THE US PLUTONIUM MATERIALS CONVERSION PROGRAM IN RUSSIA

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ABSTRACT

Progress has been made in Russia towards the conversion of weapons-grade plutonium (w-Pu) into plutonium oxide (PuO_2) suitable for further manufacture into mixed oxide (MOX) fuels. This program was started in 1998 in response to US proliferation concerns and the acknowledged international need to decrease the available weapons-grade Pu. A similar agenda is being followed in the US to address disposition of US surplus weapons-grade Pu. In Russia a conversion process has been selected and a site proposed. This paper discusses the present state of the program in support of this future operating facility that will process up to 5 metric tons of plutonium a year.

INTRODUCTION

The United States Department of Energy's (US DOE) Plutonium Materials Conversion Program for the Russian Federation is designed to assist Russia in defining and obtaining a path for the destruction of their surplus weapons-usable Pu. A similar domestic DOE activity is also currently defining a path for destruction of US weapons grade plutonium. These two sister programs arose from the September 1998 meeting between Presidents Clinton and Yeltsin after which they issued a " Joint statement of principles for management and disposition of plutonium designated as no longer required for defense purposes." Presidents Clinton and Putin reiterated the goal of this program at their Moscow summit meeting in June 2000. The US and Russia have each committed to convert 34 metric tons of weapons grade plutonium to forms that are unusable for weapons. Los Alamos National Laboratory (LANL) is lead laboratory for US/Russian collaborations on plutonium conversion of surplus weapons-usable plutonium.

The current economic situation in Russia threatens progress without international support. The DOE and US Congress recognize the value in moving the Russian disposition effort forward. The US is therefore funding significant disposition efforts in Russia.

OVERALL DESCRIPTION

There are two overall paths for converting weapons grade plutonium into the least weapons-usable forms: conversion to fuels for nuclear reactors and immobilization into a form from which reconfiguration into plutonium for weapons is difficult. Figure 1. gives the proposed paths for the US and Russia. This paper addresses the box "Pu Conversion (new)". The difference between the two schemes is largely one of emphasis. Russia considers plutonium a valuable commodity that can be converted to energy in the form of nuclear fuel with only small amounts being wasted, i.e., immobilized. The US considers plutonium a danger that needs to be disposed of safely with smaller amounts being developed as nuclear fuel. For both countries the nuclear fuel is in the form of MOX fuel, a mixture of uranium and plutonium oxides.

