end.

III. HELIUM RELEASE (P. Kleinschmidt)

Results of the first two runs of the minicomputer-controlled automated data acquisition system for use in the helium release program are shown in Figs. 6 and 7. The release rate and temperature are shown as functions of time for a 2.77-g and a 0.215-g sample of $^{238}\text{PuO}_2$. The release rate curve for each sample displayed peaks at 200 s (1115°C) and 300 s (1445°C) for the larger sample, and at 240 s (1200°C) and 360 s (1450°C) for the smaller sample.

ERRATA

The amount of plutonium found in the ECT-2 impact shell was 32 μg , not 32 g as reported in the May report (S. Bronisz, Comp., "Space Nuclear Safety Program, May 1983," Los Alamos National Laboratory report LA-9918-PR, p. 3).

The vent hole in PEF-44 was free of deposits, not full of deposits as reported in the April report (S. Bronisz, Comp., "Space Nuclear Safety Program, April 1983," Los Alamos National Laboratory report LA-9906-PR, p. 1).

The intended impact velocity of the 5-W heat source is 13 mps, not 18 mps as reported in the July report (S. Bronisz, Comp., "Space Nuclear Safety Program, July 1983," Los Alamos National Laboratory report LA-9939-PR, p. 2).

Date = 8-16-83 Time = 10:30:13 17661-10A 2.77gm PLUTONIA

Fig. 6. Helium release rate from a 2.77-g $^{238}\text{PuO}_2$ sample peaked at 200 and 300 s.

Date = 8-19-83 Time = 15:1:44 17662-10B 0.215gm PLUTONIA

Fig. 7. Helium release rate from a 0.215-g $^{238}\text{PuO}_2$ sample peaked at 240 and 360 s.

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