



The Transportation of MOX Fuel

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Plутonium recycling in the form of mixed oxide (MOX) fuel is a mature industry in Europe, with successful operational experience in MOX fuel fabrication plants and with MOX fuel loading in reactors. Today 22 reactors in Europe are operating with MOX fuel, of which eleven are located in France, seven in Germany, and the remainder in Switzerland and Belgium.

Fabrication plants are located in three European countries. In France there are two plants, one at Cadarache and the other located on the Marcoule site. Belgium is operating one plant on the Dessel site. In the UK, MOX fuel is fabricated at Sellafield. Presently, German reactors are loaded with assemblies fabricated at Dessel and Sellafield. From Dessel, transport is by road. Transports from the UK are made by road, then sea, then road again.

Regulatory Requirements

Due to the high plutonium inventory of MOX fuel assemblies the shipments have to be performed to the most stringent safety and security (physical protection) standards. Packages and transport operations have to be in compliance with recommendations established by the International Atomic Energy Agency (IAEA) for the safe transport of radioactive materials.¹ Such recommendations are introduced into mode-specific international regulations, such as:

- The European agreement concerning the International Carriage of Dangerous Goods by Road (ADR).
- The International Maritime Dangerous Goods (IMDG) code.

Physical protection requirements are basically laid down in the IAEA document INFCIRC 225,

Revision 3, and are further detailed in national regulations and guidelines which are classified “restricted”. MOX fuel shipments fall into the highest security class (category I), for which a large number of technical and administrative requirements have to be met. In addition, for maritime transports, the INF-Code² of the International Maritime Organisation (IMO) has to be observed. This code contains provisions for ships transporting irradiated nuclear fuel, plutonium and high level radioactive waste.

Packages

Packages are designed to meet the Type B criteria as set out by the IAEA.¹ This means that they are safe both in normal and accidental conditions of transport. The package utilised for shipments to German reactors has a capacity of two PWR or eight BWR MOX fuel assemblies.

Road Transport System

Security during transport is achieved by a combination of

- an armoured transport vehicle,
- an armoured escort vehicle,
- an armoured control centre,
- communication lines between vehicles, control centre and police,
- vehicle tracking.

In addition, intensive training of drivers, guards and control centre operators is vital for the security of transports.

Vehicle

The Nuclear Cargo + Service (NCS) security vehicle “SIFA” is a tractor/trailer combination with five



Figure 1. The NCS security vehicle and an NCS escort vehicle.



Figure 2. Inside the NCS transport control centre.

axles. Both driver cabin and load compartment are armoured (see Figure 1). The load compartment dimensions are 2050 x 2300 x 6070 mm, and the maximum payload is 14 tonnes.

In order to allow a variety of materials to be transported, the security concept does not rely on specific features of LWR MOX fuel or the packaging. In view of the increasing number of shipments, a transport vehicle tailor-made for LWR MOX fuel would be advisable. Such a specialised vehicle is in preparation.

Communication

There are voice communication lines between the vehicles, from the vehicles to the control centre, and from both the vehicles and the control centre to police offices. In addition sensor information (door locking, alarms, etc.) is automatically transmitted to the control centre.

Vehicle Tracking

The location of the transport vehicle is identified by a global positioning system (GPS) satellite navigation sensor, and the location data are transmitted by Inmarsat C satellite communication to the NCS control centre at Hanau, Germany. The

location data are displayed on digitised maps (see Figure 2). A special feature of the system developed by NCS is the high frequency of data reports compared to other tracking systems.

Training of Staff

The level of requirements for education and training of staff members involved in security class I shipments is unique in the transport business. There is a large number of subjects which they have to be familiar with, ranging from self defence to radiation protection. There are short intervals of, in some cases, only three months before re-training. Training comprises a substantial fraction of the total working time.

During one transport operation a total of eight trained people are continuously involved in the shipment, both in the vehicles and the control centre.

Transport by Sea Vessel

About four years ago, air shipment of plutonium from and to Germany was effectively banned following decisions made by the German licensing authorities. Therefore a concept for sea transport, specifically for shipments between the UK and



Figure 3. The “Arneb”, a Ro-Ro vessel licensed for INF2 and security category I shipments.

Germany, had to be developed. It was clear that the normal method of shipping a container, with its typical loading/unloading procedures, was not possible in view of the German security category I requirements.

The solution was to ship the NCS security vehicle on board a specialised roll-on roll-off (Ro-Ro) vessel. In this way, security on board the ship was assured and interfaces otherwise occurring during transportation were avoided.

A suitable vessel, the “Arneb”, was selected and modified according to NCS specifications, to comply fully both with the INF-code and security requirements (see Figure 3). After a very intensive evaluation of all technical, logistical and regulatory aspects, the project was accepted by all organisations involved. The first security category I sea transport between the UK and Germany took place in October 1996.

Transport Experience

Security class I shipments with the NCS transport vehicle have been performed since 1982. Since

then about 520 000 km of transport experience have accumulated, of which one-third involved LWR MOX fuel assemblies. More than 150 shipments of MOX fuel have been performed from three manufacturers to nine destinations. Since October 1996, five road/sea/road shipments from the UK to Germany or vice versa have been performed.

All transports were carried out without events of particular importance as far as safety and security is concerned. There were two Greenpeace actions related to MOX fuel shipments in 1997 at a German port. However, these did not substantially delay transport operations.

References

1. *Regulations for the Safe Transport of Radioactive Material (1996 Edition)*. IAEA Safety Standard Series, No. AT1.
2. *Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium and High Level Radioactive Wastes in Flasks on Board Ships*. IMO Resolution A748 (18), November 1993.