The Uranium Institute 25th Annual Symposium
30 August-1 September 2000: London

Management of Plutonium Derived from Military Programmes

Valentin Ivanov

In this paper I will provide some brief information about the situation concerning the disposition of Russian military-grade plutonium under an agreement between the Russian and US governments. This covers the disposition of plutonium that was declared by the Presidents of the United States and Russia in 1998 as surplus for defence proposes and which has been withdrawn from nuclear military programmes.

The Russian government's conception of disposition is to use this plutonium in MOX fuel for light water reactors (in Russia these will be VVER-1000 reactors), and partially for fast reactors (in Russia these will be BN-600 and BOR-60).

In this way, in the relatively near future MOX fuel containing military-grade plutonium will appear in the nuclear fuel market. Of course, in the first place according to existing plans it will be only in the Russian fuel market. But there are some circumstances in which this MOX fuel could be available to foreign markets. I will say more about these circumstances later.

The details of the procedures and conditions for military-grade plutonium elimination in the intergovernmental agreement reached by Russia and the United States are at this moment on the table of Russian Prime Minister Mikhail Kasyanov, and I hope that simultaneously they are on the table of US Vice President Al Gore. I hope that in maybe several days or weeks the agreement will be signed.

Table 1 shows the mass of the surplus plutonium which will be eliminated during this project, amounting to 34 tonnes each from Russia and the USA. Of the Russian material, 25 tonnes is in metal form (from pits and clean metal) and 9 tonnes are in oxide form. This oxide was manufactured for future conversion to metal but of course such conversion has been prohibited since the beginning of the 1990s.

It is planned that no less than two tonnes of plutonium per year will be dispositioned in the initial phase. Under existing plans this is the capacity which will be available. This phase is due to begin in 2007 and will last until production can be increased at the relevant conversion and fuel fabrication plants and new reactors are ready.

Disposition of up to five tonnes of plutonium per year is planned for the second phase. But frankly speaking, even in 15 years there may not be enough reactor units available in Russia to achieve such a disposition rate. There are particular requirements for control of plutonium disposition, which will be important during our future work.

The initial isotopic composition of weapons-grade plutonium is classified in Russia. It cannot be directly used in MOX fuel and will be blended with civil plutonium. Nevertheless, after blending the plutonium will still be military-grade type, that is the content of Pu-240 in the whole mass will be less than 10%. So to be exact, the blended plutonium will not be civil plutonium, it will be a complex mixture. Nevertheless, after blending the plutonium will be suitable for all the required procedures.

Under the agreement, after civil plutonium is admixed with the military-grade material for the first time, the mixture's composition has to meet the qualitative requirements for weapons-grade plutonium and will be made available for analysis of its isotopic composition and mass. The mass of the added civil plutonium will not be counted in the quantity of the declared surplus plutonium. This means that we shall actually eliminate not just 34 tonnes, but approximately 37 tonnes of plutonium.

Irradiated nuclear fuel which contains weapons-grade plutonium will be subject to control and cannot be reprocessed to extract fissile components during the term of the agreement. It is important to note that this point will require the organisation of specific controls on such spent fuel.

The agreement contains specific requirements for the spent nuclear fuel. For thermal reactors, each spent fuel assembly should be irradiated to a burnup level of no less than 20 000 MWd/t. The radiation level from each spent fuel assembly should be no less than 1 Sievert per hour one metre from the accessible surface at the centreline of the assembly 30 years after irradiation has been completed, for light water reactor and fast reactor fuel.

We have defined the requirements fully for spent fuel from light water reactors, but we will need to develop these further for fast breeder reactors. In Russia we have already started to irradiate some such MOX fuel in BN-600, and immediately this is unloaded we will carry out some investigations and adjust the requirements.

There are a number of major tasks to be accomplished before the full-scale launch of the agreement can proceed:

- Evaluate the required investments and operating costs.
- Select plant sites and justify investments.
- Harmonise LWR MOX fuel technologies with Russian nuclear fuel specifications.
- Procure licences to use lead test assemblies in a VVER-1000.
- Develop and implement regulatory documents with GAN (the Russian nuclear regulator).
- Finalise research to validate the use of MOX fuel with weapons-grade plutonium in VVER-1000s and BN-600.

Work is underway on all of these points now to varying degrees. On the first point, this work has been completed and we have information about the costs of future projects.

Table 2 shows the main dates and events anticipated in the programme. The main points which I would emphasise are that the start of production of MOX fuel is due in 2007, and that approximately at the end of 2009 we would expect the first spent fuel to arrive at the dedicated storage facility for this kind of fuel.

In Table 3 there is a summary comparison of the preliminary cost estimates made by two working groups, a Russian/French/German team and a Russian/American team. This shows that the costs for preparation and construction are approximately US$800 million, and operating expenditure will be approximately US$900 million.

It is important to understand that there are no economic or technological requirements or reasons to start this work immediately in Russia. Elimination of military-grade plutonium is a political goal. The economic situation in Russia and the situation with the capacity of our nuclear industry are such that there are no reasons to start this work, and for maybe 10 or more years we will not have funding available for such projects.

Nevertheless, together with our American colleagues we started this work to develop an agreement, and immediately after the signing we will start to realise the project. The US government has undertaken to allot US$200 million to fund the project, but as Table 3 shows we need about US$1.74 billion. It is stipulated in the agreement that the Russian Federation may suspend implementation if the necessary sources of funds are not defined.

To accomplish the task, Russia needs external aid. Most importantly, Russia is in need of investments to set up facilities to fabricate MOX fuel for LWRs and storage facilities for spent MOX fuel.

Thus we can see that the main problem for the whole project is funding. However, there are some proposed solutions to this funding problem.

