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DISPOSITION OF URANIUM-233

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DISCLAIMER

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ABSTRACT

The United States is developing a strategy[1] for the disposition of surplus weapons-usable uranium-233 (^{233}U). The strategy (1) identifies the requirements for the disposition of surplus ^{233}U; (2) identifies potential disposition options, including key issues to be resolved with each option; and (3) defines a road map that identifies future key decisions and actions. The disposition of weapons-usable fissile materials is part of a U.S. international arms-control program for reduction of the number of nuclear weapons and the quantities of nuclear-weapons-usable materials worldwide. The disposition options ultimately lead to waste forms requiring some type of geological disposal. Major options are described herein.

I. INTRODUCTION

Uranium-233 is an isotope produced by irradiation of thorium with neutrons in a nuclear reactor. Uranium-233, along with high-enriched uranium (HEU) and plutonium, can be produced in significant quantities for manufacture of nuclear weapons. The U.S. has investigated using ^{233}U in nuclear weapons, in reactors, and for other purposes. The U.S. and several other countries have significant quantities of separated ^{233}U. Somewhat < 2 metric tons of separated ^{233}U-containing uranium are in the U.S. inventory. Half of this material is considered high-quality ^{233}U with few isotopic impurities.

Uranium-233 at a minimum must be handled in glove boxes because of its high alpha activity. The ^{233}U also contains variable quantities of the impurity uranium-232 (^{232}U). One of the daughter products of ^{232}U decays with a 2.6-million-electron volts gamma-ray. This emission produces a radiation field that requires much of the material to be stored inside shielded vaults. The radiation is sufficient to create major handling complications, but is not sufficient to prevent its use as a weapons-usable material. The high-radiation field does prevent the use of existing commercial nuclear-reactor-fuel-fabrication facilities for blending down much (but not all) of the ^{233}U material in inventory with depleted uranium (DU) so that the material can be used as commercial nuclear reactor fuel.

II. DISPOSITION REQUIREMENTS AND ISSUES

Two basic requirements for ^{233}U disposition are to (1) convert the material to non-weapons-usable material and (2) disposition the material as a useful material or a waste. Uranium-233 can be converted to non-weapons-usable material [equivalent to < 20 wt % Uranium-235 (^{235}U)] by isotopic dilution with DU to <12 wt % ^{233}U. Final disposition of ^{233}U is more complex due both to technical and institutional factors. Alternative paths for disposition of surplus ^{233}U have been identified. The path forward requires four major policy decisions:

- *How much ^{233}U is surplus?* Some limited uses for the ^{233}U material have been identified. Uranium-233 is used in various procedures that analyze for uranium in many fuel cycle facilities and for safeguards measurements. In addition, one of the daughter products of ^{233}U, bismuth-213 (^{213}Bi), is being investigated for its use in cancer therapy. The ^{233}U inventory includes some high-quality material and other materials with isotopic impurities (^{232}U and ^{235}U) that limit or encumber any potential non-weapons use of the material. For civilian uses of ^{233}U, some of the material may not be useful even if there is a future demand for all high-quality ^{233}U.

- *Should ^{233}U that is kept for programmatic purposes be blended with DU to eliminate its potential use as a weapons material?* For many potential civilian applications of ^{233}U, isotopic dilution does not eliminate its potential usefulness. With enriched uranium, the policy has been to use different enrichments for different purposes. Such a policy also may be viable for ^{233}U.

- *Should the surplus ^{233}U be placed in storage rather than permanent disposal? If surplus ^{233}U is placed in storage, should it be isotopically diluted with DU to eliminate its potential use as a weapons material?* If, for any reason, the excess ^{233}U can not be disposed of as a waste, the option remains to place the material in long-term storage.

- *What are the preferred disposition options for surplus ^{233}U?* The options for ^{233}U disposition are significantly different from those for HEU and plutonium for two reasons. First, the quantities of ^{233}U are small compared to those of HEU and plutonium. Second, some of the ^{233}U inventory contains significant quantities of ^{232}U and its highly radioactive daughter products. The resultant radiation levels prohibit the use of facilities designed for HEU or plutonium for processing ^{233}U.

III. DISPOSITION OPTIONS

Many disposition options exist. Some of the options can handle only certain batches of ^{233}U in inventory with specific nuclear or chemical characteristics, whereas other options can dispose of the entire inventory. Three major disposition options (and associated waste forms) that can handle the entire inventory have been identified:

- *High-level waste (HLW) glass with DU from HLW sludge.* Uranium-233 is mixed with existing HLW liquids and sludges containing DU. The mixture is then converted to HLW glass for disposal in the spent nuclear fuel (SNF)/HLW repository. This option minimizes waste volumes by beneficial use of excess DU currently in the HLW sludge at the Savannah River and Hanford sites in the United States. The option also results in a high-quality waste form for ultimate disposal. However, there are engineering issues on how to mix the ^{233}U with the HLW sludge.

- *Special repository waste form for SNF/HLW repository.* Uranium-233 is mixed with fresh DU and converted into a uranium oxide final waste form for disposal in the SNF/HLW repository. This option does not depend upon other programs for treatment of the ^{233}U before its disposal. However, the option results in larger final waste volumes due to the addition of fresh DU to the ^{233}U. This option may require legislative changes.

- *Special repository waste form for the Waste Isolation Pilot Plant (WIPP).* Uranium-233 is mixed with fresh DU and converted into a uranium oxide final waste form for disposal at WIPP. This option also does not depend upon other programs for treatment of the ^{233}U prior to disposal. However, the option results in larger final waste volumes due to the addition of fresh DU to the ^{233}U. This option will require legislative changes.

IV. CONCLUSIONS

Multiple paths for disposition of ^{233}U exist. It is likely that the preferred strategy for disposition of ^{233}U will involve more than one option. The path forward for determining the preferred disposition option or options will be to (1) resolve the key technical and institutional issues and (2) initiate a decision-making process pursuant to the National Environmental Policy Act to determine the preferred option or options.

REFERENCES

Forsberg, C. W. and A. M. Krichinsky 1997. *Strategy for the Future Use and Disposition of Uranium-233: Overview*, ORNL/MD/LTR-60, Oak Ridge National Laboratory, Oak Ridge, Tennessee.