Disposition of Fissile Materials from Weapons

by

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I. Introduction.

The United States and Russian initiatives to declare, safeguard and dispose of excess stocks of weapon fissile materials are progressing at a painfully slow pace. On the U.S. side progress has been slowed by the technical complexity of the problem, the reluctance of the Department of Defense (DOD) to relinquish militarily useful fissile materials and to open U.S. weapon facilities to bilateral safeguards, and by the slow pace of the National Environmental Policy Act (NEPA) process for deciding how to dispose of the plutonium. On the Russian side there are the added problems of a lack of money and opposition by hard-liners to U.S.-Russian cooperative efforts. Both sides have allowed negotiations on the wide range of fissile material control issues, including the data exchange, production reactor cut-off, the highly enriched uranium (HEU) purchase agreement, to bog down, and the previous atmosphere of good will is eroding.

II. The Urgent Need to Reorder Priorities.

Since the breakup of the Soviet Union, at least five serious cases of diversion of weapon-usable fissile material have occurred--three involving 1.5 to 3 kilograms (kg) of HEU, and the other two involved over 150 grams of HEU or plutonium (Table 1). Most, if not all, of the materials were stolen from Russian nuclear facilities, and in two cases the materials were intercepted outside of Russia. We are told that the U.S. has been informed that a larger amount of weapon-usable material was stolen, and that a substantial fraction remains unaccounted for, but we do not know the details, and are not in a position to judge the validity of this case. Russian Interior Minister Viktor Yerin recently announced that his ministry is investigating 30 cases in which radioactive material was stolen from nuclear facilities (*The Washington Post*, February 24, 1995, p. A15).

Among the very highest bilateral U.S.-Russian security priorities should be to insure the adequate physical security and material accounting of the more than one million kg of weapon-usable fissile material in Russia. The Administration's efforts to assist Russia in material physical security and material control and accounting (MPC&A) have not been commensurate with the proliferation risks posed by these materials. I presented my analysis of the deficiencies in the Administration's MPC&A effort this past January in remarks at the Carnegie Endowment for International Peace Conference on Nuclear Non-Proliferation in January 1995. I will only summarize a few points here.

The Administration's MPC&A effort under DOD administered Nunn-Lugar was a failure and it is now being transferred to the Department of Energy (DOE) where it will be folded into the DOE administered Lab-to-Lab MPC&A initiative that was launched last April. Despite showing remarkable progress in the last few months, the Lab-to-Lab effort

will not succeed unless there are significant changes made in the scope of its mission and the level of funding. The current objective of the Lab-to-Lab MPC&A effort is:

> to make rapid improvements in the protection, control, and accounting of nuclear materials, especially weapon-usable materials (separated plutonium and highly enriched uranium), by working directly and cooperatively with Russian laboratories and institutes. Implementation at operating nuclear facilities in Russia, many of which are highly sensitive and inaccessible to foreigners, will be carried out by the Russian laboratories, with technical cooperation from U.S. laboratories.

To be effective and to gain access to sensitive Russian nuclear weapon facilities, the cooperative MPC&A program must be viewed by Russia as completely reciprocal both in its mission and its implementation. Moreover, as presently defined, the mission has no ultimate goal, and no quantitative means of measuring progress or success. This will result in the program becoming budget-limited. The available annual budgets will define what can be accomplished, instead of overall objectives and specific program milestones defining the annual budgets.

We believe these major deficiencies in the cooperative MPC&A effort could be overcome by revising the mission of the Lab-to-Lab program to have respective national laboratories jointly research, develop, and demonstrate, on a bilateral basis, a monitoring and safeguards regime that covers *all nuclear weapons and weapon-usable fissile materials* in the weapon states. Only then will the parties be forced to address methods for adequately safeguarding the most sensitive facilities and materials in both countries. This cooperative RD&D effort could be done without making a political commitment to adopt the bilateral, or multilateral, safeguards program once demonstrated. Do the RD&D first; then have the political debate over whether the program should take on treaty status. This expanded mission should have complete reciprocity. U.S. and Russian specialists would have equal access to each other's facilities. By covering *all weapon-usable fissile materials and nuclear weapons*, special interests, e.g., Minatom, and the U.S. Navy, cannot exclude coverage on the basis that their materials or facilities are too sensitive. RD&D on safeguards applicable to the weapon states should begin initially on a *bilateral* basis because rapid improvements in MPC&A are needed in Russia, nuclear components are involved, and the Russians do not want the IAEA at their fuel-cycle facilities at this time.