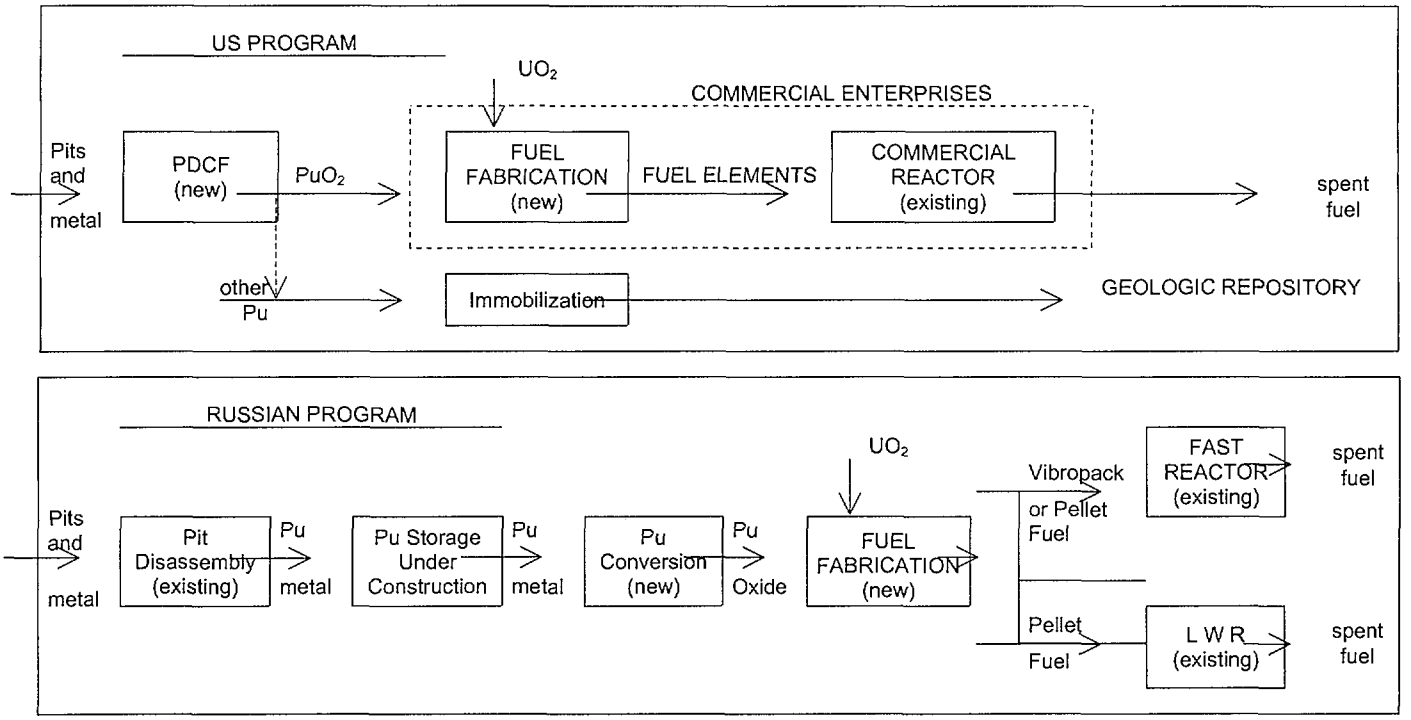

Figure 1. US and Russian Conversion Pathways

Russia has both fast reactors and water reactors that can be used for burning MOX fuel. Fast reactors can use either pellet type fuel or vibro-compacted (vibro-packed) fuel. Vibro-packed fuel is made from plutonium oxide generated using a pyroelectrochemical conversion (molten salt) process. Both this conversion process and the vibro-compaction process for making fuel are relatively simple and require less equipment and processing steps than required to make pellet fuel. Vibro-packed fuel offers a pathway for an early start for burning weapons-grade plutonium in fast reactors. Light water reactors, however, require pellet fuel. Pyroelectrochemical conversion makes a coarse oxide that, while suitable for vibro-packed fuel, has not been demonstrated as suitable for fabricating MOX pellets. It is clear that a decision on fuel types must be made before a final decision on the conversion process can be made. Until this decision has been made, the alternate pyroelectrochemical process is being pursued as well as the main aqueous solution process (1).

PROJECT MANAGEMENT AND LICENSING

Russia and the US have jointly produced a schedule and road map for the overall project to which each party has agreed. A simplified level one schedule is shown in Figure 2. A level 2 roadmap has also been developed.

