



A MOX Fuel Plant in Russia: The Engineering Work Has Started

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The Moscow summit of the Group of Seven (G7) countries on nuclear matters in April 1996 provided a political framework for one of the most significant of current challenges: ensuring a coherent policy towards the disposition of weapons-grade fissile material resulting from the disarmament efforts of the USA and Russia.

International technical assessments have showed that the transformation of weapons-grade plutonium into mixed oxide (MOX) fuel is a very efficient, safe, non-proliferating and economically effective solution. In this regard, Cogema and Siemens jointly set up a technical programme to address the incineration of weapons-grade plutonium in MOX fuels.

The main aim of this programme is the construction of a MOX fuel fabrication plant in Russia dedicated to weapons-grade plutonium. Such a plant would be based on the two companies' industrial capabilities and experience. The facility would be operated by the Ministry of Atomic Energy of Russia (Minatom), which is a partner in the project with Cogema and Siemens. Minatom is in charge of coordinating the related activities of Russian research and construction institutes.

The project will take into account international standards for non-proliferation, safety and waste management. French and German officials restated this position during their last bilateral summits held in Fribourg in February 1997 and in Dijon in June 1996.

Minatom and the whole Russian nuclear community have already expressed their interest in cooperating with Cogema and Siemens in the field of MOX fuel. This follows governmental

agreements signed in 1992 by French, German and Russian officials. Russia has already been carrying out research and development on MOX fuel fabrication and utilisation for many years.

Overall, the Cogema–Siemens MOX fuel proposal gives a realistic answer to the management of weapons-grade plutonium with regard to the technical, industrial, cost and schedule factors.

Experience in the Field of MOX Fuel

Plutonium recycling in the form of MOX fuel is now a mature industry in Europe, with successful operational experience in large-scale MOX fuel fabrication plants and with MOX fuel loading in reactors in both France and Germany.

Up to 22 reactors in Europe are presently loaded with MOX fuel and up to 50 are expected to be in the near future. In France, 11 reactors are presently using MOX fuel, and up to 28 reactors will be by 2005. In Germany, seven reactors are loaded with MOX fuel at present, and a total of 13 to 17 will be by 2005. Four reactors in Switzerland and Belgium are also using MOX fuel.

To carry out this MOX fuel loading programme, Western European countries have equipped themselves with state-of-the-art MOX fuel industrial capabilities. France is currently operating two plants, one at Cadarache and the other one, MELOX, located on the Marcoule site. Belgium is operating one plant on the Dessel site.

The Cadarache MOX fuel plant has a capacity of 40 t per year, of which 10 t are FBR fuels. This plant has already processed more than 30 t of plutonium into liquid metal reactor (LMR) and LWR fuels. This gives Cadarache a flawless

industrial reference for plutonium recycling.

The MELOX plant, brought on line in 1995, represents the world's most efficient and modern MOX fuel fabrication plant, truly bringing MOX fuel fabrication to industrial maturity. Its new automated design enables the plant to produce assemblies at a rate well above one 500 kg assembly per day. MELOX is scheduled to reach a capacity of 160 tHM per year. Ongoing adjustments at MELOX will take its capacity to over 250 tHM/y by 2000.

The Belgian Dessel MOX fuel fabrication plant has a capacity which reaches over 35 t of MOX fuel per year. It should be noted that each one of these three plants is or will soon be adapted to the fabrication of both PWR and BWR assemblies. The MIMAS fabrication process implemented in these three plants (improved in the case of MELOX to become the Advanced MIMAS process) is therefore well established and qualified.

As for Germany, MOX fuel fabrication experience dates back to the mid 1960s. Since then the two-line Hanau plant has delivered 6 tHM of FBR MOX fuels and about 160 tHM of LWR MOX fuels, which represents the industrial recycling of more than seven tonnes of plutonium.

Unfortunately, the Hanau facility, which was in use from 1972 and reached a final annual MOX fuel capacity of about 25 t, had to shut down for political and public acceptance reasons in the early 1990s. For the same reasons, the construction of the new Hanau MOX fuel plant, which was nearing completion, had to be cancelled.

The achievement of complete mastery of the fabrication process for PWR and BWR MOX fuels, and the current in-core performance of such fuels, have led Cogema and Siemens to fully understand the benefits of industrial plutonium recycling. Advantage can be taken of this experience in the fabrication and utilisation of MOX fuel incorporating weapons-grade plutonium.

Russian MOX Fuel Experience

Russia began using plutonium as a nuclear fuel in the second half of the 1950s for small fast research reactors. Systematic study of plutonium fuel began in 1970 in the BOR60 reactor. This programme committed the Russian nuclear industry to the plutonium-fuelled fast breeder reactor as the most efficient way to expand nuclear fuel resources.

Large batches of MOX fuel pins fabricated using different technologies with plutonium of various isotopic compositions have been tested in the BOR60 reactor. With continued successful MOX fuel tests,

Russian researchers expanded the scope of the tests to the prototype fast reactors BN350 and BN600, which have generally been fuelled with enriched uranium. The Paket plant, located on the Mayak site near Chelyabinsk, was completed in 1993; it is an industrial demonstration plant capable of producing up to 40 plutonium fuel assemblies annually.

