

Shipments of unirradiated MOX-fuel-elements to Nuclear Power Plants in Germany with special security truck service – an overview to the last 20 years

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Abstract

Since 1979/1980 contracts between the operators of the nuclear power plants and the reprocessing plant in La Hague, France, and Sellafield, UK, were in force.

These contracts being granted by changing of notes between the government of the Federal Republic of Germany and the government of France (dated: 25. April 1979) and the United Kingdom (dated: 18. July 1980).

Nearly 5 400 tons of heavy metal of spent fuel from nuclear power plants in Germany was delivered since 1973 until mid 2005 to the reprocessing facility in France; nearly 850 tons of heavy metal of spent fuel to British Nuclear Fuels facilities in the United Kingdom and roughly 200 tons of spent fuel to the former reprocessing facility in Karlsruhe, Germany. Up to the reprocessing contracts between COGEMA and BNFL and German Nuclear Power Utilities a total amount of 38 000 kg of plutonium (Pu_{fiss}) is expected from these facilities.

This paper will describe in detail the experience of shipments of unirradiated MOX-fuel-elements with a special security truck service within Germany to the existing Nuclear Power Plants and will give an outlook to future procedures.

The first shipments with plutonium from France to Germany started in the early 1980ies. The destination in Germany was the MOX-fabrication plant in Hanau. Up to problems with the licensing procedure in Germany the MOX-facility in Hanau was set out of order in 1991. Up to now the fabrication of fresh MOX-fuel was transferred to Belgium, France and the United Kingdom. The German Government has decided, in accordance with the power utilities, to phase out nuclear power by limiting the standard lifetime of the nuclear power plants to 32 years from the date of their commissioning. The phasing out was fixed 2002 in the "Act for the Regulated Termination of the Commercial Use of Nuclear Power". In this law, a remaining operation time is fixed for each nuclear power plant and during this time period the use of fresh MOX-fuel must be finished.

If the routine shipments of unirradiated MOX-fuel-elements will be continued, the last shipment from France will arrive at a Nuclear Power Plant in Germany not later than 2011 and from the United Kingdom not later than 2013.

Introduction

The use of MOX-Fuel in NPP's in Germany started early in the 70ies. MOX-Fuel-fabrication was situated within the nuclear facilities in Hanau, Germany, during this period. Plutonium from the reprocessing facilities in Karlsruhe (WAK) and in La Hague, France, and (COGEMA) was used.

Table 1: MOX Experience in Western Europe

Country	No. of NPP's using MOX-fuel	First MOX-Loading
Germany	10	1972
Switzerland	3	1984
France	20	1987
Belgium	2	1995

From Karlsruhe, Germany, Plutonium was shipped as Plutonium-Nitrate, from GOGEMA, France, Plutonium was shipped as Plutonium-Oxide, and all shipments were truck-shipment.

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The reprocessing facility in Karlsruhe, Germany, was in use for 20 years from 1971 to 1991. Reprocessing of spent fuel elements from Nuclear Power Plants in Germany started in France, COGEMA, in 1973 and is finished up to now end of 2007, the last shipment of spent fuel took place in April 2005.

Within the time period 1980 to 1989 the construction of a reprocessing facility in Germany within an industrial capacity of 700 tons of heavy metal was discussed and a licensing procedure was started in 1984 and five years later stopped in 1989 due to the decision of the German's nuclear industry to provide new contracts with COGEMA and BNFL for a long time period.

In 1991 the small reprocessing facility in Karlsruhe was shut down after 20 years of service and the MOX-fuel fabrication in Hanau was stopped up to a contamination incident. A Shipment of unirradiated MOX-fuel from Hanau to the nuclear power plant Gundremmingen in 1991 was the last one because the MOX-fuel fabrication in Hanau was never set in service since this time. The licensing procedure for a new MOX-facility in Hanau could not fulfill all requirements and so far this procedure was stopped, this facility never produced a single MOX-fuel-element for a NPP in Germany.

MOX-shipments in Germany are today always international shipments between France, Belgium, United Kingdom and Germany.

Up to the use of MOX fresh fuel in Pressure Water or Boiler Water Reactor types only two different packages for BWR- and PWR-MOX-fuel are necessary.