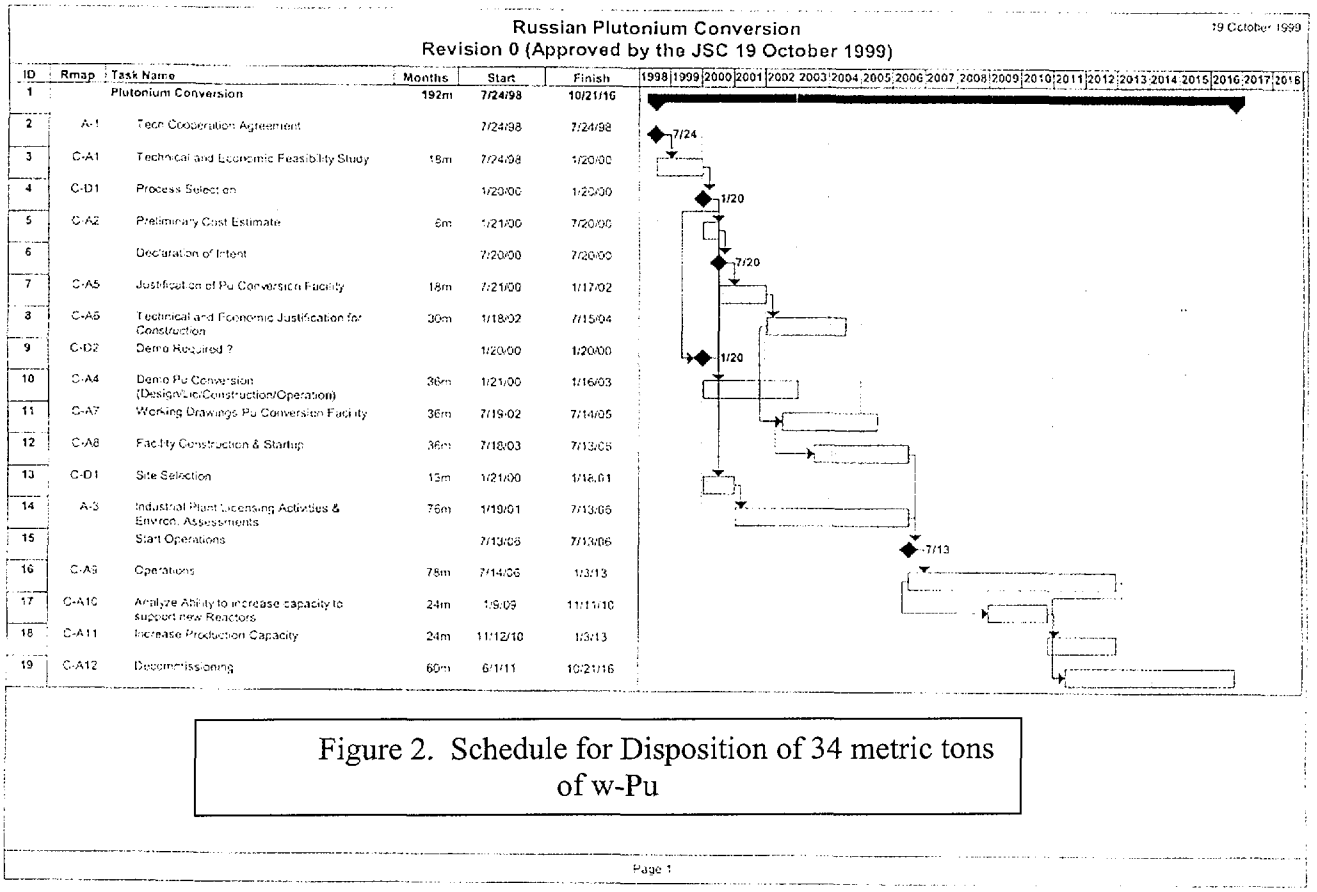

Figure 2. Schedule for Disposition of 34 metric tons of w-Pu

This is an aggressive schedule resulting in the completion of disposal of 34 metric tons of w-Pu by 2012. Workshops have been held on how Russian nuclear facilities are designed, licensed, constructed and commissioned. Preparative work for both demonstration and industrial scale plants is in progress. There are questions as to whether a demonstration plant is essential but we expect resolution of this in the next three months.

The industrial scale plant licensing procedures are outlined in Figure 3. The Technical and Economic Feasibility study has been completed (the US equivalent is Preliminary Design Study) and we are anticipating the Declaration of Intent to be formally issued by MINATOM in the near future (the US equivalent is the Record of Decision). As the French CHEMOX process has been selected for the industrial scale process, the Justification of Investment (the US equivalent is the Conceptual Design Report) has been initiated with French funding (2).

