

FROM WEAPONS PLUTONIUM TO MOX FUEL : THE DEMOX PROJECT

COGEMA : C. SEYVE / L. GAIFFE

MINATOM : E. KUDRIAVTSEV / Y. KOLOTILOV

SIEMENS : G. BRÄHLER / H. METTLIN

The G7 Moscow summit in April 1996 on nuclear matters provided a political framework to deal with one of the most significant challenges facing the nuclear industry today : To find a solution to the weapons grade fissile material disposition issue resulting from the disarmament effort by both the USA and Russia.

International technical assessments have shown that the transformation of weapons grade plutonium into MOX fuel is a very efficient, safe, non proliferating and economically effective solution.

Since 1992, both France and Germany have developed bilateral cooperation programs with Russia in order to assess the feasibility of recycling weapons grade plutonium in Russian reactors.

These cooperation studies came to a similar conclusion: The loading of MOX fuel (made from weapons plutonium) into Russian VVER 1000 and fast reactors, in particular the Balakovo units and the BN 600, is feasible.

Both programmes also developed concepts for pilot plants to fabricate fuel for these reactors.

In autumn 1996, Russia, Germany and France decided to combine their efforts in a joint initiative for the peaceful management of weapons plutonium in Russia.

Consequently, COGEMA and SIEMENS have launched, with the support of MINATOM, a joint project, which includes the design, construction and start-up of a MOX demonstration plant in Russia : The DEMOX project.

COGEMA AND SIEMENS EXPERIENCE IN THE MOX FIELD

The DEMOX facility will implement COGEMA's A-MIMAS (Advanced MIMAS) process for VVER fuel fabrication. This process has been developed for 30 years by COGEMA and Belgonucléaire and has been optimized and implemented in the MELOX plant . Up to now, over 1 000 MOX Fuel Assemblies fabricated by A-MIMAS or MIMAS process have been loaded into European reactors. Currently 30 out of 31 European reactors working with MOX fuel are loaded with fuel fabricated by COGEMA and Belgonucléaire.

For BN fuel fabrication, COGEMA experience is also available. This fabrication has been developed for 30 years in the Cadarache facility, accumulating a manufacturing experience of 135 tHM of FNR (Fast Neutron Reactor) fuel.

SIEMENS has gained substantial experience in MOX fuel fabrication over the past 30 years: it has produced 160 t of LWR MOX fuel and 8 t of FNR MOX fuel. Its first industrial facility has been in use in Hanau since 1972, with a final capacity of 25 t per year. The knowledge and skills accumulated over this period were used in the design and construction of a new larger plant in Hanau (capacity: 120 t of Heavy Metal – HM – per year) which was nearly completed in 1995. This new plant has never started due to political factors. The other plant was shut down in the early 1990's for the same reasons, but has been restarted in 1998 for clean out: processing of the plutonium now in storage into MOX pellets, rods and assemblies.

RUSSIAN EXPERTISE IN THE MOX FIELD

The use of plutonium as nuclear fuel started in Russia in the second half of the 1950's.

Since then, Russia has gathered a very diversified experience in both fabrication and irradiation: see Table 1. This experience pertains to experimental or prototype programs.

Concerning the industrial scale experience, the construction of a large MOX Fast Neutron Reactor fuel fabrication facility was well advanced in the 1980's (complex A 300 at Mayak). However, the construction was suspended together with the BN-800 program.

Table 1 : Russian expertise in the MOX field

Facility	Location	Annual capacity	Manufacturing process	Reactor loaded	Number of MOX FA* loaded (Pu mass)	Year loaded
VNIINM	Moscow	Pilot scale	Co-milling	FNR : BOR 60	(a few tens of kg)	1973
			Plasma chemistry	FNR : BOR 60	2 fuel pins (1 kg)	1981
				PWR : MIR	(a few hundred g)	1992
			Ammonia co-precipitation	PWR : MIR	(a few hundred g)	1992
RIAR	Dimitrovgrad	1 ton MOX	Pyrometallurgy (vibrocompaction)	FNR : BOR 60	(a few tens of kg)	1975
PAKET	Cheliabinsk / Mayak	10 -12 FA's 300 kg MOX	Carbonate co-precipitation	FNR : BOR 60	(10 kg)	1980
			Co-milling	FNR : BN 350	10 FA's (80 kg)	1980
			Ammonia co-precipitation	FNR : BN 350	(70 kg)	1980
				FNR : BN 600	8 FA's (80 kg)	1992
Upgraded PAKET (93)	Cheliabinsk / Mayak	40 FA's 1 ton MOX	Co-milling	FNR : BN 600	14 FA's (100 kg)	1990's
Complex A 300	Cheliabinsk / Mayak	60 tons MOX (50% complete)	—	FNR : BN 600	—	—
	Krasnoyarsk	Planned	—	PWR : VVER 1000	—	—