Normally the fresh MOX-fuel is directly shipped per special-security-truck from the MOX-fuel-fabrication plant in Dessel, Belgium, to the nuclear power plants in Germany, which are: Brokdorf, Unterweser, Grohnde, Emsland, Philippsburg-2, Neckarwestheim-2, Isar-2, Gundremmingen B and C and Grafenrheinfeld.

During the last years only one shipment from the United Kingdom to Germany took place in 1996. This was a road-ship-road-shipment from Sellafield to Barstow, by ship as an IMO class I – "INF" ship for special purpose from UK to Germany, Bremerhaven, and than by road and a special security truck to NPP Unterweser. The next shipment from the United Kingdom is under investigation and scheduled for 2008 with MOX-fuel to the NPP Grohnde in Lower Saxonia.

In the year 2000 the German Government has decided, in accordance with the power utilities, to phase out nuclear power by limiting the standard lifetime of the nuclear power plants to 32 years from the date of their commissioning.

This agreement between the Federal Government and the power utilities was ratified on 11 June 2001. The key points of this agreement relevant to the managing of spent fuel are as follows:

- Reprocessing will be discontinued and replaced by the direct disposal of spent fuel elements.
- The delivery of irradiated fuel elements to La Hague and Sellafield for reprocessing will be terminated by the middle of 2005.

The actual situation will be described in the following.

As a result of this contract the total amount of Plutonium from the reprocessing process of spent fuel from NPP's in Germany should be used for fabrication of unirradiated MOX-fuel and these MOX-fuel should be used in Nuclear Power Plants with an authorization for MOX-fuel use.

As a result of reprocessing of spent fuel in France (COGEMA) and in the United Kingdom (BNFL) nearly 37.000 kg Pu_{fiss} should be used for the fabrication of fresh MOX-fuel elements and should be loaded as MOX-fuel in NPP's up to the year 2013. Up to 31.12.2006 an amount of 27.840 kg Pu_{fiss} is still used as MOX-fuel in Nuclear Power Plants in Germany.

Safety and Security Requirements

Since 1983 shipments of MOX-fuel for Nuclear Power Plants in Germany have to fulfill the safety and security requirements. The fundamental safety–aspect for shipments of MOX–fuel is the use of an approved type B (U) F – or type B (M) F – package for fissile material. Different packages for Pressure Water and Boiler Water Reactors are needed:

Table 2: Approval for Type B (M) F-96 and B (U) F-96 packages for MOX-fuel

Type of package	Approval	Max. number of MOX-fuel-elements
ANF – 18 /MOX	D/4348/B(M)F-96	2 (PWR)
MX 6	F/380/B(U)F-96 (Ab)	16 (BWR)
MX 6	F/380/B(U)F-96 (Ac)	6 (PWR)

Up to the different types of MOX–fuel elements the mass of Plutonium-fiss varies between 80 kg and 150 kg of Pu_{fiss} within the package.

For shipments of unirradiated MOX-fuel elements not only safety requirements should be fulfilled during transport but also security measurements.

The goals of protection and security for MOX-shipments are:

- to prevent any diversion of fissile material
- to prevent any release of radioactive material

The protection against disturbance by third parties is derived from the German „Atomic Energy Act“and these national requirements are supplemented by international recommendations:

- INFCIRC 225
- International Convention for the Physical Protection of Nuclear Materials

The „security philosophy“in the European countries such as United Kingdom, France, Belgium and Germany are

- identify an attack by reliable surveillance
- law enforcement agencies shall be notified through communication systems
- the act should be delayed by means of barriers
- protection of the shipment will be assumed by the law enforcement agencies in order to prevent the act

Use of MOX-fuel in Nuclear Power Plants in Germany

The first loading of fresh MOX-fuel in a commercial Nuclear Power Plant started 1972 in Obrigheim (KWO, 300 MWe). Up to now 11 dedicated Nuclear Power Plants have an authorization for MOX-use (see table 3).