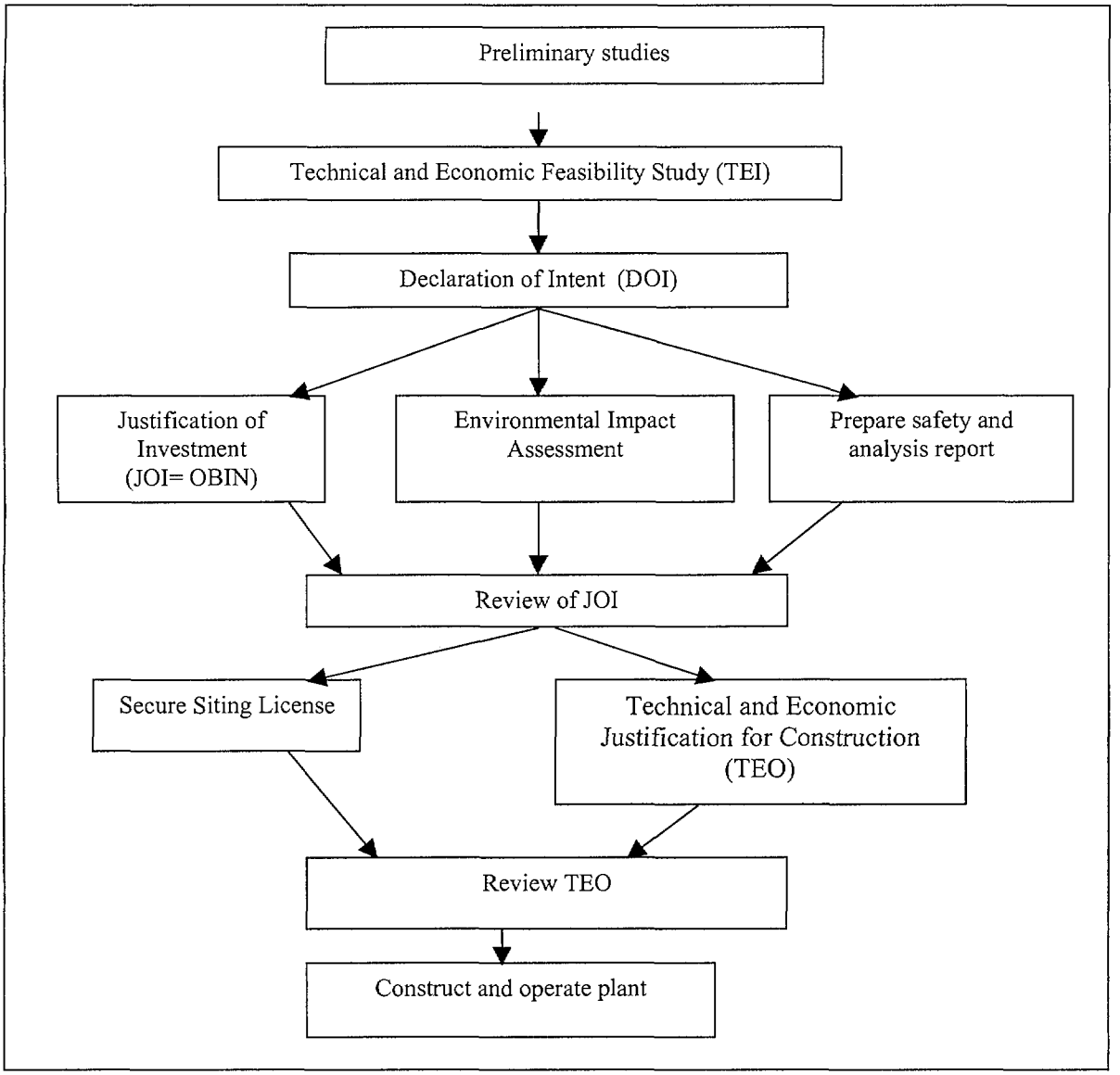

Figure 3. Industrial Scale Plant Licensing Procedures

CHEMISTRY OF CONVERSION

US/Russian multidisciplinary teams have conducted studies comparing efficiency, safety, environmental impact and costs of the various schemes available for the chemistry of the conversion process. This resulted in the May 2000 announcement by the Russian MINATOM that the chosen process for conversion employs an aqueous method with oxalate used as the precipitating agent. This method is used in France, Belgium and the U.K. and is schematically shown in Figure 4.