DEMOX PROJECT

Objective

DEMOX project concerns the fabrication of MOX fuel from plutonium (and uranium) oxide.

It is an industrial demonstration plant having the following characteristics:

* Fuel Assemblies

- Built in Russia.
- Use of PuO₂ prepared (by an upstream facility: CHEMOX) from Russian W-Pu
- Able to produce fuel for existing Russian VVER-1000 reactors and possibly for BN-600 reactors (processing at least 2 tPu/y, corresponding to 52 tHM/y of MOX).
- Based on West-European industrial experience and on Russian expertise, as described in the corresponding paragraphs here above.
- In operation in early 2000's

The aim of DEMOX is to validate on an industrial scale the fabrication of MOX fuel from W-Pu in Russia. The operation of this plant by the Russian party will also enable the operator to master the safe fabrication of MOX fuel on an industrial scale.

The extension of the MOX fuel fabrication capability (up to 5 t Pu/y) is envisaged. It would allow the plutonium to be disposed of on a quicker time scale, in a greater number of reactors.

DEMOX project basic data

The main basic data of the project are as follows:

- Type of assemblies and capacity:
Russia intends to start the program for the use of W-Pu by introducing MOX fuel into 4 existing VVER 1000 and 1 BN 600 reactors.
In the studies already performed, the corresponding capacity has been considered :
 - 1.76 t Pu/year (51 t HM/y) of VVER-1000 fuel
 - 0.24 t Pu/year (1.2 t HM/y) of BN-600 fuel
- Site location is under decision at the moment. The sites considered are MAYAK and KRASNOYARSK (GKhK).
- The reference process chosen is Advanced-MIMAS process.
- A maximum use of the equipment available from SIEMENS Hanau new plant will be made.

Schedule

The schedule of the project is shown on Figure 2. The explanations concerning each phase are given in the paragraphs below.

	1997				1998				1999			
	Tri 1	Tri 2	Tri 3	Tri 4	Tri 1	Tri 2	Tri 3	Tri 4	Tri 1	Tri 2	Tri 3	Tri 4
Harmonization (COGEMA / SIEMENS)												
Consolidation with Russian party												
Basic Design												
Consolidated Cost Estimate												
Setting up of financing scheme												
Milestone for construction												

Figure 2 : Schedule of DEMOX project

Harmonization Phase

The Harmonization Phase was performed by COGEMA and SIEMENS on the basis of the studies performed separately in the previous years.

An integrated Project Team, including specialists from both COGEMA and SIEMENS with a SIEMENS project manager, has been working at COGEMA's offices in France.

The aim of this phase was to assess the feasibility of the implementation of COGEMA's A-MIMAS process in SIEMENS Hanau equipment.

DEMOX block diagram of process functions is defined by A-MIMAS process from powder entrance to sintering operation. The first step of the Harmonization work was to assess whether Hanau equipment is suitable to implement these process steps (see figure 3). Concerning the sintered-pellet area, Hanau equipment is assessed on the basis of technological requirements. Concerning the rod fabrication and control area, Hanau equipment will be assessed according to Russian specifications.

Concerning the front-end of the plant (reception and storage of incoming products) and the assembly area, the corresponding equipment is not available from Hanau and has to be newly constructed according to Russian specifications.

The results of the assessment are shown on Figure 3. The main conclusions are that most of available Hanau equipment can be used in DEMOX, with only minor adjustments (e.g. adjustment of sintering temperature profile) to adapt it to A-MIMAS process.

From these results was deduced the list of selected Hanau equipment.