Most of the weapon-usable material in the world is in weapon states and is not covered by any international safeguards. The recent weapon-usable material thefts have occurred in a weapon-state (Russia), not facilities now under IAEA safeguards. Given the substantial nuclear proliferation risks today, building toward a comprehensive non-discriminatory safeguards regime that covers the weapon states should be a high priority in its own right. If we are to achieve deep reductions in the global nuclear weapon arsenals, a safeguards regime covering the weapon states is essential. To convince other weapon states to reduce their own arsenals significantly, they must be convinced that weapons retired

under current and future arms agreements have been dismantled and all weapon-usable materials are accounted for. If we fail to implement today a comprehensive verification regime over the nuclear stockpile reduction process and fissile material inventories in the U.S. and Russia, this failure may constrain in the future how far we can go in reducing global arsenals and ending further proliferation of nuclear weapons. Thus, we should initiate the RD&D for such a regime now. Had this program been initiated a year ago, even on a bilateral basis, we would have improved our chances of achieving an indefinite extension of the Non-Proliferation Treaty (NPT).

Despite NRDC having presented these arguments to officials of both the U.S. Government and the Russian Ministry of Atomic Energy (Minatom), neither side has shown any serious interest in pursuing a safeguards regime for the weapon states. Instead of focusing its greatest attention on securing the over 1000 tonnes (t) of weapon-usable fissile material in Russia, the Clinton Administration has spent a large fraction of its political and diplomatic capital on securing a cut-off of plutonium production for weapons at Tomsk and Krasnoyarsk--about 1-2 t of plutonium per year--and has little to show for this effort other than the creation of considerable ill-will on both sides.

Last month at a meeting of experts from the G-7 plus one, Canadian experts recommended that the countries fingerprint all stocks of fissile material to assist in curbing the diversion of this material. Even this limited but sensible proposal was rejected by the United States and other weapon states.

III. Nuclear Weapons and Fissile Material Data Exchange.

NRDC and the Federation of American Scientists have been advocating an exchange of data on nuclear weapons and weapon-usable fissile material since 1989. Last year the Clinton Administration finally endorsed the idea. In the National Defense Authorization Act for FY 1995 (Section 3155), Congress amended Section 144 of the Atomic Energy Act of 1954, to allow DOE and DOD to release restricted data and formerly restricted data, as necessary, to further fissile material and other weapons material control and accountability programs. In September 1994 Presidents Clinton and Yeltsin agreed to "exchange detailed information at the next Gore-Chernomyrdin Commission on aggregate stockpiles of nuclear warheads, on stocks of fissile materials and on their safety and security." Congress required that the data exchange be made through an agreement for cooperation similar to agreements the U.S. has with the U.K. and France. At the December 1994 Gore-Chernomyrdin meeting the U.S. tabled a draft agreement for cooperation and a draft list of warhead stockpile information that the U.S. was willing to exchange with Russia. In January of this year Ambassador James Goodby tabled a proposed list of fissile material data to be exchanged. The Russian response has been to say that they need more time to organize themselves. To date, no further negotiations have taken place.

It is unclear whether the data exchange will require approval by the Russian parliament. Getting parliament's approval for such an agreement may be difficult. Also, the U.S. Congress has provided a grace period through calendar 1995 during which the agreement for cooperation would not have to be submitted to the Senate. If the Agreement is not negotiated and signed before December 31, the new Republican controlled Senate will have an opportunity to reject it.

Even if these political issues are resolved, the U.S. DOD and the Russian Ministries of Defense and Atomic Energy likely will seek to keep the data classified and available only to the two governments. The DOD will want to classify these data in order to avoid public disclosure of the number of nuclear weapons it plans to retain in "inactive reserve" to avoid public embarrassment over this number. The currently proposed "inactive reserve" is very large.

