The Options for and Status of Military Surplus Plutonium in the United States and Russia

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1. Introduction

Plutonium, especially that in separated form, is of concern due to the threat of its use in nuclear weapons. This is true for plutonium from both nuclear weapons programs and from the civilian nuclear energy industry: both weapons grade and reactor grade plutonium can be used in nuclear weapons (1). This paper will focus on the progress (or lack of progress) made toward disposing that plutonium which has been declared excess to military needs in both the United States and Russia. First, though, I would like you to consider three facts:

(1) At the close of the second millennium, the world is awash in plutonium. As of the end of 1998, approximately 1,350-1380 metric tons of plutonium had been produced, of which 1,115 t (David Albright, unpublished data) was in civilian spent fuel and 235-265 t were for military purposes. One of the two largest holders of military plutonium, the United States has 99.5 t of separated plutonium, some of which is still in warheads (2). Russia has an even larger stock of about 130 – 140 t of separated plutonium (some in warheads) in addition to at least 30 t of separated plutonium in the civilian nuclear power sector (3).

(2) Though the total inventories of plutonium may not seem impressive, consider that it takes only 4 to 6 kilograms (1/250th of a ton) of weapons grade plutonium to make a nuclear weapon (4). Currently, then, the world has enough plutonium for more than 225,000 nuclear bombs, each of which is capable of destroying a city. Of course, not all this plutonium is intended for nuclear weapons. In fact, the civilian nuclear power industry has produced most of the plutonium in the world and most of it is still contained in irradiated nuclear fuel. A small fraction of this civilian plutonium will be reused to fuel nuclear power reactors.

(3) Plutonium that is separated from nuclear fuel – either in the civilian or military sector – and will not be reused as nuclear reactor fuel is essentially impossible to eliminate from the planet, unless we blow it up in thousands of nuclear explosions, certainly an unpopular idea. The only other way to eliminate the material is to send it into outer space, which would be another unpopular plan, based on the record of failed rocket launches and the potential to distribute plutonium dust into the atmosphere.

This paper will first consider what has happened in plutonium disposition in the United States and then in Russia. It will end with a discussion of potential problems that may slow the process of plutonium disposition. First, though, I will provide some policy background to the discussion.

Under the START I and START II treaties and unilateral pledges made by Presidents Bush, Gorbachev, and Yeltsin, thousands of nuclear weapons will be dismantled, causing many tons of plutonium to be surplus to military needs. In September of 1998, Presidents Clinton and Yeltsin signed a joint pledge to develop a Bilateral Plutonium Disposition Agreement. This Agreement will cover 34 metric tons of plutonium in both countries that is considered surplus to military needs. In particular, the Agreement will cover specific schedules for disposition of the plutonium, the types of facilities to be built or changed, financing commitments, nonproliferation policies, transparency and verification conditions, and other conditions to be met by one or both countries (5). In assenting to be party to this Agreement, Russia has agreed to forgo its preferred disposition approach, which is to store their plutonium for a few decades until advanced breeder reactor technology is established and then to use the plutonium in these reactors. Negotiations on the Agreement began in early 1999 and are being completed now, with a final Agreement expected in late spring, 2000 (5). The plans are to begin actual plutonium disposition in both countries by 2007.

Although the near-completion of the Bilateral Agreement is promising, the basic theme of the story presented here is that neither country will actually begin to dispose of its plutonium until the other country also does so. As a result, plutonium disposition will only proceed simultaneously and in lock step. Therefore, it is essential that both countries are ready technically and politically to proceed, and this means that both countries need the capacity to disposition plutonium and the financial capability to do so, neither of which are yet assured.

2. U.S. Progress on the Agreement

Arguably, the United States has made more progress with excess weapons plutonium disposition than Russia, though neither side has yet to dispose of one gram of the material. All the progress on the U.S. side has been in formal policy decisions, for example, which stocks of plutonium are to be dispositioned, how they are to be dispositioned, and where they are to be dispositioned. Russia, on the other hand, has made few major policy decisions.

2.1 U.S. Policy Decisions

The first major U.S. policy decision on plutonium disposition was a 1995 presidential statement declaring 52 metric tons of plutonium excess to military needs. This amount included 38 metric tons of weapons plutonium and 14 metric tons of scrap plutonium. In January 1997, the Department of Energy issued a Record of Decision (6) that determined the method of plutonium disposition: a "dual-track" plan that would burn some plutonium as mixed oxide fuel (MOX) in existing, domestic, light water reactors and would immobilize the rest in a solid form.

