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ISOTOPIC POWER FUELS MONTHLY STATUS REPORT FOR SEPTEMBER 1972

Eugene Lamb

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ISOTOPES DEVELOPMENT CENTER

ISOTOPIC POWER FUELS MONTHLY STATUS REPORT FOR SEPTEMBER 1972

Eugene Lamb

Isotopes Division

OCTOBER 1972

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ISOTOPIC POWER FUELS MONTHLY STATUS REPORT FOR SEPTEMBER 1972

Eugene Lamb

CURIUM-244 FUEL DEVELOPMENT

(Division of Space Nuclear Systems Program 04 30 05 03)

Curium Oxide Fuel Development and Properties

$^{244}Cm_2O_3$ Compatibility Program

The materials[1] to be tested with $^{244}Cm_2O_3$ are being procured. Orders have been placed with Thermo Electron Corporation for 56 inner capsule assemblies (9 different materials), 35 intermediate capsule assemblies (graphite), 16 capsule holders (Al_2O_3 and BeO), and 15 outer container assemblies (tantalum and Hastelloy X). We expect to receive the inner and intermediate capsule assemblies by November 1, 1972, and the remaining components by December 15, 1972. Five inner capsule assemblies of Hafnalloy were received from TRW on October 3, 1972.

Precious metals melting stock for inner capsule fabrication was to be obtained from the High-Temperature Alloys for Space Isotopic Heat Sources program at ORNL and, after primary fabrication into rod shape, the rods were to be sent to Thermo Electron for final machining. However, due to previous program commitments and priorities, these materials have not yet been released for use in the Curium Program. No estimate of a fabrication completion date can be made until this material is made available.

The short-term testing of BeO-Cm_2O_3 will be resumed, and SiC-Cm_2O_3 couple tests will be initiated by the end of October. Evaluation of the couples will be by (1) differential thermocouple to determine eutectic formation and their melting point and any phase changes that occur, (2) mass spectrometer to determine reaction products and rate of mass loss, and (3) x-ray diffraction to identify compound formation. Preliminary information indicates a reaction between BeO and $^{244}Cm_2O_3$ at 1400°C.

Thorium dioxide has been selected as one ceramic material for investigation with $^{244}Cm_2O_3$. Three rods of ThO_2 were isostatically pressed into rods at 60,000 psi and densified to 97.1% theoretical at 1900°C in the Ceramics Laboratory of the Metals and Ceramics Division. However, attempts to machine the rods were unsuccessful due to the formation of radial and longitudinal cracks. Additional rods were fabricated at a reduced pressure and these specimens are currently being machined.

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[1]Eugene Lamb, *Isotopic Power Fuels Monthly Status Report for July 1972*, ORNL-TM-3955, Oak Ridge National Laboratory, p. 1.

Vapor Transport of $^{244}Cm_2O_3$

The mass spectrometer is now operable for testing. Vacuum in the range 10^{-7}-10^{-8} torr at temperatures to 1500°C has been demonstrated. Two methods, oscilloscope and function generator, are now functional to sweep the spectrometer through its mass range. Residual gases in the cell are being used to tune the instrument prior to calibration by generation of known vapor species in a Knudsen-type vapor pressure apparatus.

X-Ray Diffraction Unit

An x-ray diffraction unit for radioactive materials is being readied for characterization of ^{244}Cm materials. The unit has a vertical-type goniometer contained in an inert-gas glove box with a furnace attachment to heat samples to 2000°C. X-ray diffraction data will facilitate the characterization of $^{244}Cm_2O_3$ for application in aerospace isotopic power generators operating for long periods at temperatures to 1400°C and having the possibility of excursions to approximately 2000°C for short time periods such as atmospheric reentry. Specific applications for the x-ray unit in our experiments are: (1) study of the $^{244}Cm_2O_3$-$^{240}PuO_{2-x}$ (decay product of $^{244}Cm_2O_3$) phase system to determine lattice parameters, density, and phase transitions; (2) determine formation of intermetallic compounds of curium-244 with iridium and rhodium (possible capsule materials for $^{244}Cm_2O_3$); (3) compatibility of Cm_2O_3 with ceramic materials such as BeO and SiC; (4) characterization of Cm_2O_3-metal systems to assist in evaluating compatibility data; and (5) identification of volatile species in product-grade $^{244}Cm_2O_3$ and residual effects on the lattice structure of the remaining $^{244}Cm_2O_3$.

