APPENDIX E
RELATIONSHIP TO NUCLEAR WEAPONS AND THE U.S. NUCLEAR WEAPONS COMPLEX

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E.1 Neptunium-237 and Plutonium-238 Proliferation Risks

E.1.1 Designations for Nuclear Materials

Special Nuclear Material (SNM) is a U.S. statutory designation used by the U.S. Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) to indicate materials bearing uranium enriched above natural in the isotopes uranium-235, -233, and several plutonium isotopes -238, -239, -240, -241, and -242. The designation SNM captures material containing stable fissile isotopes of uranium and plutonium.

Special Fissionable Material (SFM) is an international statutory designation used by the International Atomic Energy Agency (IAEA) to indicate materials bearing uranium enriched above natural in the isotopes uranium-235, uranium-233, and plutonium-239. The designation SFM captures weapons-usable uranium and mixtures of plutonium isotopes through capture of plutonium-239.

Other Nuclear Material is a recent designation for neptunium-237. This designation captures weapons-usable materials that are not legally recognized as SNM or SFM (DOE 2003b).

Source Material (SM) is a universal statutory designation to indicate materials bearing uranium that is depleted in the isotope uranium-235, or at the natural isotopic ratio, and thorium. The designation SM captures materials from which fissile materials may be derived.

High Enriched Uranium Reactor Fuel

All uranium enriched in uranium-235 with an isotope weight percent equal to or greater than 20 is called high enriched uranium (HEU). HEU fuel is required to operate the two irradiation facilities proposed in the *Draft Environmental Impact Statement for the Proposed Consolidation of Nuclear Operations Related to Production of Radioisotope Power Systems (Consolidation EIS):* the High-Flux Isotope Reactor (HFIR) and the Advanced Test Reactor (ATR). Both research reactors use aluminum clad HEU oxide plate fuel. The HEU contained in the HFIR and ATR fuel plate is 93 percent enriched and could be used as a fissile material in nuclear weapons following chemical separation from the fuel matrix and metallurgical processing.

International and domestic safeguards regulations treat uranium that is enriched above 20 percent, as material that is usable as fissile material for nuclear weapons. However, higher assays are more readily usable than lower assays.

E.1.2 Neptunium-237

Plutonium-238 production requires the production and irradiation of neptunium-237 targets. Neptunium-237 targets are typically made of purified, concentrated neptunium-237 dioxide with an aluminum binder, canned or clad in aluminum. The production of plutonium-238 requires:

- The production of purified neptunium-237 dioxide from neptunium-237 solution followed by target fabrication;

- Irradiation to build in plutonium-238 via neutron capture and beta decay, solvent extraction, and ion exchange processing to separate and purify neptunium-237 and plutonium-238 from fission products and other waste products; and

- A repeat of the cycle to produce additional plutonium-238.

Each cycle reduces the inventory of neptunium-237 available for plutonium-238 production, since neptunium-237 is converted to plutonium-238 in the process. During the production cycle, neptunium-237 is in different solid (e.g., oxide powders and pressed solid matrices) and liquid (e.g., nitrate solutions) forms.

Neptunium-237 is designated as other nuclear material by DOE (DOE 2003b). The U.S. Government and the international community recognize the utility of neptunium-237 in nuclear weapons. For the purposes of DOE safeguards, neptunium-237 is treated as equivalent to uranium-235 (DOE 2003b). As such, it is subject to DOE safeguards that are similar to those for very highly enriched uranium and is reportable in gram quantities.

Neptunium-237 is a fissionable material that could be used in a nuclear fission weapon. Its critical mass needed for such a weapon has been estimated to be about 40 to 60 kilograms (88 to 132 pounds) and, unlike plutonium-238, it does not render such a weapon unrealistic because it does not emit significant amounts of decay heat (NRC 1978). Less than 40 kilograms (88 pounds) of neptunium-237 would be used annually to produce plutonium-238 at DOE facilities.