IV. Declarations of Excess Materials.

In an effort "to further demonstrate our commitment to the goals of the [Non-Proliferation] Treaty," in his speech at the Nixon Center for Peace and Freedom Policy Conference on March 1, 1995, President Clinton announced that "200 tons of fissile material" had been "permanently withdrawn from the U.S. nuclear stockpile." While this material by definition is no longer needed for national security purposes, the makeup of this 200 tons, from whence it came, and where it resides remains classified. Administration officials are working to confirm the numbers to avoid a repetition of previous declarations which later proved erroneous.

I have attempted to piece together the makeup of the 200 tons from conflicting statements by several Administration officials. I am told that 160-165 tons will be HEU and just under 35-40 tons will be plutonium. I estimate that some 10-20 percent of the 200 tons is not fissile material removed from weapons, but is from other DOE stocks. For example, the HEU inventory includes the uranium recovered from reprocessing Savannah River production reactor driver fuel, perhaps as much as eight tons. Typically, this fuel has a U-235 enrichment of about 50 percent and contains about 25-35 percent U-236. The high U-236 content makes it unattractive for weapons or power reactor fuel. There is a total of 24.4 t of HEU at the Savannah River Site stored as metal, irradiated and unirradiated fuel, oxide and other forms. How much of this is in the 200 tons excess is unclear. The HEU portion of the 200 ton inventory also contains 10-15 t of UF_6 in storage at Portsmouth that was never in weapons, and a few tonnes of >90% U-235 metal (oralloy) that does not meet Navy fuel specifications. In fact, none of the HEU meets Navy specs. The bulk of the HEU, perhaps as much as 130 t, is components from the secondaries of nuclear weapons. The average enrichment of this material is on the order of 50 percent. Fifty tonnes of the HEU will be transferred to the United States Enrichment Corporation (USEC). The enrichment of this is not specified. A decision on the ultimate disposition of the remaining HEU has not yet been made.

On the plutonium side DOE has an estimated 20 t or so of plutonium in pits at Pantex, and not all of these pits will be declared excess. The Department has another 34 t of plutonium at other sites, but this includes some 15 t of fuel-grade plutonium, about half of which is in the form of fuel elements; 3.8 t of ZPPR fuel at INEL supplied by the British; and 6 t of plutonium residues, of which 1.5 t is fuel-grade. If the declared excess contains more than about 34 t of plutonium the excess will include either fuel-grade plutonium or plutonium in spent fuel or residues or some combination of these stocks.

Despite the 10-20 percent smoke-and-mirror content the President should be applauded for this effort. If you want to be picky, the President's declaration was given in "t-o-n-s" which is short tons. If the Administration comes up with 200 metric tons we can credit the President with having provided a 10 percent bonus. Where the President's announcement falls short is his failure to declare that this material will be placed under IAEA safeguards, and his failure to prepare credible program budgets and schedules for doing so.

Russia declared its willingness to sell 500 t of HEU from weapons to the United States. Since the U.S.-Russian agreement defines the amount and price of the uranium in terms of the 4.4% enriched LEU equivalent of 90% enriched HEU, Russia has in effect declared as excess more than twice the amount of fissile material as the United States. This is probably in line with the much larger quantity of HEU that was produced for weapons in Russia as compared to the United States.

V. Disposition of Excess HEU.

A. Disposition of U.S. HEU. The Department of Energy is preparing its Environmental Impact Statement (EIS) on Fissile Material Disposition, covering excess plutonium, HEU and U-233 stocks. In its pre-decisional draft, DOE has retained as reasonable alternatives: a) direct sale of HEU, b) blend to LEU (19% U-235 or 5% U-235) and sell, and c) blend to 19% U-235 or less and discard as waste. Blending to LEU for subsequent sale as power reactor fuel is the obvious preferred option. The real issue that is not on the table is whether the sale arrangements will be designed to provide maximum benefit to the taxpayer, the ratepayer, the USEC, the uranium brokers, or the uranium mining industry.

B. Disposition of Russian HEU. On January 14, 1994 the USEC, serving as the Executive Agent for the United States, entered into a contract with the Russian Federation to purchase uranium recovered from dismantled nuclear weapons for use in commercial electricity production. The United States will purchase 500 t of HEU converted to 15,260 t of LEU (4.4% U-235) over 20 years, at a rate of 10 t of HEU equivalent per year for the first five years and 30 t per year for the remaining 15 years. Until the United States and Russia consummate the data exchange we will not know the true significance of the U.S.-Russian HEU deal in terms of its impact on Russia 's nuclear weapon stockpile and reserve.