Impact Testing of Heat Source Materials

Sabot Heaters

Recalibration of the timer for the impact device has been accomplished using a Strobotac and a rotating wire. The timer was in excellent agreement with the calibrating device.

Three samples of Mo-ThO_2 cermet were impacted at a temperature of 800°C. The desired impact velocity of each of the samples was 300 ft/sec. The impact velocity of the first sample was 273.2 ft/sec. The impact cup which contained the sample was 1-in. OD with a 1/8-in. radial clearance between the impact cup and the heater cavity. Examination of the impact cup and heater after firing showed that the heated cavity walls were swaging around the impact cup and reducing the impact velocity. A second sample was fired in which a 3/16-in.-high ring was tack-welded onto the sabot impacting surface in the catcher box on the assumption that this additional distance would allow the impact cup to clear the heater cavity before the cavity swaged around it. An old impact cup with only 0.015 in. of radial clearance between cup and heater cavity was used. This clearance

was insufficient, and the impact cup lodged in the heater cavity. Approximately 7/32 in. of the cup exited the cavity before the cavity walls swaged around it.

To achieve free flight of the impact cup, the heater mandrel wall thickness must be increased and the maximum outside diameter of the impact cup must not exceed 1 in. The leading edge of the impact cup will clear the cavity and can, therefore, be larger than 1 in. in diameter, which will facilitate centering of the impact cup in the cavity. A new impact cup and heater mandrel were designed to incorporate these findings for the heated impact sabots (Fig. 1), and one of the newly designed units was fabricated and fired. The impact velocity of the third sample was 295 ft/sec, which is within the limits of the gun calibration. Examination of the impact cup after this third shot showed that the cup cleared the heater cavity, and the impact was centered and at right angles to the granite block. In all three cases, however, the sample of the Mo-ThO_2 cermet did not fracture upon impact, and no particles were generated.

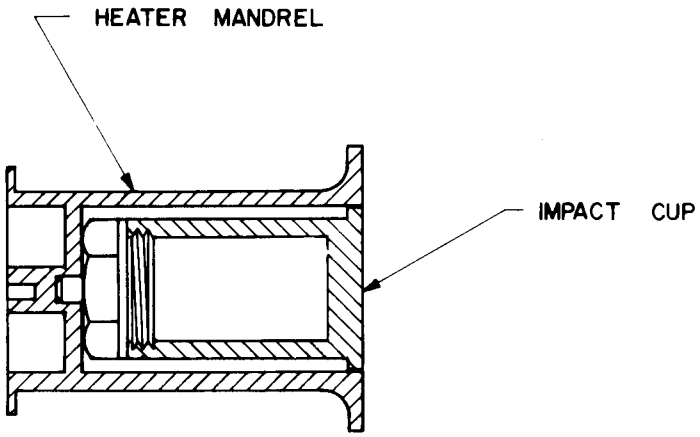

Fig. 1. New Heater Mandrel and Impact Cup Design.

APPENDIX

Curium-244 Inventory

Cumulative Receipts and Usage	Curium-244 (g)		Less Decay 4-30-72
Cumulative Receipts from SRL		2488	
Allocated to 04 Heat Source Program		2148	
Current Use in ORNL Test Program	(379)		
Analytical Samples from Test Program	(1)		
Shipped to Lovelace Foundation	(10)		
Shipped to SRL for Analysis	(2)		
Test Program Residues for Recycle	(83)		
Discarded to ORNL Tank Farm	(6)		
Raw Material Inventory, 04 Heat Source Program		1667	1544
Allocated to 05 Transuranium Program		340	
Transferred to TRU	(109)		
Shipments to Other Sites	(27)		
Transferred to Target Fabrication Group	(5)		
Raw Material Inventory, 05 Transuranium Program		199	184
Total Raw Material Inventory on September 30, 1972		1866	1728

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