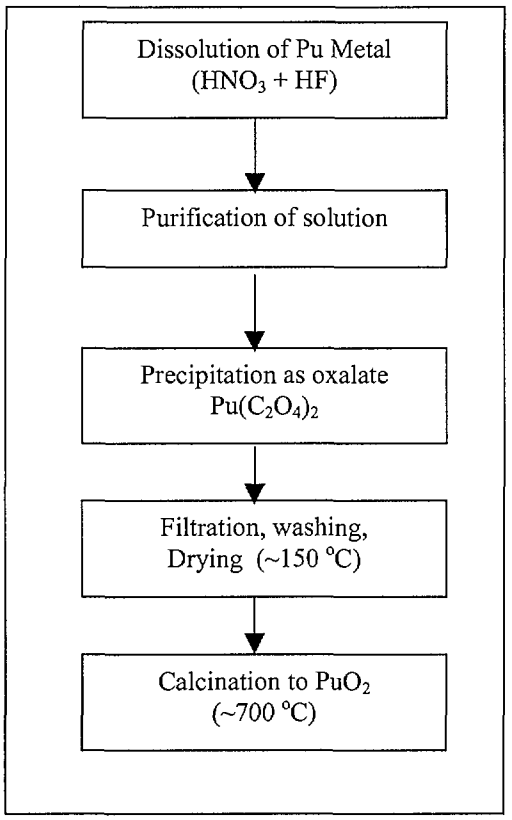

Figure 4. Schematic of chosen conversion process using aqueous system with oxalate precipitation

If the demonstration is implemented, it will be sited at Chelyabinsk-65 Mayak Production Association, south of Ekaterinburg in the Ural Mountains. This is one of the main radiochemical complexes in Russia, including a reprocessing plant, Plant 235. The building selected is number 101. This building was previously used for radioactive chemical processes and has been evaluated for residual contamination. It is the Russian consensus opinion that the building can be decontaminated and renovated to an acceptable condition for the housing of the demonstration conversion procedure.

ENGINEERING STUDIES AND SCALE-UP

Engineering studies have been performed at The State Specialized Design Institute (GSPI) in Moscow. These studies provide pre-conceptual layouts, resource requirements, and environmental impact analyses for the full-scale facility as well as initial cost estimates.

Table I. shows a summary schedule and capacity for the demonstration and industrial-scale plants. The size of the demonstration plant is determined by the needs of the reactors to be first fuelled with

the MOX fuels. The industrial facility is scheduled to start operating in the same time frame as the US Pit Disassembly and Conversion Facility (PDCF).

	Capacity	Schedule
Demonstration facility	~ 350 Kg	Construction and operation 2000-2003
Industrial facility	2MT/Y increasing to 5 MT/Y	Operation begins 2006

Table I. Summary Schedule and Capacity of the Two Plants.

Table II. shows the engineering studies that have been completed by GSPI in support of the engineering for the choice of the conversion process and for the industrial scale plant.

Part	Title
I	Methodology to compare technologies
II	Engineering report on two of the four processes
III	Engineering report on two of the four processes
IV	Cost estimates for processes
V	Technical and cost comparisons
VI	Data for feasibility study for oxalate precipitation process
VII	Model schedule for conversion plant.

Table II. Development Program performed by GSPI in support of choice of conversion process.

THE ALTERNATE PROCESS

Because of the uncertainty induced by the lack of decision on the type of fuel to be produced, an alternate process is under development at the State Scientific Research Center of the Russian Federation, Research Institute of Atomic Reactors (NIIAR) in Dimitrovgrad. For this pyroelectrochemical process (high temperature molten salt), Pu metal is dissolved in a molten salt bath, oxidized, and the resulting plutonium oxide precipitated. This is a dry high-temperature process that can make either plutonium oxide or can be used to co-precipitate mixed oxides of plutonium and uranium. Vibro-packed fuels fabricated from pyroelectrochemically produced oxides have been reactor tested in Russia, but the oxide has not been demonstrated as suitable for pellet fuel.

