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SANDIA SYSTEMATIC DECLASSIFICATION REVIEW
1st Review Date 10/15/97
Authority: ADC ADD
Name: W. H. LAWRENCE
2nd Review Date 10/22/97
Authority: ADD
Name: W Layne
Decision (Circle Numbers):
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2 Classification Changed to: U NCL
3 Contains No DOE Classified Information
4 Correlate With
5 Contains UCNI?
6 Comments:
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Lt. Colonel W. K. Kern, Chief
Aerospace Safety Section
Engineering & Test Branch
Division of Reactor Development
U. S. Atomic Energy Commission
Washington, D.C. 20545

Ans to Inquiries #6.

Dear Werner:

Re: Safety Philosophy for Pu-238 Powered SNAP Units

Pu-238, in recent years, has found considerable demand for use as a heat source for the reliable production of electrical power for earth satellites. This demand results from the long half life, relatively high power density, and the non-penetrating alpha radiations; characteristics which make the material attractive in spite of the high cost. Probably the most important desirable characteristic is the non-penetrating alpha radiations which permit use of the power source with sensitive satellite payloads and which result in a minimized radiological hazard to the population in general. The hazards to human health from Pu in the oxide form have been evaluated by Bio-Medical experts to be restricted to those which result from particles which can be inhaled and deposited in the lung. This situation has been estimated to exist only for particle sizes smaller than about three microns.

A number of safety studies have been made recently by several investigators in order to design power units for optimized safety and also, to provide independent assessments of the possible hazards inherent in the application of Pu-238 on space missions.

Throughout most of these safety studies the investigators have been convinced that systems can be designed to absolutely contain the metal fuel under all plausible accident environments associated with the launch portion of any space-mission. The stumbling block of uncertainties has inevitably been manifested by an inability to adequately describe the fate of the fuel under circumstances of premature re-entry of the satellite into the earth's atmosphere. To optimize safety in the event of such an unplanned occurrence the designers are currently providing for disassembly of the generator to expose the Pu metal fuel to the high temperature re-entry environment expecting that this will result in harmless deposition of the fuel in an oxide form in the upper atmosphere where it will undergo dilution by dispersion prior to arrival in the biosphere.

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW
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AUTHORITY: W. C. Layne
Emelda Selph 11/3/97
PERSON CHANGING MARKING & DATE
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This design concept is attractive but still involves several problems which so far have not been investigated enough to allow confidence in describing the fate of the fuel after re-entry. These are:

1. Current capsule designs will not assure fuel release under all re-entry conditions, i.e., steep entry angles that may result in too little total heat.

2. Vaporization of the metallic fuel cannot be supported for heating rates resulting from shallow re-entry at orbital velocity.

3. The debris characteristics are not known. Particle sizes are expected to be smaller than the stable size described by the Weber number criteria because of oxidation and droplet explosions.

4. The mechanical characteristics of the resulting oxide are not known but pessimistically it may be very flaky and readily break down into inhalable sizes.

5. Fallout rates and concentrations depend upon the particle sizes. For diameters greater than ten microns the particles will reach the surface in hours, and therefore result in excessive surface concentration.

Because of the above uncertainties and the difficulties of adequately describing the phenomena, we believe that immediate attention should be given to an attractive alternate approach to the safety problem.

This approach would propose the use of the fuel form being developed by Mound Laboratory and described as plutonium dioxide microspheres. These microspheres have been made in the 50 to 250 micron size and consist of hard black glossy appearing spherical particles which are apparently non-reactive chemically and insoluable in most fluids including sea water.

Calculations made on particles in this size range indicate that the temperature rise experienced during an orbital decay re-entry by such particles will not reach the melting temperature of the material. Since the particles are already "burned", no further chemical reactions should take place during a re-entry so one would expect that the released fuel of this type would reach the ground in the same form and size as the original release.

Before this fuel form is adopted it would be prudent to make investigations into several areas. It is felt, however, that the necessary investigation could be completed in sufficient time to allow use of this fuel form on the next space generator powered by plutonium. These areas are:

1. Solubility in sea water
2. Mechanical strength and stability
3. Effects of helium buildup and radiation decay on mechanical properties

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4. Effects of thermal cycling
5. Melting point
6. Specific heat
7. Adhesion between particles
8. Body takeup from ingestion
9. Compatibility with capsule materials

We strongly recommend that this approach be considered for all future plutonium powered devices and in particular for the SNAP-19, and that the above investigations be undertaken. The change over to this different form of Pu-238 could be quite simple and possibly consist only of a replacement of the metallic form of the fuel with the oxide form with no other change to the capsule or generator.

Sincerely yours,

V. E. Blake

V. E. Blake, Manager
Aerospace Nuclear Safety

VEB:7410:dh

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