Later in 1997 the Department of Energy made two additional decisions regarding the immobilization of plutonium. They decided on a can-in-canister design that would have cans of plutonium-containing glass or ceramic loaded onto a rack inside a larger canister around which would be poured highly radioactive glass, which provides a radiation barrier to theft (7). The basic reason for the choice of this design over a homogeneous design was cost. By September 1997, the Energy Department had selected ceramic over glass as the waste form of choice for plutonium (8). Ceramic had a number of advantages over glass including cost, safety, transparency, and repository performance.

In January 2000, the Department of Energy announced its latest policy decision on plutonium disposition (9). This second Record of Decision established a hybrid plan, by which up to 33 metric tons of plutonium would be dispositioned by burning as MOX fuel and 17 metric tons would be dispositioned by immobilization. It also determined that most disposition facilities would be located at the Savannah River Site in Aiken, South Carolina. The Savannah River Site will acquire (1) a pit conversion and disassembly facility where the plutonium "pits" (cores of nuclear warheads) will be dismantled and converted to PuO_2 powder, (2) a MOX fuel fabrication facility to be run by a consortium of Cogema, Duke Energy, and Stone and Webster, and a (3) immobilization facility to produce the plutonium-containing ceramic and the canisters with high-level waste glass. The Record of Decision also selected the nuclear power reactors in the United States that would burn the MOX fuel: Duke Power's Catawba and McGuire plants (2 reactors at each site) and Virginia Power's two North Anna reactors. Virginia Power has recently pulled out of the agreement for financial reasons and it is not clear whether other reactors will be added to fill the gap (10). In a effort to prove the technical viability of the MOX process, Los Alamos National Laboratory recently made MOX guide test assemblies that were irradiated at the Idaho Test Reactor and are now being examined by scientists at Oak Ridge National Laboratory.

2.2 Disposition Plans

Although the United States has declared at least 50 metric tons of plutonium as excess to military needs, only 34.5 metric tons of the total is actually weapons grade and available for disposition-

ing processes. As a result, in the Bilateral Agreement, the Russians have decided to match only 34 metric tons of plutonium, not the original 50 metric tons mentioned in previous statements. Of the weapons grade plutonium available for disposition in the United States, 25 metric tons of clean metal will be burned as MOX fuel; 9.5 metric tons of impure metal and oxides will be immobilized; 3.1 metric tons are so dilute that they will be repackaged and sent directly to the Waste Isolation Pilot Project repository in Carlsbad, New Mexico; and 0.6 metric tons of plutonium-containing spent fuel will go directly to a repository when one becomes available (11). Of these sources of weapons plutonium, only the clean and impure metal and oxide are covered under the Bilateral Agreement. The remaining 14 metric tons is reactor grade plutonium: 7.4 metric tons of impure metals and oxides will be immobilized and 6.9 metric tons of spent fuel will go directly to a repository (11).

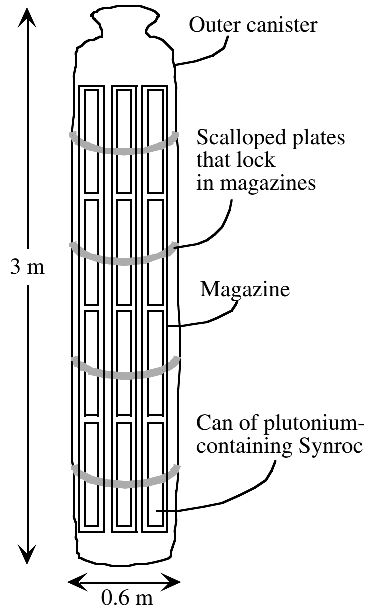

Figure 1: Schematic drawing of current can-in-canister design

Plutonium disposition in the United States will not be cheap. Recent cost estimates are approximately $4 billion (in year 2000 dollars) for disposal of 50 metric tons of plutonium (12). To process 33 metric tons of plutonium through the pit disassembly and conversion facility alone will cost $1.2 billion, including sunk costs, development costs, design and construction costs, and operating costs. Both the MOX option (for 33 metric tons of plutonium) and the immobilization option (for 17 metric tons of plutonium) will cost $1.4 billion each, including sunk costs, development costs, design and construction costs, and operating costs. The MOX option cost estimate includes the cost of modifying reactors for MOX use and the credit for the effective value of the fuel.