E.1.3 Plutonium-238

One method for the production of plutonium-238 requires the production of purified neptunium-237 dioxide targets followed by target irradiation to build in plutonium-238 via neutron capture and beta decay, solvent extraction, and ion exchange processing to separate and purify neptunium-237 and plutonium-238 from fission products and other waste products, and a repeat of the cycle to produce further plutonium-238. During the production cycle, plutonium-238 is in different solid (e.g., oxide powders and pressed solid matrices) and liquid forms (e.g., nitrate solutions). During the process of production of plutonium-238 from neptunium-237 targets, a small amount of plutonium-239 is also produced by second neutron captures by plutonium-238. Since the desired product is relatively pure plutonium-238, the secondary production of plutonium-239 is intentionally limited. This limits the buildup of plutonium-238 to about 10 to 15 percent of the neptunium-237 content of the fresh target.

Plutonium-238 is designated as SNM. However, isotopically concentrated plutonium-238 (above 80 percent) is generally not recognized as a nuclear proliferation threat. However, this material is rigorously protected against loss, theft, and sabotage (through physical protection and accounting) and is strictly contained (to prevent accidental release), due to the health and safety risks presented by the material. Under DOE safeguards, plutonium-238 is reportable in 0.1-gram quantities.

E.1.4 Summary

Neptunium-237 and plutonium-238 are fissionable materials capable of undergoing and sustaining a fission reaction. As such, they are theoretically capable of being used in a nuclear weapon. However, the unique high decay heat per unit mass of plutonium-238 renders it untenable for use in a fission nuclear weapon because the inherent heat would deform any shape they could be formed into for the quantity needed for such a weapon. The generated heat would also deleteriously affect other components of a nuclear weapon that are collocated with the fissionable material and would cause unacceptably high temperatures in a nuclear weapon precluding its ability to achieve detonation. Neptunium-237 can be used in a nuclear fission weapon without concerns regarding heat generation, although its required weapons mass is much greater than that of plutonium-239 and larger than its expected annual use to produce plutonium-238 (DOE 2000).

E.2 Non-Defense National Security Plutonium-238 Applications

Along with National Aeronautics and Space Administration (NASA) deep space satellite applications, plutonium-238, in radioisotope heater units and radioisotope thermoelectric generators, is needed to support non-defense national security missions. By contract, no imported Russian plutonium-238 can be used for national security (DOE 2002a). Due to its classified nature, a non-defense national security application can be characterized by what it is not, as delineated below.

- It is not used in any nuclear weapons.
- It is not used in any nonnuclear weapons.
- It is not used in any military satellites or in space.
- It is not used in any missile defense systems.

E.3 Relationship of Plutonium-238 to the DOE Plutonium Nuclear Weapons Complex

Concerns have been raised regarding the relationship of plutonium-238 production, handling, and management with DOE nuclear weapons complex plutonium. Plutonium-238 is not a viable material for nuclear weapons because of its high natural decay heat production, which causes numerous complications and daunting technological problems in designing a functioning nuclear weapon. However, since plutonium-238 is an isotope of plutonium, it may be mistaken for a component of the DOE plutonium nuclear weapons complex.

Weapons grade plutonium is considered to be about 93 to 94 percent plutonium-239, with the balance being principally plutonium-240, and plutonium-238 constituting much less than 1 percent. DOE has reported that, as of 1994, it had an inventory of approximately 99.5 metric tons (218,900 pounds) of plutonium throughout the DOE complex and at U.S. Department of Defense (DOD) facilities (DOE 1996b). Of these 99.5 metric tons (218,900 pounds) of plutonium, only 4.5 percent was located at Idaho National Laboratory (INL), with the majority of the inventory at DOD facilities as well as the DOE Pantex Plant in Texas, and the DOE Hanford Site in Washington. In contrast, the total mass of neptunium-237 to be shipped from the Savannah River Site (SRS) to INL is expected to be about 0.3 metric tons (660 pounds) (DOE 2000), which could be converted to about 0.1 to 0.2 metric tons (220 to 440 pounds) of plutonium-238 by irradiation in ATR and HFIR over a period of 35 years. This mass of plutonium-238 represents less than 0.1 percent of the DOE complex inventory of plutonium (mostly weapons grade plutonium-239).