DEVELOPMENT AND RESEARCH

A laboratory-scale development program for the selection of the conversion process has recently been completed at the A.A.Bochvar All-Russian Research Institute of Inorganic Materials (VNIINM) in Moscow. This research program is outlined in Table III.

Part	Title
I	Aqueous conversion processes
II	Combined process
III	Pyroelectrochemical conversion process
IV	Comparative analysis of MOX fuel produced by different processes.
V	Containers for storage and transport of PuO_2
VI	Radiation and critical safety
VII	Non-destructive assay

Table III. Development Program performed by the Bochvar Institute (and sub-contracted institutes) in support of choice of conversion process.

PACKAGING AND TRANSPORTATION

Naturally storage and some transportation of PuO_2 is inevitable and safety is a major concern. Bochvar is in the process of designing a container in which PuO_2 can be shipped safely to the fuel fabrication facility. In addition, the long-term chemical and physical changes in PuO_2 are being studied.

SAFETY

Safety is of paramount importance in the design, construction, and operation of the new facilities. Preliminary studies have focussed on the areas that are most vulnerable to safety concerns. These safety issues include radiation and criticality, both during normal and abnormal operating conditions. A plan has been established whereby Russia will use US criticality and safety computer codes to validate Russian codes for plant design criteria. The codes to be used initially are BUGLE 96, ISO-PC 2.1 and SCALE 4.4. The institutes that will collaborate with Bochvar for safety issues are the Institute of Physics and Power Engineering, (IPPE), Obninsk and the Russian International Nuclear Safety Center (RINSC), Moscow.

FUTURE DEVELOPMENT

In addition to engineering issues, now that a process has been chosen, it is possible to consider process improvements for the oxalate precipitation process and the pyrochemical process. At a recent US/Russian workshop three general areas have been selected for collaborative development to not only to improve the Russian program but also be valuable to the American program (3). These areas are:

Stabilization oxidation states of plutonium

A recurring challenge in Pu chemistry is the multiple oxidation states (+3, +4, and +6) found in aqueous solution. Many separation processes are based on dissimilar chemical behavior of plutonium in different oxidation states. Current practices to produce Pu solutions with one

oxidation state preferentially stabilized could be improved. Improvements include aspects of plutonium oxide purity, associated waste stream impacts, reagent hazards and process efficiency.

Plutonium metal dissolution

The characteristics that affect the dissolution of Pu and PuO_2 in nitric acid/hydrofluoric acid are incompletely understood. The complexing properties of fluoride exert a catalytic influence on the dissolution. The speed and completeness of dissolution also affect the economics of fuel production. However, fluoride itself is an impurity that can only be tolerated below certain levels (~ 250 ppm). The kinetics and mechanism of fluoride catalysis need to be better understood.

Room Temperature Ionic Liquids (RTILs)

Use of these liquids will assist the pyroelectrochemical process in the removal of gallium from Pu metal. Gallium is added to w-Pu to stabilize the correct phase and must be removed before conversion to MOX fuels. Little is known about the chemical behavior of gallium and gallium oxides in this media due mainly to the practical difficulties associated with experimenting at elevated temperatures (>600°C). A solution to this problem is to study the chemical behavior of the element under less severe conditions using room temperature ionic liquids (RTIL). A room temperature process could potentially decrease operation time, and be less hazardous to the operator.

SUMMARY

Since its inception in 1998 the US DOE Plutonium Materials Conversion Program for the Russian Federation has made progress in defining a path forward for converting for w- Pu conversion to PuO_2 for MOX fuels. The initial engineering and chemical research and development has been completed, a conversion process has been chosen and a site selected for the demonstration and industrial plants.

ACKNOWLEDGMENTS

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