The United States has developed a schedule for plutonium disposition, although it is entirely contingent on agreement with the Russians and the availability of funds to cover the costs outlined above. The pit disassembly and conversion facility is to begin operations by 2006 with the first MOX fuel to be burned in 2007 (12). Immobilization should begin in 2008 if enough cesium is available from the Savannah River Site high-level wastes for the radiation barrier in the high-level waste glass. Savannah River ran into problems extracting cesium from the high-level waste salts when they discovered that their extraction method of choice, in-tank precipitation, created a safety hazard by produ-cing too much benzene (13). The Department of Energy, with the aid of the National Academy of Science, is currently considering four alternative processes to extract the cesium (13).

MOX production and use is well established technology used in Europe, but immobilization of plutonium in a ceramic is a new technology and deserves further explanation. The type of ceramic to be produced is a variant of Synroc (14) that has as its plutonium-contai-ning phases zirconolite, pyrochlore, and branne-rite (15). It will be produced in glove boxes via a cold-press and sinter technology similar to that used in MOX fuel fabrication (16). The pluto-nium will be incorporated into the crystalline matrices of the phases above to form the Synroc ceramic. Pucks of the ceramic will be loaded into twenty-eight cans, each containing approximate-ly 1 kg of plutonium, for a total of 28 kg per canister. Four of these cans will be loaded into a magazine, which will lock into an inner frame inside the larger canister, and seven magazines will be loaded into the canister in all (16).

The canister itself will be 3 m in height and 0.6 m in diameter. Radioactive waste glass containing Cs will be poured into the void space in the canister containing the cans to provide a radiation barrier similar to that posed by a spent fuel assembly. Each canister will have a radiation barrier of about 1.3 TBq (36 kCi) to provide a dose rate of about 6.5 Sv/hr (650 rem/hr) at 1 m from the mid-plane of the canister (17). The Department of Energy recently completed a successful test-pour of non-radioactive glass into the canister to ensure that all void spaces are filled.

3. Russian Progress on the Agreement

The vast majority of Russia's 34 metric tons of excess plutonium will be disposed of via the use of MOX in Russian power reactors. The Russians have yet to identify the specific stocks that will make up their portion of the Bilateral Agreement, and they have not released any formal policy decisions on location of disposition processing. Most likely, a pit disassembly and conversion facility, similar to that planned for the Savannah River Site will be constructed at the Mayak facility at Ozersk (previously Chelyabinsk-65). Currently, it appears that five Russian reactors will be used for weapons plutonium disposition: the BN-600 fast reactor (currently operating with a uranium core) and four VVER-1000 light water reactors at the Beloyarsk facility (personal communication, Terry Tyborowski, 2000). Locations for MOX fuel fabrication facilities are still under discussion, and especially contentious at the moment is the decision of whether to use vibropak or pelletized fuel for the BN-600 reactor. If vibropak fuel is used, then it may be fabricated at the Dmitrovgrad facility. Options for the production of pelletized fuel are Mayak and Zheleznogorsk (previously Krasnoyarsk-26) (personal communication, Terry Tyborowski, 2000). In addition to the MOX option, the Russians have verbally agreed to immobilize approximately one metric ton of plutonium, though no details on where a facility would be constructed or what sources of plutonium would be immobilized are available (personal communication, Laura Holgate, 2000).

4. The Bilateral Plutonium Disposition Agreement

The Bilateral Agreement intends to cover a number of issues related to excess weapons plutonium disposition. For instance, both the United States and Russia have agreed not to reprocess the spent MOX fuel containing excess weapons plutonium until all 34 metric tons are processed, and both sides have agreed not to reseparate immobilized plutonium (5). Furthermore, both countries have agreed that any exports of weapons-plutonium-containing MOX fuel will be subject to the approval of the United States and Russia (5).

Continued proliferation prevention is the main goal of the Agreement and consistent with that goal are provisions for safeguards during the disposition process. Full-scope safeguards will not be possible for either country, but some form of International Atomic Energy Agency (IAEA) monitoring is certain. In the United States, IAEA monitoring will most likely begin after pit disassembly and conversion is complete and continue through the rest of the plutonium processing (18). In Russia, IAEA monitoring will occur further into the process because Russia classifies its plutonium isotopic compositions longer than does the United States (18).

