# The Transports of Nuclear Fuel Cycle: An Essential Activity, Safely Managed

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## 1 - INTRODUCTION

Transports associated with the nuclear fuel cycle normally use public means of transport by rail, road, sea and air and it might therefore be expected that they would be the Achilles heel of the cycle from a safety point of view. In fact, decades of smooth transport operations show that most probably the weak point of the cycle is elsewhere.

- In fact, despite a few minor accidents, no radioactive releases resulting in a significant exposure of the public or the environment have occurred. On the other hand, during the last quarter, the news media have reported major spillages of crude oil and chemicals of high toxicity which have jeopardized the environment, the explosion of gas tankers with dozens of fatalities, and even the sinking of a nuclear submarine.

- All reports show that the radiation exposure to the public resulting from transports is negligible, i.e., far below 1% of that due to the whole nuclear industry.

  Similarly, the radiation exposure of transport workers has been lower than anticipated over several decades and this has encouraged the IAEA to reduce the allowable annual dose to 5 mSv, thus implementing their ALARA principle.

- Due to the lack of accidents with emotional appeal, the media seem only moderately interested by the fuel cycle transports so that the public know little about them.

- The demonstrations and attacks by opponents of the nuclear industry against transports have been limited and have been used as an attempt to freeze the activity of different plants or disposal sites, and to focus public attention on the nuclear issue, rather than to question the fuel cycle transports themselves or the safety principles ruling them.

  When looking for explanations of such a favourable situation, which we should endeavour to perpetuate, without being surprised if any incident occurs, one finds two major reasons:

- First, the awareness by the fuel cycle operators, of the vital importance of a safe and reliable implementation of the necessary transports.

- Secondly, the results of assessments of safety conducted by international organizations and most countries, which have resulted in detailed international recommendations, as well as uniform

national and modal regulations, thus establishing the necessary link between the basic rules for radioprotection and the needs of the Transport Industry.

## 2 - DIFFERENT SENSITIVITY LEVELS OF TRANSPORTS WITHIN THE FUEL CYCLE

Before coming back to the reasons which justify a reasonable optimism towards the fuel cycle transports, let us recall some facts about them. Figure 1 is a diagram of the cycle for LWR fuel, identifying the possible transports within that cycle.

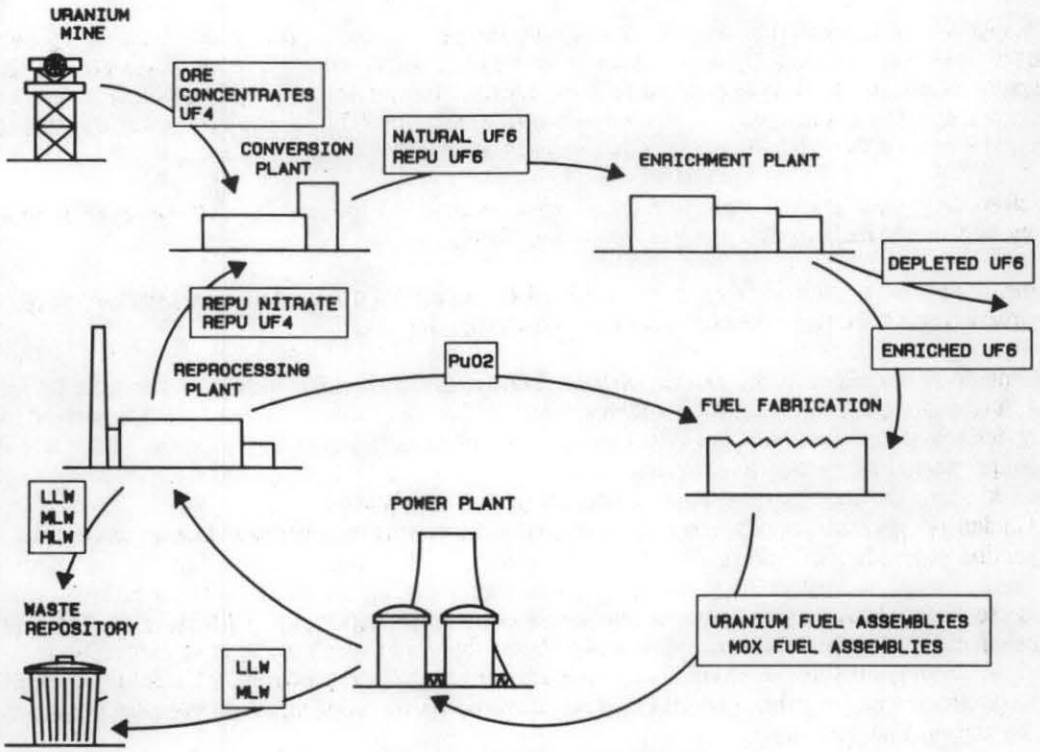


Fig.1 LWR FUEL CYCLE

According to Regulations, these transports may be categorized as follows:

- Those concerning ores, concentrates or compounds of non-irradiated natural or depleted uranium; they include all transports from mining to enrichment and that of enrichment tails. These materials are classified as Low Specific Activity ones (LSA) and, indeed, the radiological hazard in case of accidental spillage is in the range of that which mankind has always faced; therefore, these materials are transported in unshielded Industrial Packagings (IP), the design of which takes into consideration possible chemical risks.

