Transportation by Road of Plutonium as a Reusable Product

J.L. Charles
COGEMA

O. Konirsch
Transnucléaire

INTRODUCTION

Since the very beginning of its nuclear programme, France has been firmly committed to recycling valuable materials contained in the spent nuclear fuel. Uranium has a fissile content close to natural uranium and can replace it as a raw material, while plutonium can be mixed with natural or depleted uranium giving rise to a new fuel: the MOX fuel.

Initiated over 30 years ago, such a strategy was fisrt aimed at recycling plutonium in fast neutron reactors. In the mid-1980s, as the fast reactor programme appeared to be delayed, the French utility EDF decided to implement plutonium recycling in Pressurized Water Reactors (PWRs) through MOX fuel.

At present, in France, a large-scale recycling industry has been set up, including reprocessing plants, MOX fuel fabrication facilities and MOX-loaded reactors. This industry is not only devoted to domestic needs but serves foreign utilities as well, such as in Germany, Belgium, Switzerland and Japan.
Plutonium by road transportation activities must be included in this picture. Due to the particular nature of the material, special care must be given to the safety and security aspects. Maybe more than other nuclear material transport, it is a specialist's business.

This paper will describe the current status of the plutonium recycling reality and the implied plutonium transports, will remind the different aspects making PuO2 and MOX fuel transportation a mature industrial activity and will consider the foreseeable future trends.

PLUTONIUM RECYCLING: THE CURRENT STATUS

The French closed fuel cycle strategy is relying on three major industrial steps which are to achieve the same flow of recycled material. Thanks to reprocessing, MOX fuel manufacturing and dedicated PWR reactors, recycling allows reduction of the demand for natural uranium, and significantly reduces the volume and potential radiotoxicity of long-lived nuclear wastes.

Reprocessing

EDF's spent fuel undergoes reprocessing in the UP2 plant at La Hague, operated by COGEMA :

- The UP2 plant, which started operation in 1966, had reprocessed various types of fuel up to 1987, after which it was dedicated to LWR fuel only. In order to meet the requirements of France's nuclear power programme, the annual capacity of UP2 has been recently increased from to 400 tons to 800 tons by adding new processing facilities. Moreover, there is another reprocessing plant at La Hague, operated by COGEMA.

- The UP3 plant successfully started operations in 1990 and its first 10 years of operation, has been assigned to the reprocessing of 7,000 tons of spent fuel from other European and Japanese utilities. Its production is ramping up according to schedule from 350 tons reprocessed in 1991 to full capacity operations in 1995.

  As of the end of 1994, total reprocessed fuel at La Hague facilities amounts to near 7,000 tU. Plant reliability and availability are well demonstrated by reprocessed quantity.

tons per year	UP2-800	UP3
1994	573	700
1995	750	800

This unique industrial complex is able to reprocess about 1,600 tons of spent fuel, serving 60 to 80 LWRs and offering high-quality recyclable energetic products and conditioned residues. In the French case, the reprocessed quantity will yearly yield 8 to 8.5 tons of separated plutonium.

MOX Manufacturing Facilities

Mixed oxide fuel is now commercially well-established and is playing an important role in France. Since a number of years, plutonium oxide is routinely transported from La Hague to the MOX fabrication facilities, and more than 200 tons of fresh MOX fuel assemblies have been transported to the EDF reactors.

a) MELOX

The MELOX plant (with a nominal capacity of 120tHM/years which can be easily extended to 160tHM/y) is located in Marcoule, enters in service in 1995 and includes all manufacturing operations from UO2 and PuO2 powders reception to assembly delivery. It appears as the first high-throughput MOX fuel manufacturing facility to be put into operation in the world. It is designed to fulfill the requirements coming from foreseeable trends in both fuel management and modern safety and environment concern. MELOX will be able to supply MOX assemblies for 20 to 25 reloads of EDF 900 MWe units per year, which corresponds to the 8 to 8.5 tons of plutonium that are separated at La Hague.

b) Others plants

MELOX has taken full benefits on the outstanding MOX fuel experience of the existing facilities at Dessel and Cadarache. The activity of the two plants, Belgonucleaire Dessel and COGEMA Cadarache will be adapted with the total need for MOX fuel (EDF and other customers.).

The fabrication of MOX fuel was initially realized in the BN Dessel plant (with an annual capacity of 35 tons). COGEMA Cadarache plant was previously dedicated to FBR fuel, but since 1989, has been modified to produce MOX fuel in parallel with the assemblies of FBR. It will reach a 30 tons production this year.
Even if the MELOX plant is at full operation, the MOX fuel fabrication capacity will not be enough to absorb the plutonium separated in France by the reprocessing of French and foreign fuel. COGEMA considers the possibility of increasing its capacities in order to serve customers who want their MOX fuel to be fabricated in France.

Dedicated Reactors

The aim of EDF's strategy is to avoid the creation of a plutonium stockpile larger than what is needed by global operational conditions (i.e. about 2 years of normal utilization). This means that the same flow of plutonium should exist simultaneously at the outlet of reprocessing plants, at the throughput of the fabrication facilities and at the input of moxified reactors.

