# NASA TECH BRIEF



## Gamma Radiation Characteristics of Plutonium Dioxide Fuel

Future deep space exploration will require power sources which do not rely upon solar energy. Radioisotope Thermoelectric Generators (RTG) are being developed which will fulfill the power requirements. Based on the energy and power available per unit mass, plutonium dioxide is a prime choice as the isotopic fuel for the RTG power system.

The nuclear radiation produced by the plutonium dioxide fuel may give rise to spurious counts and electrical noise within the spacecraft electronics and the various scientific detectors. Since the radiation sensitivity of these instruments is a function of both the magnitude and spectrum of the gamma flux impinging upon them, it is necessary to evaluate these effects accurately.

The investigation was conducted in the following manner: (1) The isotopic composition of production-grade plutonium dioxide fuel was established. It was noted that this composition may vary with the fuel processing method. (2) The sources of gamma radiation produced by the plutonium isotopes, the isotope decay products, and the fuel contaminants were determined. (3) The gamma flux at the surface, as well as other detector positions exterior to a typical fuel capsule design, was calculated. This was performed for three different thicknesses of fuel.

The gamma rays from the plutonium dioxide fuel are derived from the plutonium isotopes and their decay products, the radioactive decay of $Pu^{236}$ and its daughter nuclides, and from the $Ne^{21}$ ($\alpha$, n) reaction with the isotope $O^{18}$ which is considered as an impurity. The corresponding gamma spectra from each source was accumulated into 20 discrete intervals of gamma energy from 0.001 to 7.000 MeV. Although the gamma radiation and neutron reaction rates are often quoted, the methods of calculation to derive the spectra have not been clearly stated. The gamma activity from the radioactive decay of $Pu^{236}$ consists of three primary decay gammas (48, 109, and 165 KeV). These are accompanied by gamma activity due to the decay of its daughter nuclides, determined from the growth of $Th^{228}$. The gamma activity of the $Pu^{236}$ daughter nuclides was calculated from the Batemann equation; principal $Pu^{236}$ daughter nuclides are $Pb^{212}$, $Bi^{212}$ and $Ti^{208}$. Gamma dose rates in both the axial and radial direction were calculated for three different capsule powers for varying isotope compositions as a function of time and distance.

### Note:

The following documentation may be obtained from:

Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.65)

Reference: NASA CR-103772 (N69-33263), Supporting Research and Advanced Development

### Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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