Table 3: Authorization for use of MOX-fuel in Nuclear Power Plants in Germany

Nuclear Power Plant	Use of MOX-fuel started	Last MOX-fuel loading
Obrigheim	1972	1999
Unterweser	1984	2006
Grafenrheinfeld	1985	2006
Grohnde	1988	2009
Philippsburg-2	1988	2006
Brokdorf	1989	2010
Gundremmingen B / C	1995	2013
Isar – 2	1998	2011
Neckarwestheim – 2	1998	2011
Emsland	2004	2011

Shipments of MOX-fuel in Germany

As mentioned above the first MOX-fuel shipment started in 1972 to the Nuclear Power Plant Obrigheim. Within the time period from 1972 to 1989 no precise shipment data are available for the federal authorities, but as a real assumption no more than 30 shipments of MOX-fuel took place between 1972 and 1989. During the time period from 1972 to 1999 MOX-fuel was used in two prototype reactor facilities and 14 commercial Nuclear Power Plants.

MOX-fuel shipments up to 1999

Table 4: MOX-shipments to Nuclear Power Plants from 1972 to 1999

Nuclear Power Plants	MOX - fuel	mass of Pu_fiss [kg]
Brokdorf	104	2.032
Philippsburg-2	108	1.886
Unterweser	108	1.653
Grafenrheinfeld	60	980
Gundremmingen B/C	212	1.163
Obrigheim	78	694
Grohnde	60	952
Neckarwestheim -2	16	390
Isar - 2	48	1.174
Neckarwestheim -1	32	337
Gundremmingen - A	80	188
	906	11.449

Figure 1: Shipments of MOX – fuel within Germany, 1990 - 1999

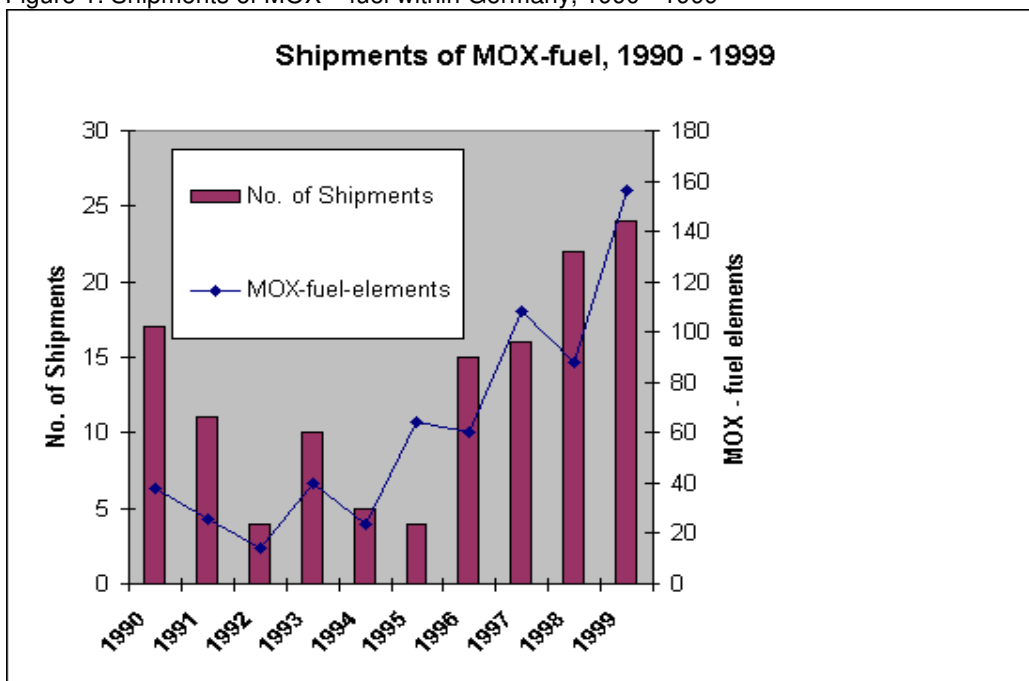
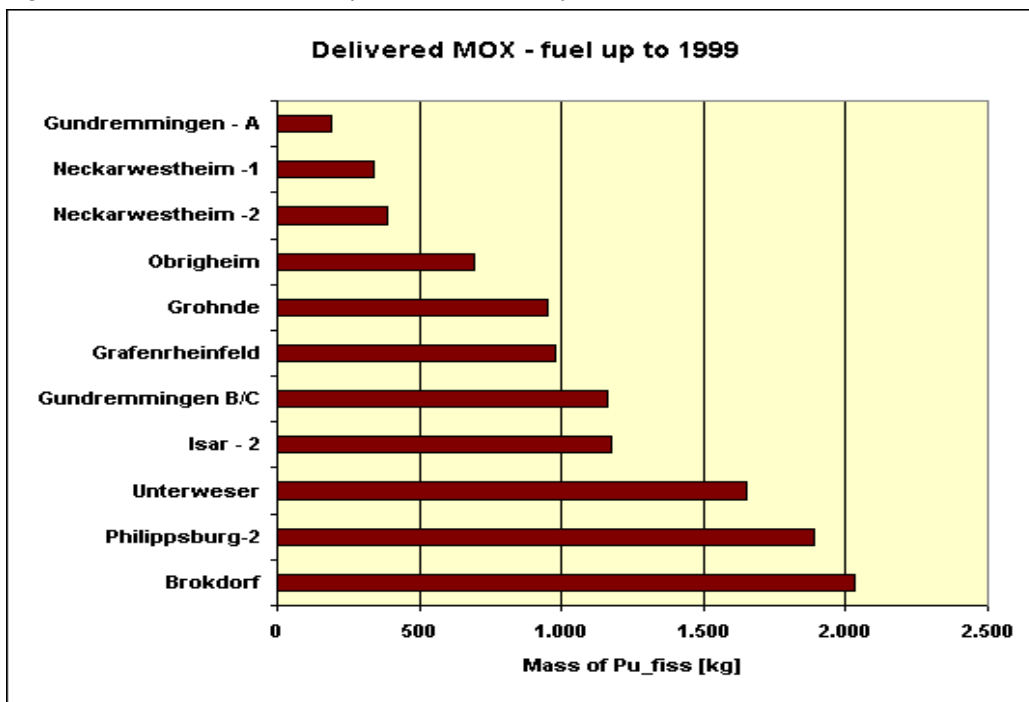