A generic safety report was issued at the end of 1986 which demonstrated the feasibility of recycling MOX with a maximum ratio of 30% MOX assemblies in each reload of one-third of the core (annual cycle). This corresponds to 16 MOX assemblies per reload, out of 52. The average concentration of plutonium is limited to a level of 5,3%.

A total of 16 reactors are already licensed in France to use MOX fuel (7 units in 1994, increasing to 9 in 1996 and to 16 in 1998). Twelve additional reactors are technically designed to receive MOX fuel, but they still have to undergo the licensing process (the first of these might be the four Chinon B units).
Twenty to twenty-height reactors could receive MOX fuel, thus absorbing the entire plutonium output of COGEMA's UP2-800 reprocessing plants and requiring most of the MELOX capacity.

As it can be seen, plutonium transport, which includes PuO2 transportation from La Hague to fabrication units and MOX fuel transportation from the latter to dedicated reactors, have to deal with year quantities: up to 16 tons of plutonium oxide powder (including foreign utilities) and, in the French case exclusively, some 300 MOX fuel assemblies in the coming years.

TRANSPORT ORGANIZATION

A comprehensive transport organization has been set up, which clearly defines the role of the different actors. It includes EDF, as the final customer, COGEMA as the general coodinator of the Transport Organization, and its subsidiary TRANSNUCLEAIRE, which designs and supplies packagings.
TRANSNUCLEAIRE performs, with affiliated road transport companies, transport operations.

COGEMA and TRANSNUCLEAIRE have developed "transport systems" both for PuO2 and MOX fuel which now operate on a high level standard, fully complying with national and international regulations. In continental Europe, transport of plutonium is performed by road. The various elements of the systems have been designed in order to ensure radiological protection (gamma and neutron), to allow fully automated loading operations and to guarantee a high level of physical protection.

They are briefly described below.

PuO2

The "FS 47 system" includes the following equipment for each transport unit:

- A series of 10 FS 47 packagings licensed as type B(U)F in France, Germany, Belgium and Japan;
- An internal rack capable of accommodating the packagings inside the transport container;
- A transport container with ISO 20 inch dimensions fitted to the trailor by means of special securing devices.

Special design trucks are used for the transport. The FS 47 packagings have a capacity of 17 kg of fissile Pu, and an overall weight of 1.5 tons. So as to increase the physical protection of all the process and to reduce the exposure to personnel, the operation of the FS 47 system is fully automated at La Hague and MELOX plants.

MOX Fuel

The FS 69 packaging is designed for the delivery of fresh LWR MOX fuel assemblies to power plants in a similar way to that of commonly used UO2 fuel assemblies. It is licensed to transport two PWR 900 MOX fuel assemblies containing altogether 75 kg of plutonium. It consists in:

- An external body composed of a lower part (caisson) and a removable upper part (lid);
- A cradle suspended to the caisson by means of elastic bearings, the numbere of which is in relation with the mass of the fuel assemblies, thus protected from external shocks and vibrations;
- A housing providing the two lodgements of the fuel assemblies, fixed to the cradle, able to tilt in a vertical position and equipped with two doors pivoting longitudinally to give access to the fuel assemblies.

Each packaging weighs 5 tons and 4 units are grouped in a protective container. The packagings are stacked on two levels and are secured on the floor and the walls. As a result, batches of eight PWR 900 MOX fuel assemblies are transported with a security truck.

Since plutonium oxide and MOX fuel are classified as category I materials, under the incentive of IAEA recommendations, a set of stringent physical protection regulations have been developed in the European countries involved in plutonium transportation, in order to guarantee that appropriate security measures are applied throughout all the various operations. These measures mainly concern systematic escort and a monitoring network for real-time follow-up of the cask's itinerary.

In the same way, great importance is attached to the guarantee that regulations are correctly complied with. Quality Assurance programmes have been set up for design, fabrication, testing, documentation, use, maintenance and inspection activities related to packagings and transport operations.

FUTURE TRENDS

Although to-date plutonium transports are performed on a large scale with sometimes comfortable safety margins, some trends are likely to make further evolution necessary.

First, as a result of the continued technical and economical optimization of the fuel cycle, EDF and other utilities fuel characteristics are evolving. Increased burn-up trend for spent fuel will induce higher constraints on PuO2 transportation activities :

- Residual thermal power per kg of separated plutonium;
- Gamma and neutronic radiation;
- Criticality.

Accordingly, the same constraints will apply to MOX fuel elements, coupled with a foreseen increase of MOX fuel burn-up, which induces a higher plutonium content. On the other hand, new trends in ICRP recommendations and occupational and public exposure regulations are to be complied with.

The diversified experience gained by COGEMA and its affiliated companies in all sectors of the fuel cycle gives evidence that the foreseen evolutions will be coped with successfully.

CONCLUSION

Transportation of plutonium recovered through reprocessing and MOX fuel assemblies to be loaded in dedicated reactors is an unavoidable step in the recycling strategy. The acquired experience, spanning over 30 years, makes it now a commonplace activity. In the French context, as of end of 1995, near 12 tons of plutonium and 500 MOX assemblies will have been recycled. These important quantities already transported, handled under high safety and physical protection standards, demonstrate the reliability of the applied organization.

Session V-2: Packaging Systems—Shipping Campaigns II