MOX fuel development has progressed to the initial design and construction phase of three or four units of the BN800 design of fast power reactor, and of a MOX fuel plant known as Complex 300, designed to produce up to 900 assemblies per year. However, construction of Complex 300 has been halted due to lack of finance.

As regards plutonium utilisation in thermal reactors, Russia is presently carrying out experimental work and analysis. The studies under way will compare the use of MOX fuel in thermal reactors with its use in fast reactors, taking into account Western European experience.

Bilateral Cooperation With Minatom

The common experience of and mutual understanding between Cogema, Siemens and Minatom have resulted in a broadly shared MOX industrial culture. Moreover, since the beginning of the 1990s France and Germany each increased their bilateral cooperation with Russia on MOX fuel.

During the past four years, the bilateral German/Russian and French/Russian cooperation studies came to similar results:

- The loading of MOX fuel made from weapons plutonium into Russian VVER-1000 reactors, especially the Balakovo units, and the existing fast reactors, especially BN600, is feasible.
- A pilot scale MOX fuel fabrication facility should be constructed, and concepts for such a plant were prepared: TOMOX 1300 on the French/Russian side, MOX Pilot Plant within the German/Russian cooperation.

As a result, Russia, Germany and France decided to combine their efforts in a joint trilateral initiative for collaboration in the peaceful use of weapons plutonium in Russia.

Consequently, Siemens and Cogema announced in late 1996 a joint project together with Minatom to establish the basis for processing initially 1300 kg of weapons-grade plutonium per year starting in 2001 or 2002, and loading the MOX fuel assemblies produced into Russian reactors. The project consists of the design, construction and start up of the first MOX fuel fabrication plant in Russia: the DEMOX plant.

Programme Overview

The French–German weapons-grade plutonium disposition programme, with the assistance of Minatom, is based on the existing industrial experience of the partners in MOX fuel, as described above. The proposal of the Cogema–Siemens alliance for MOX fuel use in Russia comprises two main elements, one for the short term and another for the medium term.

For the short term, construction of the DEMOX fabrication plant will be performed. In the medium term, the possibility of constructing a large MOX fuel plant in Russia to allow the recycling of weapons-grade plutonium in a greater number of reactors will be investigated. This will include consideration of new reactor designs, such as the VVER-640 and the BN800, which would be well-suited to use MOX fuel.

The design and construction of the planned MOX plant, DEMOX, will benefit from the experience of Cogema and Siemens in the field of MOX fuel, which will result in savings of time and money. Specifically, this means that DEMOX will:

- utilise the MELOX Advanced MIMAS fabrication process;
- make optimal use of the Hanau MOX plant's design and unused equipment;
- incorporate the technological and commissioning experience from the Cadarache and MELOX plants.

Minatom will provide PuO₂ to the fabrication plant and will be the responsible for the operation of the BN600 and VVER-1000 reactors.

DEMOX Plant Construction

The joint Cogema–Siemens project for the construction of DEMOX began in March 1997. For this project a joint French–German team was created and is working in Cogema's offices led by a German project manager.

The programme comprises three different phases: firstly, a process of harmonisation and consolidation, and completion of the basic design; secondly, the construction phase; and thirdly, operation of the plant by Minatom.

The first stage of phase one was completed at

the end of June 1997 by the joint French–German team. This included harmonising the existing bilateral projects (MOX Pilot Plant and TOMOX 1300), and establishing a comprehensive blueprint for the use of Cogema's Advanced MIMAS process with the existing Hanau equipment, covering various factors such as safety concepts and operability.

The joint team has also started working with the Russian side to prepare basic data in anticipation of beginning the preparation of the basic design before the end of 1997. The entire first phase of the programme is due to be completed in June 1998, by which time the basic design will be finished.

Safety is one of the most important concerns of the Cogema–Siemens–Minatom cooperation. Appropriate international safety standards will prevail for radiation protection of workers and staff, environmental protection, physical protection, safeguards, waste treatment, etc. These standards will be implemented with the help of the Russian institutes involved in the project.

Cogema and Siemens, together with their partner Minatom, will ensure that the assessment and completion of the financing scheme for the project proceed at the same rate as the technical studies. This will allow a decision on the construction of DEMOX to be taken as soon as 1998.

Conclusion

By 2001 an entire industrial system for the peaceful disposition of weapons plutonium could be available in Russia, based on the fabrication of MOX fuel using weapons-grade plutonium and the use of the MOX fuel assemblies in Russian reactors.

This is the best solution for the peaceful disposition of weapons plutonium in terms of both economy and speed, due to the unique experience of Cogema and Siemens in the field of MOX fuel, the ability to use the Hanau MOX fuel plant's existing design and equipment, and the assured support for start up and operation provided by the experience gained in MOX fuel plants where the same Advanced MIMAS process has already been implemented.