The U.S-Russian HEU deal may be falling apart. About two-thirds of Russia's gross revenues of $11.9 billion (unadjusted 1993 dollars) will come from the value of the separative work (90 million SWU), and one-third from the value of the uranium feed (430 million lb U_3O_8). The initial price of the material is $780 per kilogram of LEU, based upon $82.10 per SWU and $28.50 per kg of UF_6. DOE extracted as part of the agreement a concession that Russia will not be paid for the feed until the uranium is sold, used to overfeed U.S. enrichment plants, or until the contract expires in 2013, whichever comes sooner. The issue of reimbursement for the uranium feed component of the sale has not been resolved. The USEC is telling the Russians they will not be paid for the feed for several years. The problem is that the Russian government expects Minatom to pay for the feed up front, which represent one-half of the $82.5 per SWU income. Minatom must also pay for the blending. In order to meet LEU specifications for U-232, U-234 and U-236 content spelled out under the agreement, Minatom must enrich the blend feed to about 1.5% U-235. In the end there is little, if any profit left for Minatom. Minatom is accusing the USEC of failing to resolve the timetable for compensation, and accusing the U.S. Commerce Department of tying up the deal with settlement of the U.S.-Russian uranium suspension agreement (the uranium dumping issue). We are now into the second year of the contract; only two tonnes of HEU have been blended and the first delivery has not yet been made. After this second year the sales the sales price must be renegotiated. Unless the parties can agree to a price that will be much more favorable to Minatom, LEU deliveries may stall or the contract may terminate.

VI. Disposition of Plutonium.

A. U.S. Plutonium. In its pre-decisional draft EIS on fissile material disposition, DOE has retained three categories of plutonium disposal options: direct deep borehole disposal, immobilization in glass, ceramic, or metal for subsequent geologic disposal, and conversion to mixed-oxide (MOX) fuel for burning in existing reactors on a once through basis. The deep borehole options, including direct emplacement or with immobilization prior to disposal, are probably not serious contenders, but are carried because they were not ruled out by the National Academy of Sciences (*Management and Disposition of Excess Weapons*, NAS, 1994).

DOE's excess plutonium is found in a wide variety of forms, including solutions, oxide, residues, and metal. Not all of the plutonium is suitable for conversion into MOX fuel. The Department, therefore, may select more than one disposal options.

All for the plutonium immobilization options that DOE has retained involve building a new vitrification facility. DOE plans to start operating the Defense Waste Processing Facility (DWPF) at the Savannah River Site in mid-1996. DWPF is designed to vitrify the 34 million gallons (129 million liters) of high-level waste (HLW) at SRS over a 24 year period. DOE claims that modifying DWPF to mix plutonium with the HLW prior to vitrification, or fuse together concentric cylinders of fission product glass and plutonium

glass, would be too expensive. We are not convinced that this is the case. If DOE does not fully consider this option in the EIS, they may confront litigation by the environmental community.

Environmentalists are also concerned that the Department is not moving ahead now with research and development on the plutonium vitrification option which could be done relatively cheaply. The Institute for Energy and Environmental Research, in its recent report *Fissile Materials in Glass, Darkly*, has recommended that DOE build three vitrification plants within the next two years to test various vitrification options.

Also, as I said at this conference last year, I believe an attractive option for Hanford would be to hire a commercial firm to build and operate a vitrification plant at Hanford and for DOE to modify the Fuel and Material Examination Facility (FMEF) to mix plutonium with defense waste prior to delivery to the commercial firm for vitrification. Last year a development team comprised of the Environmental Corporation of America, Raytheon Company, and SGN/Numatec, Inc. submitted a proposal to DOE whereby they would construct a copy of the vitrification plant at La Hague that was designed by SGN and is operated by Cogema. DOE rejected the proposal on the basis that it would not accept a sole source bid for this undertaking.