- Those concerning LSA materials slightly contaminated by transuranic traces, i.e., reprocessed uranium (REPU) and low level wastes (LLW) generated at all stages of the fuel cycle; these materials belong generally to the LSA category and are therefore transported in unshielded Industrial packagings, except in a few instances where the amount of impurities imposes packagings of type A or even type B to avoid that in case of accident, radioactive releases exceed the allowable limits.

- The nuclear industry has to concentrate most of its efforts upon a few "sensitive" transports necessary to deal with materials that present major radiological hazards linked:

- Either to criticality, in case of non-irradiated enriched UF6, UO2 and uranium fuel assemblies.
- Or to a high specific activity induced by irradiation, in case of High and Medium level wastes (HLW and MLW) resulting from reprocessing of spent fuel.
- Or to both, criticality and high activity, in case of spent fuel, PU02 and MOX fresh fuel assemblies.

## 3 - REASONS JUSTIFYING ENHANCED SAFETY

As shown by the repercussions of the Mont-Louis sinking — itself quite insignificant as concerns radioactive spillages — any transport accident involving nuclear materials may jeopardize all the transports within the nuclear fuel cycle and, ultimately, stop nuclear energy generation, a situation that is not acceptable especially in Western Europe where the share of nuclear electricity exceeds 30% and even reaches 70% in some countries such as France.

Therefore, it is quite normal that the nuclear industry attributes the utmost importance to transport quality and in particular, pays special attention to Safety.

Another reason is economics, due to the value of the transported materials. Furthermore, long delays would be needed to replace "sensitive" materials, due to:

- Limited availability on the market of these materials.
- Limited storage space at different plants.
- Specificity of procurement specifications.
- Requirements of Quality Assurance.
- Risk of interference or production schedules at different plants.
- Burden of physical protection and administrative requirements when any change occurs in routine proceedings.

Of course, these delays would cause a cascade of extra costs, especially if finally a reactor cannot be fueled in time, to be added to indirect ones borne by Insurances (attempts to recover lost materials, decontamination of environment, replacement of lost or contaminated equipment, third party compensations, etc.) but obviously soon recovered by the adjustment of the premiums to be paid by the nuclear industry.

Therefore enhanced safety in the fuel cycle transports supports strongly the economy and reliability of fuel supplies to reactors. Furthermore, it is all the more acceptable since the volume of transports is quite limited in the case of nuclear fuel, compared to that in the case of fossile fuels, especially coal and gas which are currently the main substitution fuels.

## 4 - SAFETY INHERENT IN UPDATED TRANSPORT REGULATIONS

Since the beginning of the sixties, the Nuclear Industry has been implementing specific transport Regulations derived from the Recommendations made by the IAEA for the Safe Transport of Radioactive Materials.

Though these Regulations are, with good reasons, considered as a model for other dangerous goods, the nuclear community still improves them periodically and permanently checks that they remain adapted to the evolution of needs, for instance:

- arrival of new products, such as MOX fuel elements,
- change of radioactive impurities accepted by standards (recent occurrence of REPU)
- new perception by the public or politicians of the transport risks (air transport of PU)

- increase of the size of the packagings and size of consignments to satisfy the growing needs while reducing unit costs and transport hazards, especially those resulting from radiation.

In fact, audits and studies are repeatedly conducted by the Nuclear industry, even often sponsored by international organizations (such as IAEA and EEC) to:

- evaluate the safety level of actual transports as well as public acceptance of associated hazards and countermeasures requested by regulations

- gather any justifications of current practices

- assess safety for accidental conditions met during transports of any goods and, if necessary, propose amendments to regulations.

- develop and run codes enabling industry to minimize the radioactive hazard according to the ALARA principle (INTERTRAN code).

## 5 - CONSERVATISM OF REGULATORY REQUIREMENTS

The high level of safety brought by the Transport Regulations is due in particular to:

- Their requirements as concerns the packages which have to resist not only to normal transport conditions but also to accidents with a severity commensurate with the hazard in the event of their failure.

- Their shielding and containment requirements that, as already noted, efficiently protect public, workers and environment.

  Furthermore, they provide for standards of resistance to accident environments that are quite conservative as demonstrated by various tests and derivations made from actual accident records. For instance, the CEGB train crash demonstration, of July 1984 showed that the impact force between a heavy locomotive running at 160 km/h and a 48 tonnes magnox cask lying between the tracks does not exceed 29 MN, whereas 75 MN correspond to the regulatory 9 meters drop on an unyielding surface.

  Similarly, one may consider the regulatory fire conditions as excessively conservative in the case of the heavy packages used for fuel cycle transports, especially because in most fires actually reported, any high temperature zone was moving quickly as a function of time; even in the case of sea transports, one can hardly imagine fire conditions that would cause the failure of heavy packages as, most probably, these conditions would have previously damaged the vessel to an extent resulting in fire extinction by flooding.