Figure 2: Delivered MOX-fuel up to the end of the year 1999



Within the time period 1990 – 1999 a total amount of 128 MOX–shipments took place with a total number of 906 MOX–fuel–elements containing 11.449 kg of Plutonium-fissile.

MOX–shipments between 2000 and 2006:

During this time period MOX-fuel was used in 8 Pressure Water Reactors and 2 Boiling Water Reactors (Gundremmingen B and C). Emsland (KKE) Nuclear Power Plant was authorized for MOX-fuel use in 2004.

Within the time period 1990 – 2006 a total amount of 311 MOX – shipments took place with an average of :

- 12 MOX–shipments per year
- 110 MOX–fuel–elements per year
- 1.353 kg Plutonium_fissile per year

Table 5: MOX-fuel shipments from 2000 to 2006

Year	Shipments	MOX-fuel-elements	Pu_f [kg]
2000	25	160	2.837
2001	34	172	2.963
2002	23	156	1.867
2003	30	204	2.530
2004	31	198	2.584
2005	22	130	2.066
2006	18	96	2.042
	183	1.116	16.889

MOX-shipments from the Beginning in 1972 up to 31 December 2006

Up to the end of the year 2006 a total amount of 27.839 kg Plutonium_fiss was shipped between the MOX–fuel facilities and the Nuclear Power Plants in Germany with an authorization for MOX–use. All these shipments were done without any accident.

Table 6: Total amount of MOX–fuel in Nuclear Power Plants up to the year 2006

Nuclear Power Plant	Pu_fiss [kg] as MOX-fuel
Gundremmingen	5.051
Philippsburg-2	3.908
Brokdorf	3.854
Unterweser	3.487
Grafenrheinfeld	3.011
Isar-2	2.925
Grohnde	2.003
Neckarwestheim-2	1.454
Prototype Reactors	1.254
	27.839

View to the Future:

Up to 2013 nearly 80 shipments of MOX–fuel elements with a plutonium content of nearly 9.500 kg Pu_fiss are necessary to finalize the use of MOX in the existing German Nuclear Power Plants.