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Space Nuclear Safety Program

July 1983

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SPACE NUCLEAR SAFETY PROGRAM

July 1983

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S. E. Bronisz

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)

An impact test of a partial General-Purpose Heat Source (GPHS) module will be conducted to determine its response to the nominal calculated environment of an orbital decay impact. We applied two safety factors to the impact conditions in the development tests to ensure that conservative environments were used. The material removed from the aeroshell surfaces to simulate reentry ablation was twice the amount calculated and the impact velocity was 110% of the calculated terminal velocity at sea level. In the nominal test, we will remove only the calculated amount of graphite and we will use an impact velocity equal to that calculated for a 1524-m altitude.

The impact assembly for the nominal test consists of fueled clads 438 and 450 and impact shell 099. It was heated to 1287°C on July 1, 1983, and will be held there for 38 days, after which it will be radiographed, loaded into a partial aeroshell, and impacted.

B. Safety Verification Tests (D. Pavone)

Two impact assemblies (PGL-020 and PGL-027) were radiographed and the 90-day, 1287°C vacuum heat

treatment was started. After aging, these impact assemblies will be put into an aeroshell to make module SVT-3, which will be impacted as the first orbital decay test in the safety verification series. On August 1, 1983, the total exposure time was 276 h.

The helium released from these assemblies is being monitored continuously. Eighty-two hours after the aging started, the amount of helium being released became erratic, indicating that the vent of at least one of the capsules was starting to become plugged. At 144 h, the signal dropped to 75% of normal, an indication that one of the vents was completely closed. This lasted for 40 h. Several times during the period of 75% release, the amount of helium released was erratic, suggesting that another vent was beginning to plug.

C. Temperature Calibrations (C. Frantz)

The first three temperature-measurement calibrations for the GPHS safety verification impact tests were completed. Their purpose was to determine the temperature correction needed to account for the effect of the single-point contact that will occur between the thermocouples and the fueled clads in the impact tests. These calibrations showed that a properly positioned

beaded thermocouple indicates a clad surface temperature that is about 30°C below the actual temperature at the orbit-decay impact temperature of 970°C. These tests also showed that thermocouple installation is critical; if it is not placed correctly, the bead can lose contact with the clad during heating and indicate an erroneously low temperature, which would result in a high impact temperature.

D. Five-Watt System (C. Frantz)

A new gas-driven gun has been designed and is being fabricated. This gun will be used for impact tests of heat sources at velocities that are below the accuracy range of our 178-mm gun. The 18-mps, end-on impact of the 5-watt heat source will be carried out in this gun.

E. Compatibility (D. Peterson)

An impurity transport experiment was started to determine whether the presence of carbon affects the transport of impurities typically found in GPHS vents. A mixture of CaWO_4 , CaSiO_3 , Al_2O_3 , ThO_2 , P_2O_5 , Ir, and CeO_2 (a PuO_2 simulant) was placed in one end of an evacuated quartz tube and carbon was placed in the other end. The tube was placed in a temperature gradient with the impurities at 1000°C and the carbon at 300°C. After 30 days, a small amount of condensate was present on the carbon.

II. LIGHT-WEIGHT RADIOISOTOPE HEATER UNIT

A. Fragment Test (C. Seabourn)

A Light-Weight Radioisotope Heater Unit (LWRHU) in a Galileo magnetometer boom housing was impacted with a 762-mps (2500-fps), 18-g, 50-cal, aluminum-alloy bullet. The capsule was not recovered. Chemical analysis of the debris in the catch box found neither platinum nor uranium, suggesting that the bullet had not ruptured the capsule.

B. Solid-Propellant Fire (C. Land and C. Seabourn)

Assembly LRF-017 (capsule 119) was exposed to a 10.5-min solid-propellant fire. After the fire, the unit was partially covered with a deposit from the burning propellant and sintered sand (Fig. 1). When the aeroshell was removed, the outer and middle pyrolytic-graphite insulators were intact but the inner layer was not (Fig. 2). As Fig. 3 shows, the inner insulator had reacted with the Pt-30Rh capsule to form a molten phase.

A longitudinal section of the capsule demonstrates the degree of interaction (Fig. 4). The formerly molten material can be seen nearly covering the outer surface of the clad. In the thinnest regions, the wall of the clad is only 0.4 mm, 40% of its original thickness. In addition to the reaction with the graphite, the capsule reacted with the UO_2 fuel simulant to form the porosity visible in several places near its inside surface.

C. Seawater Immersion (C. Seabourn)

Fueled LWRHU assembly RU-10-15 was removed from its ambient-pressure seawater aquarium after 20 months. After it had dried, alpha activity was detected on the graphite components. A complete post-mortem examination will be performed.

D. Capsule Surface Contamination (C. Land and W. Stark)

Seventy-six LWRHU production fueled clads were removed from storage and examined for plutonium contamination; all were still swipe-free. They were counted directly to determine the amount of bound plutonium present. The results of the direct counts (Table I) indicate that the amount of contamination is quite small.

III. HELIUM RELEASE (P. Kleinschmidt)

The data acquisition system for helium release measurements was completed and successfully tested. A computer controls the temperature pulse and measures helium intensity, temperature, and time and calculates the release rate and the fraction released. The test data can be printed, plotted, or stored on a disk.

Fig. 1. LRF-117 was partially covered with fire products and sand (2X).

(a)

(b)

Fig. 2. The outer and middle pyrolytic-graphite insulators were intact (a), but the inner insulator was not (b) (2X).

Fig. 3. The inner insulator reacted with the clad during the fire (8X).

Fig. 4. The clad reacted extensively with both the insulator and the fuel simulant (8X).

TABLE I. Direct Counting Results from LWRHU Production Capsules.

Contamination Level (counts/min)	Number
0-1000	42
1001-2000	16
2001-3000	5
3001-4000	2
4001-5000	2
5001-6000	2
6001-7000	3
7001-8000	1
8001-9000	1
9000-10000	2

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