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SPECIFICATION FOR PLUTONIUM DIOXIDE

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SPECIFICATION FOR PLUTONIUM DIOXIDE

H. R. Wisely

1.0 Scope

- 1.1 This specification replaces Specification HW-76566 Rev. 1, in defining the physical and chemical requirements of the  $\text{PuO}_2$  powder used for PRTR fuel elements.
- 1.2 The scope of this specification excludes discussion of/or provision for preventing criticality incidents, health and safety requirements, and hazards avoidance. Observance of this specification does not relieve the user of the obligation to fulfill the requirements of AEC Nuclear Safety Guide - TID-7016, American Standard Radiation Protection for Nuclear Plants, and all other Federal, State, and local regulations on possessing, shipping, processing, or using radioactive or source and special materials.

2.0 Lot Size

- 2.1 A lot is defined as a quantity of material that is uniform in isotopic, chemical, and physical characteristics. The lot size shall be agreed upon between buyer and seller.
- 2.2 A lot may be divided for packaging as identifiable sublots or batches to be agreed upon between buyer and seller.

3.0 Sampling and Quality Control Procedures

- 3.1 A representative sample shall be taken from each lot of  $\text{PuO}_2$  powder for the purpose of determining chemical and physical properties.
- 3.2 The sample shall be sufficient to perform the specified quality control tests at the seller's laboratory.
- 3.3 Complete analytical data shall be provided for each lot.
- 3.4 The buyer reserves the privilege to sample at random from any subplot or batch for the purpose of ascertaining the quality of the lot, and provisionally accept or reject the entire lot on the basis of tests performed on such a sample.
- 3.5 Lots found to be unacceptable shall not be resubmitted unless all defects have been corrected by the seller.

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#### 4.0 Physical Properties

- 4.1 All of the powder in each lot shall pass through a 325 mesh U.S. Standard Sieve, or equivalent. Sieving practice shall be in accordance with ASTM-B214-56.
- 4.2 Milled powder that agglomerates due to excessively fine particle size and/or adsorbed moisture is unacceptable.
- 4.3 Specifications regarding surface area of the powder shall be agreed upon between buyer and seller.

#### 5.0 Isotopic Composition

- 5.1 The plutonium isotopic composition of the  $\text{PuO}_2$  powder lot shall fall within the limits specified by the buyer. Unless otherwise agreed, the lot may be composed of a homogeneous blend of  $\text{PuO}_2$  batches that, individually, do not meet the isotopic requirements.
- 5.2 The plutonium isotopic composition of the  $\text{PuO}_2$  powder, as determined by mass spectrographic analysis, shall be provided for each lot.
  - 5.2.1 When all of the powder in the lot is derived from a single plutonium metal button, or from a single solution batch, the isotopic content of the Pu in the button or the solution batch will be accepted as representative of the  $\text{PuO}_2$  powder.
  - 5.2.2 When the  $\text{PuO}_2$  powder lot is formed from a homogeneous blend of oxide derived from more than one button or solution batch, the isotopic content of the blended oxide shall be determined from a representative sample of the oxide lot.

#### 6.0 Chemical Properties

- 6.1 All chemical testing shall be performed on portions of the representative sample taken from the  $\text{PuO}_2$  lot, and shall be done by methods that have been mutually agreed upon.
- 6.2 Acceptable  $\text{PuO}_2$  must meet the following specifications:
  - 6.2.1 The plutonium content shall be at least 87.5 weight percent of the  $\text{PuO}_2$ .
  - 6.2.2 The oxygen-to-plutonium ratio shall be  $2.00 \pm 0.05$ .

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- 6.2.3 The chlorine content shall not exceed 10 ppm.
- 6.2.4 The fluorine content shall not exceed 10 ppm.
- 6.2.5 The carbon content shall not exceed 100 ppm.
- 6.2.6 The boron content shall not exceed 2 ppm.
- 6.2.7 The total impurity content, calculated as the "equivalent boron content" (EBC), shall not exceed 4 ppm on a weight basis relative to plutonium. The method of calculation and a list of impurities to be included are given in Appendix A.

#### 7.0 Packing and Marking

- 7.1 The plutonium dioxide shall be packaged in a tightly closed metal can which is sealed within a vapor tight bag. The exterior of this bag shall be free of smearable contamination. This package shall be enclosed within a dust tight, rigid container suitable for storage.
- 7.2 No single package of  $\text{PuO}_2$  shall contain more than 2.6 kg of oxide.
- 7.3 The rigid exterior carton shall be clearly marked as follows:

$\text{PuO}_2$  Lot Number

Net Oxide Weight (gms)

Pu Content (gms)  
%Pu-240

Allotment Number

#### 8.0 Inspection

- 8.1 Material which, upon subsequent inspection and testing at the buyer's laboratory, fails to meet this specification is subject to rejection and return to the seller at the seller's expense.

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APPENDIX ACALCULATION OF THE EQUIVALENT BORON CONTENT (EBC)

The EBC shall be calculated by the following formula:

$$EBC = \frac{(\text{Atomic wt. of boron})(\sigma_a \text{ impurity})}{(\text{Atomic wt. of impurity})(\sigma_a \text{ boron})} \times (\text{ppm impurity})$$

The EBC values for the elements listed below were calculated from  $\sigma_a$  data given in the Argonne National Laboratory Publication ANL-5800, "Reactor Physics Constants" Second Edition, July 1963.

| <u>Element</u> | <u>EBC/ppm</u> | <u>Element</u>     | <u>EBC/ppm</u> |
|----------------|----------------|--------------------|----------------|
| Aluminum       | 0.000127       | Molybdenum         | 0.000403       |
| Barium         | 0.000125       | Nickel             | 0.001122       |
| Beryllium      | 0.000016       | Phosphorus         | 0.000092       |
| Bismuth        | 0.000002       | Potassium          | 0.000758       |
| Boron          | 1.000000       | Silicon            | 0.000082       |
| Cadmium        | 0.312085       | Silver             | 0.008362       |
| Calcium        | 0.000157       | Sodium             | 0.000327       |
| Carbon         | 0.000005       | Tin                | 0.000075       |
| Chlorine       | 0.013652       | Titanium           | 0.001734       |
| Chromium       | 0.000854       | Tungsten           | 0.001495       |
| Cobalt         | 0.009232       | Vanadium           | 0.001405       |
| Copper         | 0.000868       | Zinc               | 0.000241       |
| Fluorine       | 0.000001       | Zirconium          | 0.000029       |
| Hafnium        | 0.008423       | <u>Rare Earths</u> |                |
| Iron           | 0.000672       | Dysprosium         | 0.083702       |
| Indium         | 0.023800       | Europium           | 0.405152       |
| Lead           | 0.000012       | Gadolinium         | 4.188365       |
| Lithium        | 0.146485       | Samarium           | 0.533281       |
| Magnesium      | 0.000041       |                    |                |
| Manganese      | 0.003441       |                    |                |

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