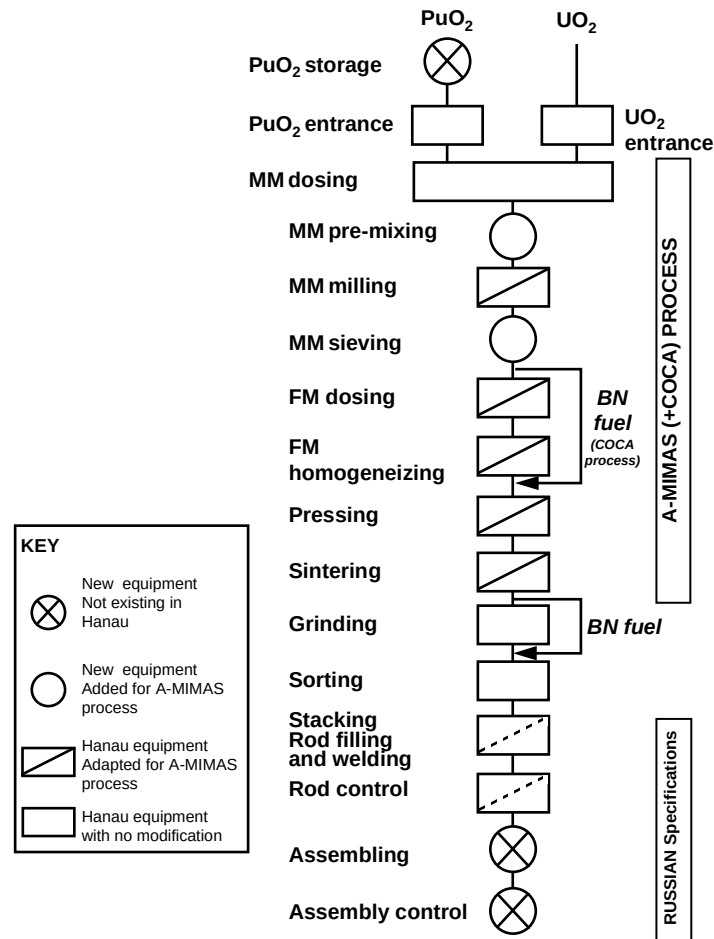


Figure 3 : results of the harmonization phase

Another result of the Harmonization Phase is a draft of the Basic Data for the Basic Design (defining the capacity of the plant, the operating parameters, transport packagings ... to be taken into account in the design).

The Harmonization Phase also enabled to examine the possibility of participation of other partners from other countries. For instance, the DEMOX project team has validated the Russian - AECL feasibility study of a CANDU fuel fabrication line within the DEMOX plant.

Consolidation Phase

The aim of the Consolidation Phase is to prepare all the necessary data to be able to start the Basic Design. This involves the participation of the 3 parties: MINATOM, COGEMA, SIEMENS.

The Consolidation Phase is in progress and covers the following tasks:

- completion and full validation of the Basic Data (already partially defined in the Harmonization Phase);

- definition of the design principles regarding the different engineering fields: safety, layout, nuclear ventilation, electrical networks, automatic control, accounting of nuclear matters, safeguards ...
- preparation and validation of the first set of Russian documents necessary to start the design phases within Russia Federation (including the "justification of investment", site evaluation and first cost estimation).

Basic Design

The objective of the Basic Design is to have an initial definition of the facility, satisfying the Basic Data that resulted from the Consolidation Phase. An important result of this Phase will also be a consolidated cost estimate.

During the Basic Design, the three parties will be working together. COGEMA and SIEMENS will perform in particular the process and mechanical equipment studies pertaining to COGEMA and SIEMENS supplied equipment according to the Russian requirements; the Russian party will perform the process and mechanical equipment studies pertaining to the functions of Russian design (in particular assembling), and also site, layout, utilities, network studies.

The Basic Design Phase is expected to provide first result in late 1999 to validate the parallel project financing.

CONCLUSION

In early 2000's, a whole industrial system for the peaceful use of weapons-grade plutonium can be started in Russia.

The DEMOX project will benefit from :

- the COGEMA/SIEMENS experience in the industrial MOX fuel fabrication field,
- the Russian expertise the handling of plutonium and fuel fabrication,
- the most updated process implemented on an industrial scale in the world: Advanced-MIMAS,
- an optimal use of existing Hanau equipment,
- the support of the international community.