A number of DOE publications (DOE 2003a, DOE 2003c, DOE 2002b, DOE 1999, DOE 1996a, and DOE 1996b) have indicated the location of current and planned future weapons grade plutonium management and operations. These documents provide the following relevant information:

- The U.S. nuclear weapon stockpile stewardship program mission (i.e., DOE National Nuclear Security Administration [NNSA] nuclear weapons complex) has activities and/or tools at the Pantex Plant, Kansas City Plant, Y-12 Plant at Oak Ridge Reservation, SRS, Lawrence Livermore National Laboratory (LLNL), Sandia National Laboratories (SNL), Los Alamos National Laboratory (LANL), and the Nevada Test Site (NTS).

- Handling, storage, management, waste handling, and refurbishment of plutonium used in nuclear weapons is performed at the Pantex Plant, SRS, LLNL, and LANL.

- The DOE NNSA *Modern Pit Facility EIS* (DOE 2003a) evaluated the environmental impacts of a new plutonium pit fabrication facility for refurbishment of aging nuclear weapons. Potential sites considered were LANL; Pantex; Carlsbad, New Mexico; NTS; and SRS.

- DOE evaluated the environmental impact of managing up to 50 metric tons (55 tons) of surplus plutonium (DOE 1999). The preferred alternative, selected in the Record of Decision (ROD), involved plutonium operations at SRS, LANL, and ORNL.

- In 1996, DOE evaluated the environmental impact of long-term storage of weapons-usable fissile materials from U.S. nuclear weapon dismantlement (DOE 1996b). Weapons-usable fissile materials were defined as all isotopes of plutonium except plutonium-238 and HEU with a minimum enrichment of at least 20 percent uranium-235. The 1994 surplus weapons grade plutonium supply of 38.2 metric tons (42 tons) included 0.4 metric tons (0.44 tons) located at INL. The Preferred Alternative, implemented in the ROD, expanded plutonium storage at Pantex and SRS, leaving the existing inventory at INL.

- DOE evaluated stockpile stewardship and management environmental impacts within the nuclear weapons complex in 1996 (DOE 1996a). That EIS identified alternative sites for stockpile stewardship and the continuing DOE sites for the nuclear weapons complex as LLNL, LANL, NTS, SNL, Pantex Plant, Kansas City Plant, Oak Ridge Reservation, and SRS. Ongoing and planned future activities and structures in support of the nuclear weapons complex were evaluated at those sites.

E.4 Idaho National Laboratory, Plutonium-238, and the DOE Nuclear Weapons Complex

INL has never been part of the U.S. nuclear weapons complex, and has not been involved in the design, analysis, testing, management, and handling of nuclear weapons. All new DOE construction plans and disposition decisions documented since 1996 regarding weapons-usable plutonium, HEU, and nuclear weapons have not included INL.

At the isotopic concentration produced and used for RPSs, plutonium-238 is not considered to be a weapons-usable fissile material. The total mass of neptunium-237 and plutonium-238 to be produced from the neptunium-237 in the Proposed Action of this EIS (0.4 metric tons [0.44 tons] of neptunium-237 and plutonium-238 combined) is a very small fraction of the total DOE weapons-usable plutonium-239 inventory (about 99.5 metric tons [109.5 tons]) and of DOE surplus weapons-usable plutonium-239 inventory (about 38.2 metric tons [42 tons]). In addition, DOE has no plans to expand the proposed Consolidation Alternative plutonium-238 production mission at INL to include any plutonium-239 or nuclear weapons related activities.

E.5 References

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