LETTERS TO THE EDITOR

$^{238}PuO_2$ AS A HEAT SOURCE FUEL

Because of the present and potential use of $^{238}PuO_2$ as a heat source fuel, I wish to point out that the neutron radiation levels for fuel currently being produced are considerably lower than those given in the recent article by Taherzadeh and Gingo, "Neutron Radiation Characteristics of Plutonium Dioxide Fuel," *Nucl. Technol.*, **15**, 396 (1972). One reason for this is that when it is important to minimize neutron levels, PuO_2 which has been depleted in ^{17}O and ^{18}O is used for the fuel, whereas in this article the PuO_2 is assumed to contain oxygen of natural isotopic abundance. Oxygen-17 and ^{18}O are the naturally occurring isotopes of oxygen which can undergo (α, n) reactions with alpha particles from ^{238}Pu. The specific neutron yield from the $O(\alpha, n)$ reaction, only, for fuel produced at Mound Laboratory which has been depleted in these two isotopes has been between 3×10^2 and 3×10^3 n/(sec g) ^{238}Pu, depending on the degree of depletion. This compares with a measured yield of 1.4 to 1.5×10^4 n/(sec g) ^{238}Pu from the $O(\alpha, n)$ reaction for undepleted PuO_2. The authors have calculated a yield of $1.99 \pm 0.45 \times 10^4$ n/(sec g) ^{238}Pu [or $(1.42 \pm 0.32) \times 10^4$ n/(sec g) (PuO_2-80% ^{238}Pu)] from the $O(\alpha, n)$ reaction for undepleted PuO_2.

Another reason for the neutron levels in the article being higher than current practice is the relatively high concentrations of low Z impurities assumed by the authors. Based on these concentrations, they have calculated a yield of 1.3×10^4 n/(sec g) ^{238}Pu for (α, n) reactions with impurities. For fuel produced recently at our laboratory, the neutron levels from (α, n) reactions with impurities have been $\leq 2 \times 10^3$ n/(sec g) ^{238}Pu.

The authors have calculated the total specific yield for a particular 2200-W(th) source fueled with undepleted PuO_2. Their value, which includes neutron-induced multiplication, is 6.42×10^4 n/(sec g) ^{238}Pu [or 4.59×10^4 n/(sec g) PuO_2]. Using the same source design but assuming the PuO_2 is depleted in ^{17}O and ^{18}O, as is currently being produced for large size heat sources, the expected total specific yield, including multiplication, would be only about 7 to 8×10^3 n/(sec g) ^{238}Pu.

Unfortunately, the article contains some errors. Two which might result in confusion for some readers are

1. *Section IIIA.* "The gamma-ray energy emitted from the excited states of the daughter nucleus ($^{234*}U$) has a maximum energy of 43.5 keV, and thus will be absorbed by the source or the shield surrounding it." Gamma rays as high as 1085 keV from the daughter nucleus have been observed, and these will not all be absorbed.
2. *Section IV.* There is the suggestion that 5.11×10^{11} might be the alpha yield per second per gram of ^{238}Pu. In the reference this value came from, 5.11×10^{11} is stated as being the yield per gram of ^{238}Pu product, which most likely means per gram of total plutonium of which 81% is ^{238}Pu.

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October 16, 1972

ACKNOWLEDGMENT

Mound Laboratory is operated by Monsanto Research Corporation for the U.S. Atomic Energy Commission under Contract No. AT-33-1-GEN-53.

REPLY TO $^{238}PuO_2$ AS A HEAT SOURCE FUEL

The author of the letter has stated that the experimental value of the neutron yield of the *current* Mound Laboratory plutonium dioxide fuel heat source is considerably lower than the reported value[1] in *Nuclear Technology*.

1. The neutron emission characteristics of plutonium dioxide fuel were estimated in Ref. 1 for a typical fuel source available at the time the report was being prepared. The difference between the heat sources selected by Ref. 1 and by Mound Laboratory is in the quantity of the low-Z impurities and ^{16}O enrichment. Obviously, if a low impurity and ^{17}O-^{18}O depleted source is used, a lower neutron yield would be expected.

In general, one can estimate the neutron emission yield of any plutonium dioxide fuel, including the current Mound Laboratory fuel, by using the *Nuclear Technology* report, provided the characteristics of the fuel are made available. Disregarding the difference between the two heat sources under question, there is good agreement between the theoretical calculation $(1.99 \pm 0.45) \times 10^4$ n/(sec g) ^{238}Pu (Ref. 1) and experimental estimated value of $(1.54 \pm 0.07) \times 10^4$ n/(sec g) ^{238}Pu (Mound Laboratory, Letter to the Editor). These numbers are in good agreement. An analytical calculation is based on the integration of the $O(\alpha, n)$ reaction rate, and the parameters involved had to be gathered from various publications. The magnitude of the reaction cross section, the