With respect to the MOX option, DOE has eliminated all proposals other than burning the MOX in existing LWR and/or Candu reactors. I believe this is the correct decision. Last year there were two proposals to use two of four of the Washington Public Power System (WPPS) reactors in the state of Washington to burn MOX fabricated from excess plutonium. One of the proposals, called Project Isaiah, was offered by Battelle Memorial Institute, Science Applications international (SAIC) and Newport News Shipbuilding, and the other was proposed by WPPS. DOE has discarded both of these options because the utility has decided not to continue to maintain the reactors. And, of course, WPPS will not maintain the reactors because DOE in not in a position to commit to the WPPS MOX option -- Catch-22.

Atomic Energy of Canada Limited's (AECL's) proposal to burn excess U.S. weapon plutonium at Ontario Hydro's Bruce Nuclear Generating Station now appears to be among the most attractive of the MOX options. The Bruce station has eight Candu reactors (four 769 MWe and four 860 Mwe) that could be dedicated for this purpose. Each reactor could burn annually fuel containing about one tonne of plutonium to about 9,700 MWd/t, or 17,700 MWd/t depending upon the fuel design. The MOX fuel would be fabricated in the U.S.--it has been suggested at the FMEF--before shipment to Canada. A parallel option for burning excess Russian plutonium has been proposed, but the details and economics are less well developed.

While NRDC favors the vitrification option, last November we suggested an alternative MOX option for consideration, whereby the U.S. Government would offer to supply fresh MOX fuel to foreign reactor operators in exchange for an equivalent quantity

of spent fuel, at a price equivalent to, or below, the sum of the current market prices for reprocessing and MOX fuel fabrication. This offer would be directed primarily at Japanese and European utilities that are likely to contract with Cogema and BNFL for a second round of spent fuel reprocessing. In effect, the U.S. would compete directly with BNFL and Cogema for spent fuel management services, but would provide these services at an equivalent or reduced price without actually reprocessing any spent fuel. Under this option, DOE in theory at least could actually make money disposing of its excess plutonium. A potential "show stopper" with respect to this proposal is the need to import and store foreign spent fuel. This problem might be avoided, or at least postponed, by deferring the return of the spent fuel until the repository is available.

B. Russian Plutonium. The situation on the Russian side with respect to disposal of excess plutonium looks bleak. By our estimates, Russia has about 200 t of plutonium, excluding that in spent fuel. About 170 t was produced for weapons and is now in weapons, dismantled pits, and in storage at various manufacturing plants, and about 30 t from processing civil reactor fuel and now mostly in storage at Chelyabinsk-65. Thus, Russia has about twice as much separated plutonium in weapons and in storage as does the United States. Moreover, despite having a plutonium surplus under inadequate physical security and material control and accounting, Russia continues to separate two to three tonnes of plutonium per year at three sites. As former Secretary of Energy Herrington once remarked about the United States, Russia is simply "awash" in plutonium.

This past January the United States and Russia agreed to study the following options for disposing of Russian plutonium from dismantled weapons: burial in deep boreholes or geologic repositories, burning as MOX in LWRs, stabilization, immobilization, and accelerator transmutation. Minatom steadfastly maintains that it should close its civil fuel cycle and use its excess plutonium as start-up cores for a breeder reactor fuel cycle. NRDC is opposed to Western assistance to implement a MOX option in Russia that would significantly advance Minatom's efforts to close its civil fuel cycle. NRDC would not necessarily oppose the construction of a plant dedicated to the fabrication of MOX from excess military plutonium for use in existing reactors. Given that Russia's excess plutonium is also found in a wide variety of forms, including forms that are unsuitable for conversion to MOX, Minatom would be well served by developing a direct disposal option even though its priority is to use excess plutonium as MOX fuel.

Russia should stop reprocessing spent fuel, and should not complete the RT-2 plant at Krasnoyarsk-26, at least until its excess plutonium stocks are eliminated. Russia does not have a geologic repository for its vitrified high-level waste. It is safer and cheaper to store plutonium in spent fuel, than to reprocess the spent fuel and separately store the plutonium as an oxide and the fission products in glass.

C. Geologic Disposal. If the deep borehole option is excluded, regardless of whether the plutonium disposition option is vitrification or MOX, it will ultimately be destined for a geologic repository. The nuclear industry in the United States is embarked on a reckless

mission of wholesale gutting of the licensing criteria for assessing the adequacy of the proposed U.S. repository at Yucca Mountain in Nevada.