As noted above, operating costs will amount to about US$900 million. This expenditure could be covered if MOX fuel produced in Russian plants using weapons-grade plutonium, with the help of the fabrication methods of Cogema and Siemens, was sold to Western European nuclear power plants.

In order to construct the necessary facilities Russia needs investment — there is no possibility to start this project without such investment. So preparation and construction will definitely need international assistance. But as far as expenditure on operation is concerned, it is possible to involve commercial processes.

It is well known that in Western Europe, in such countries as France, Belgium, Germany and Switzerland, there is great experience in using MOX fuel successfully in LWRs. As a result of our preparations and investigations for these projects together with our French and German colleagues, we believe it is possible to make use of their experience, technology and equipment for realising the disposition of military-grade plutonium in Russia.

In Russia, we have developed modern technology to fabricate MOX fuel with weapons-grade plutonium, but so far only for fast reactors. As I mentioned above, we have started to irradiate such fuel, with the first batch of 50 kg of plutonium now loaded in the BOR-60 pilot fast reactor and the BN-600 (our commercial unit). In 2000 we have prepared the next batch of 100 kg of metal weapons-grade plutonium.

However, it is only possible to use approximately 300 kg of plutonium in the hybrid core in BN-600 and we have problems with extracting the radial blanket from this reactor in order to start using the whole core. In any case, the whole core is only approximately 1.2 t/yr. So we need to use light water reactors to achieve our disposition target, for which we need to construct facilities to manufacture LWR MOX fuel.

There are many ways of solving the funding problem for this involving commercial organisations. One idea which I would like to discuss is to organise an international leasing company. This leasing company would buy MOX fuel and irradiate it in reactor units in Western Europe or maybe other parts of the world. After irradiation the spent fuel would be returned to the special storage facility in Russia.

Leasing is a familiar concept involving the sale and later return of a product, and so we hope it will be an attractive proposal. I would like to take this opportunity on behalf of Minatom to invite governments and private companies to participate in the realisation of this project which aims to eliminate weapons-grade plutonium and achieve real disarmament. It is an important and noble task.

Table 1. Quantities and methods of disposition.

For the Russian Federation			For the United States of America		
Quantity (Mt)	**Form**	**Method of disposition**	**Quantity (Mt)**	**Form**	**Method of disposition**
25.00	Pits and clean metal	Irradiation	25.00	Pits and clean metal	Irradiation
9.00	Oxide	Irradiation	0.57	Oxide	Irradiation
			2.70	Impure metal	Immobilisation
			5.73	Oxide	Immobilisation

Table 2. Dates and events.

Dates	**Events**
January 2002	Update Scientific Research Institute of Atomic Reactors (NIIAR) facilities to enable fabrication of vibrocompacted fuel for BN-600(hybrid zone)
October 2000	Produce a demo unit for fabricating VVER-1000 MOX LTAs for “MOX-Demo” at NIIAR (with the assistance of NCCP)
January 2003	Update the PAKET unit to fabricate BN-600 pellet fuel at Mayak (Chelybinsk)
January 2003	Construction of demo unit for converting weapons-grade Pu into oxide at Mayak
April 2004	Begin transition of BN-600 core to hybrid zone with MOX fuel at Beloyarsk NPP
April 2004	Fabricate VVER-1000 MOX LTAs at NIIAR
July 2003	Start of construction of an industrial-scale Pu conversion facility at Mayak
July 2003	Start of construction of an industrial-scale MOX fabrication facility
July 2006	Start of operation of industrial-scale Pu conversion facility
2007	Start of operation of industrial-scale MOX fabrication facility
2008	Fabrication of an industrial batch of VVER-1000 MOX fuel for Balakovo NPP
2009	Put in operation spent MOX BN-600 fuel storage at MChC (Krasnoyarsk)

Table 3. Summary comparison of preliminary cost estimates for plutonium disposition in Russia, prepared by trilateral Russian/French/German (R/F/G) and bilateral Russian/US (R/US) working groups.

	Preparation & Construction		**Operations**		**Totals**	
(All figures in millions US$, 2000)	**Scen. Var. 1 (R/F/G)**	**Base Case (R/US)**	**Scen. Var. 1 (R/F/G)**	**Base Case (R/US)**	**Scen. Var. 1 (R/F/G)**	**Base Case (R/US)**
BOR 60	–	–	7.5	–	7.5	–
BN600	44.3	117.9	8.4	38.4	52.7	156.3
Lifetime extension		–	14.0	–	14.0	–
VVER 1000	81.0	98.6	14.0	66.0	95.0	164.6
Lifetime extension	–	?	7.5	?	7.5	–
Pilot facilities:						
Conversion	21.7	21.7	8.7	11.6	30.4	33.3
BN/Paket	28.2	28.2	23.2	29.0	51.4	57.2
BN/RIAR	11.6	11.6	19.3	19.9	30.9	31.5
Lead test assemblies (3)	51.0	?	–	?	51.0	–
BOR-60 fuel	–	–	3.0	–	3.0	–
Conversion plant (CHEMOX type)	109.8	88.3	167.2	163.7	277.0	252.0
D&D costs (included in above)	–	–	17.0	–		
MOX fabrication Plant (DEMOX type)	424.3	269.6	475.2	329.9	899.5	599.5
D&D costs (included in above)	–	–	70.0	–		
Transportation	33.1	32.0	75.4	84.5	108.5	116.5
Storage	20.0	20.2	88.0	87.5	108.0	107.7
Licensing costs for operators	tbd	?	–	–	–	–
GAN (regulator)	tbd	–	tbd	included	tbd	included
Immobilisation	n/a	93.9	n/a	106.1	n/a	200.0
Totals	**825.0**	**782.0**	**911.4**	**936.6**	**1736.4**	**1718.6**

Note: VAT is excluded in both sets of results.