Most important to the success of weapons plutonium disposition will be the ability of both countries to pay for the process and to proceed with disposition of plutonium at equivalent rates. At the outset of negotiating the Agreement, Russia declared that it would not be able to cover the costs of its own plutonium disposition and the United States agreed to help them seek other sources of financing. To this end, the Department of Energy is currently completing a cost estimate for the Russian disposition program. Preliminary cost estimates are in the range of $1 billion to $3 billion for processing 34 metric tons of Russian weapons plutonium (personal communication, James Lacy, 2000). For its part, the United States Congress appropriated $200 million last year for plutonium disposition in Russia and the Clinton administration has proposed another $200 million to be spent over the next five years. Clearly, though, there is a need for further financing if plutonium disposition is to happen.

Another potentially problematic result of the Agreement is the lack of symmetry in plutonium disposition rates between the two countries. The Agreement sets out two phases of plutonium disposition, with the first phase seeing two metric tons of plutonium processed per year in each country and the second phase seeing four metric tons of plutonium processed per year (5). The problem is that at the outset the United States will likely be able to dispose of up to five metric tons of plutonium per year, of which four metric tons of plutonium will be that covered in the Agreement (personal communication, Laura Holgate, 2000). Russia, on the other hand, may not even be able to process 2 metric tons per year. It is likely that the U.S. Congress would not approve such an unsymmetrical arrangement and would withhold funding as a result. Therefore, it is essential to bring the two countries' disposition rates into line with one another.

5. What Needs to Be Done: Areas for International Help

It should be clear from the above discussion that for plutonium disposition to proceed in either country, Russia would need help in two areas: financing and disposition capability. Other countries, especially those in Europe may not initially see the need to help with plutonium disposition. On the other hand, European countries, as immediate neighbors of Russia, may actually be the first to feel the results of "leakage" of plutonium from Russia. The potential dangers of "loose nukes" and unsecured fissile materials in the former Soviet Union have been reported on at length by a number of experts (see for example, 19, 20, 21). More importantly, it is in the interest of all nations to ensure the dismantling of Cold War stockpiles of nuclear weapons. Until these weapons are fully dismantled and the fissile materials that powered them returned to a state from which it would take a large effort to reuse them in weapons, the whole world is in danger. To see progress in disarmament, it will be necessary to prove that it is possible to dispose of plutonium from dismantled weapons. To that end, the United States and Russia will need the aid of other countries.

First, the United States is seeking financial aid to help Russia complete the disposition process. U.S. representatives will attempt to find additional funding from the G-8 nations at the summit meeting in Japan in July 2000. It should also be mentioned that the U.S. Congress could appropriate enough funds to cover Russian plutonium disposition (especially if they give up certain other projects such as national missile defense), but the likelihood of that happening with the current Congressional membership is low.

Second, Russia will need help in reaching the target of disposing four metric tons of plutonium per year. One possibility outlined in a National Academy of Science report (22) is to burn some of the Russian MOX fuel in Canadian CANDU reactors. The first tests for such a plan will occur in the summer of 2000 at the Chalk River facility in Ontario, Canada. The use of Canadian reactors is complicated by the distances over which fresh MOX fuel would have to travel and the ability of CANDU MOX fuel to meet the spent fuel standard. Another option would be to use more Russian VVER-1000 reactors - there are seven operating VVER-1000 reactors in Russia, but the three remaining reactors may require too many safety upgrades to make MOX use viable. European reactors would make better candidates for Russian MOX fuel use because of their history of MOX usage, especially those in Germany, France, Belgium, and Switzerland. These countries have reactors that are licensed to use MOX, although MOX made from weapons plutonium may require additional licenses. These countries may see Russian MOX as attractive because Russia would be required to take back the spent fuel, thus relieving them of the burden of what to do with the waste. On the other hand, transport of MOX fuel is contentious in Europe, especially Germany, and many of these countries have stockpiles of their own plutonium that they are struggling to use as MOX fuel. If European countries were to aid Russia in its plutonium disposition, then certainly the respective governments would have to be involved in the negotiations along with nuclear industry representatives.

Clearly, disposition of excess weapons plutonium is technically within the grasp of both the United States and Russia. The uncertainty lies in political agreements to be reached by both countries. The completion of the Bilateral Plutonium Disposition Agreement will be the first major step towards the start of actual disposition. It is in the interest of all countries to reduce the nuclear risk by encouraging plutonium disposition. Once both the United States and Russia actually begin to dispose of their weapons plutonium, a precedent will be established that should encourage further arms reductions.

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