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OVERALL VIEW OF USED FUEL LOGISTICS IN EUROPE

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ABSTRACT

For 50 years, AREVA TN has been performing up to 250 shipments/year of used fuel assemblies in Europe and in the world, mainly for recycling at the AREVA La Hague reprocessing plant, but also for interim storage, depending upon the used fuel management choice made by the customer.

In order to comply with the different requirements of the different Authorities, AREVA TN has organized these shipments accordingly. Since the specifications of the used fuel assemblies are different from one European offloaded nuclear power plant to another, and as the handling possibilities are also very diverse, AREVA TN has designed several casks to be used worldwide. In addition, AREVA TN has designed dual-purpose casks in order to comply with the possibility of storing the used fuel assemblies in the casks after shipment.

The purpose of this paper is to describe:

- The range of spent fuel casks developed by AREVA TN and their evolution in compliance with authority and customer requirements
- Fleet management of casks, trucks and rail cars including preventive and corrective maintenance, transport licence renewals, technical assistance for loading and unloading operations...
- The organization of worldwide spent fuel transportation including scheduling, documentation, supplier control, customer and authority interface, crisis management...
- The specificity of casks for transportation and the AREVA TN dual purpose casks.

INTRODUCTION

Based on its experience in the organization of the shipment of nuclear material in France for 50 years, AREVA TN has extended this expertise abroad to develop similar schemes, adapting them to the international rules and specific national regulations of its foreign customers.

Due to the evolution of the regulations and customer needs over these 50 years, AREVA TN has continually improved the transport scheme, renewed the designs of its casks, and updated its fleet of transport means.

Furthermore, in response to AREVA requirements for the end of the fuel cycle, AREVA TN now proposes dual-purpose solutions which comply with both storage and transportation needs.

1. USED FUEL FLOWS IN EUROPE

For the management of used fuel, most Western European countries need to transport elements of high radioactivity. Currently, four countries in Europe conduct shipments of this type regularly: Sweden, the Netherlands, Italy and France.

In Sweden, shipments are made using maritime means to a centralized pool in casks developed and manufactured by AREVA TN. These shipments are managed and operated locally by SKB. All other transport, more than 250 shipments annually representing 1200 tML of used fuel, is operated by AREVA TN.

In the past, logistics means for the transport of used fuel were also developed for customers in Switzerland, Spain, Germany and Belgium. A revision of their license renewal is regularly done to anticipate and satisfy future needs.

The destination of the flow operated by AREVA TN is the La Hague used fuel treatment plant in the north of France. After departure from the NPP, the casks loaded with used fuel are transported either by rail or by road and rail. All rail shipments converge at the railway terminal in Valognes, operated by AREVA TN.

The casks are then loaded on heavy vehicles to travel the last 25 kilometers to the La Hague plant. After unloading, either in underwater or dry conditions as the flow necessitates, the casks are transferred to a logistics platform for reutilization or maintenance.

From a logistics point of view, the key elements in the infrastructure are the railway terminal and the cask maintenance workshop.

Characteristics of the railway terminal in Valognes:

- Facility owned and operated by AREVA
- More than 400 casks per year
- 15 people
- Includes indoor facility to perform radiological surveys
- Facility for “light” maintenance of rail cars

Characteristics of the cask maintenance workshop:

- Facility owned and operated by AREVA at the La Hague plant
- Up to 60 casks per year
- Usual activities (not exhaustive) :
 - visual inspection of all components
 - verify fuel compartments
 - dismantling the trunnions and their screws
 - check of neutron absorber in the basket walls

2. TRANSPORT MEANS

2.1. Range of spent fuel casks

The first industrial fleet of spent fuel casks for transportation on a grand scale was developed in the late 1970s according to the IAEA 73 standards.

The characteristics of the transported burned fuel were limited to an initial maximum enrichment of the uranium at 3.7% and a maximum burn-up at 40 000 MWd/tU.

AREVA TN's first generation of casks was conceived: The TN[®]12/1 and TN[®]13/1 for the transport of burned fuel offloaded respectively from 900-MW plants, 1300-MW plants, and, for plants having a limited handling payload (< 80tons), the TN[®]17.

During the 1980s the need for more stringent regulations led the IAEA to implement IAEA 85 which called for improved demonstration of package safety. Concurrently, the power companies increased the efficiency of power plants with fuel up to 4% to 4.5% of enriched uranium with a burn-up up to 52 000 MWd/tU at end-of-cycle.