As early as 1957 the National Academy of Sciences recommended that the preferred method of permanent disposal would be in a stable geologic formation (they suggested salt deposits) deep within the earth. In the late-1970s the Department of Energy began a process of systematically selecting the best candidate geologic medium to be followed by selection of the best site. First, the Department of Energy, and then the Congress coopted that process and forced the decision to locate the first repository at Yucca Mountain. Also, in the late-1970s the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC) began developing licensing criteria for the repository. Before EPA published its high-level waste criteria (40 CFR 191) in 1993, the nuclear industry persuaded Congress to exempt Yucca mountain, and have EPA write new disposal criteria only after receiving recommendations from the National Academy of Sciences. The Academy has not yet submitted recommendations to EPA. Still concerned that Yucca Mountain may have difficulty meeting even the new standards, the nuclear industry is now asking the Congress to gut the licensing criteria.

The latest incarnation of the nuclear industry's preferred licensing approach is found in two bills introduced this year. First, on January 5 of this year Senator Bennett Johnston introduced S.167, to amend the Nuclear Waste Policy Act of 1982. Among other things Senator Johnson's bill replaces EPA's high level nuclear waste disposal criteria by a single standard requiring that the annual dose to an average individual not exceed one-third of the annual dose from natural background radiation. This translates into an individual risk limit of 100 mrem annually, a factor of seven higher than the individual risk limit in the EPA rule. On February 23 Congressman Fred Upton introduced a similar bill in the House that exempts Yucca Mountain from EPA regulations and substitutes the 100 mrem individual risk limit.

More importantly, these two egregious bills toss out two basic tenets of the now more than 60 year old health physics profession--the ALARA principle and the need to establish a limit on the collective dose to populations when population groups are exposed to low doses of radiation over long periods. They also toss out fifteen years of carefully developed, scientifically based, and peer reviewed nuclear waste regulations. The Johnson and Upton bills replaces these by an ill conceived, cynical and arrogant standard presented by the nuclear industry--a standard that is based on bald politics rather than science and that could dramatically endanger public health for centuries to come. Those of you affiliated with the Nuclear Energy Institute and the various nuclear utilities that are pushing these bills should be ashamed--truly ashamed.

Table 1. Diversions of Significant Quantities of Weapon-Usable Fissile Material from Institutes in Russia.

Oct. 1992:	an employee of the Luch Production Association, which manufactures nuclear space reactors, in Podolsk was apprehended at the Podolsk train station with 1.5 kilograms of HEU in his suitcase.
May 1993:	27 crates containing 4 tonnes (t) of beryllium (Be) metal and a small quantity of HEU were discovered in a bank vault in Vilnius, Lithuania. The DOE claims there were 2 kg of U-235 mechanically implanted in the beryllium. The Lithuanian Nuclear Power Authority (VATESI) claims there were 3860 kg of pure Be and 140 kg of a Be alloy containing 150 g of uranium enriched to 50 percent. The CIA account is consistent with that of claim of VATESI, and differs from DOE's. Apparently, the beryllium was intercepted as it was being shipped from the Minatom Institute of Physics and Power Engineering (IPE) in Obninsk, by a company called AMI (two mobsters) in Zarechny, Sverdlovsk region (Yekaterinburg), to an organized crime group in Lithuania.
Feb. 9, 1994:	3 kg (90% U-235) HEU stolen from the Elektrostal plant near Moscow. A St. Petersburg butcher was apprehended in an attempt to sell it.
Aug. 10, 1994:	German authorities intercepted 0.5 kg of material in a suitcase at the Munich airport after arrival by plane from Moscow. Of this, 0.3-0.35 kg were Pu-239 (87.5% Pu-239). The Pu was a peculiar mixture of oxide powders similar to mixed-oxide (MOX) fuel. The suspected couriers, two Spaniards and a Columbian were arrested. Also in 1994 (on May 10, June 13, and August 14) German authorities intercepted smaller samples of plutonium and HEU.
Dec. 14, 1994;	3 kg of HEU (87.5% U-235) were seized by Czech authorities in Prague.