  Also, the probability for a large package accurately secured in a plane to be ejected and then to impact a rather unyielding surface is so low that different probabilistic assessments concluded that the current IAEA requirements are adequate even for air transports.

  Therefore, one may conclude that the risk of large radioactive spillage during a transport within the fuel cycle would most probably result from a wrong implementation of the Regulations or from terrorist actions, rather than from accidental conditions exceeding the regulatory ones.

## 6 - REGULATORY REQUIREMENTS FOR QUALITY ASSURANCE AND EMERGENCY PREPAREDNESS

The safety inherent in Transport Regulations is furthermore enhanced by the rigorous implementation of these Regulations that results from their own requirement for a comprehensive Quality Assurance Program to control all transport activities, equipments and individuals having responsibilities. Subsequently, fuel cycle transports may be sub-contracted, for rationalization and economy only to

specialized companies with trained and qualified staffs. As each one's responsibilities have to be clearly defined in advance, people are motivated and the duties are reliably accomplished, while the duplication of work may be avoided.

In addition, as the Regulations require measures for a quick and efficient answer to any abnormal situation, one has to develop emergency procedures (and possibly special equipments such as in the case of UF6 transports). Transport staffs should also be trained for the satisfactory implementation of these procedures and of national emergency plans established by authorities to facilitate communications and quickly dispatch specialists and special equipment if any significant release of radioactive materials occurs, thus minimizing the resulting exposure of the public and environment.

## 7 - ADDITIONAL MEASURES TAKEN BY THE NUCLEAR FUEL INDUSTRY TO ENHANCE TRANSPORT SAFETY

Beyond the strict implementation of Regulations, safety is enhanced at different steps of the fuel cycle by the following options taken by industry:

- Maximum capacity of packagings and conveyances: this presents obvious economical advantages but primarily the doses received by public and environment are reduced since allowed dose rates are limited by Regulations independently of package contents.

  For instance, the dose received by the environment during the transport of a large cask designed for 24 spent fuel assemblies is approximately 8 times lower than that delivered by the 8 transports necessary in the case of a smaller cask designed for only 3 assemblies and moved at the same speed along the same route.

- As far as possible, transports by rail rather than by road, thus minimizing again public radiation exposure.

- Enough spare hardware to deal with an efficient maintenance program and a specialized shop to perform that maintenance: this results from a sound interpretation of the Regulations which lay the emphasis for basic safety mainly upon package integrity. Obviously, that conflicts with economy and therefore, in order to mitigate that burden, most of the Operators in the fuel cycle prefer to own any special equipment necessary to perform their transports; this is to minimize investments, facilitate maintenance, simplify quality assurance implementation especially as concerns maintenance, while keeping open the possibility to rely upon competition between transporters who have therefore only to provide standard equipments and high quality services.

- Standardization of packagings which minimizes the risks of operator errors and radiation hazard, in addition to obvious economical advantages as concerns hardware procurement and maintenance, as well as diversification of commercial partners. Therefore, standardization is generally pushed well beyond necessary just to match plant interfaces with packagings and other transport hardware.

## 8 - SAFETY ENHANCEMENT BROUGHT BY SPECIALIZED TRANSPORT/ENGINEERING COMPANIES

A large number of operators in the fuel cycle sub-contract transport preparation and operations as well as design/procurement activities related to transports, to specialized companies selected for their experience, efficiency and reliability.

Even if the choice of such a company is basically made according to safety criteria, that obviously favors overall economics by sharing the cost to maintain a competent staff between several customers.

That also avoids the repetition of the usual errors due to the lack of experience or repetitive exercise in fields as diversified as Physics (in particular Nuclear Physics), Radioprotection, Engineering,

Fabrication technology, Transport Systems, Regulations (in different countries), Transport management, import/export paperwork, Relationship with authorities and with the media.

Such a team of specialists may remain aware of the latest issues in their respective fields with feedbacks to other ones thanks to quick communications between them.

For instance, it is hardly conceivable that a competitive cask might be designed by an engineering company without involvements in nuclear transports.

Similarly, cask operations are better implemented when easy and quick communications with equipment designers remain possible.

Even most of the routine paperwork requires to some extent a technical or legal background better provided by people experienced with equipment developments or regulations implementation.

This is the reason why Transport/engineering companies such as TRANSNUCLEAIRE and NTL have evolved.

In association with major fuel cycle operators, such as COGEMA, who own the main transport hardware for the economical reasons already mentioned, such specialists offer the safest option for an efficient implementation of the fuel cycle transports.

## 9 - CONCLUSION

The high degree of safety recommended by the IAEA for the transport of Radioactive Materials is generally well accepted by the fuel cycle industry who fully realize its necessity for economical and reliable transports. Therefore that Industry continuously endeavours to follow the IAEA recommendations efficiently, in particular through the assistance of specialized transport companies, familiar with the implementation of these recommendations, as well as different applicable regulations, and experienced in different fields, from the development of transport equipment to the management of International transports.