In response to these events, AREVA TN improved the design of its casks with the TN[®]12/2, TN[®]13/2 and TN[®]17/2 with the same characteristics as the previous series from the 1970s but with an increase in weight.



Figure 1. TN[®]12/2 on its storage frame

In the beginning of the 21st century, the introduction of IAEA 96 standards led to a major change: the criticality assessment had to take into account a partially or fully flooded cavity to demonstrate the safety of the package. This additional requirement for the safety demonstration was not compatible with the full payload of the IAEA 85 casks, necessitating the limitation of their payload for full IAEA 96 compliance.

Moreover, to optimize fuel efficiency, the majority of customers have increased the lifetime of the fuel in NPP cores from 3 to 4, or even 5 years, and have required an increase in the initial enrichment of the uranium to a value of 5% to 5.2% in the near future.

Based on these requirements, AREVA TN has developed a range of casks complying with the up-to-date regulations as well as future customer requirements.

Two packages have been developed to meet additional needs of the market: the TN[®]117 is a very light weight cask (less than 60 tons) designed for several types of transported short fuel assemblies; the TN[®]9/4 was developed for the transport of medium fuel assemblies.

AREVA TN will replace the heavy TN[®]12/2 and TN[®]13/2 casks with the TN[®]G3S and the TN[®]G3L. With a gross weight of less than 115 tons, their capacity is respectively 12 assemblies for UO_x for PWRs or 32 BWR used fuel assemblies with a maximum burn-up of 70 000 MWd/tU and a maximum initial enrichment of 5%. They were also designed taking into account a 2-years cooling time. More specifically, the TNG3 is a very high performing cask capable of withstanding a heat load of 70kW with a weight of only 115 tons, exemplary of the cutting edge technology of AREVA TN cask design.

AREVA TN is expecting the license for these casks in 2015 and the first operational use in EDF plants before 2019.



Figure 2. TN[®]G3 mock-up for drop test

To complete this new generation of casks for the transportation of spent fuel, AREVA TN is developing a light-weight cask (less than 80 tons) to replace the TN[®]17/2. This new cask is planned to be used first in the Borssele plant in the Netherlands.

Most recently, for export, AREVA TN has developed a large capacity cask (up to 32 BWR fuel assemblies), the TN Elan. This cask is able to transport fuel assemblies with a maximum burn-up of 60,000 MWd/tU, a maximum initial enrichment of 5%, and a short cooling time of only 20 months. The weight is 100t.

AREVA TN has also developed a cask, the TN[®]112, to transport 12 assemblies containing high burn-up MOX fuel (up to 50 000 MWj/tML – 500 days minimum cooling time). The TN[®]112 is an adaptation of the TN[®]12/2 which accommodates only 4 burned MOX fuel assemblies with a longer cooling time. Two TN[®]112 casks are already in operation for EDF.



Figure 3. TN[®]112 on a rail car

2.2. Particular characteristics of transport casks

The main characteristics of transport casks are described hereafter:

- Elastomer seals
 - Several open/closed cycles can be executed before the necessity of replacement
 - Storage casks in general incorporate metallic seals, which only can be used once
 - The conception of elastomer seals must take into account consequential damage due to a drop and high temperatures due to fire
- Shock absorbers
 - Designed to respond to drop test requirements
- Steel cladding
 - Must be capable of resisting multiple cycles of immersion in a pool followed by periods of exposure to air, and internal wall must be perfectly decontaminable for maintenance under acceptable dose conditions
 - All AREVA TN casks contain stainless steel cladding

2.3. Dual-purpose solutions

AREVA TN customers may have different needs based on different management choices of their used fuel: either immediate transport of used fuel to a reprocessing facility or to centralized storage, or storage casks which can be used later for the transport of used fuel.

To respond to both of these needs, AREVA TN has developed the dual-purpose cask which complies with both storage and transport regulations. Dual-purpose casks streamline the management of used fuel as the transfer of the cask to a specific utility is not necessary. In that way, safety is greatly improved by limiting dose exposure, and associated and costly tasks can be avoided.

The dual-purpose cask can also be used for the transportation of certain types of fuel (damaged fuel assemblies, reusable fuel, HLW,...) before it is used for the storage of standard fuel. This solution is sometimes shared between different utilities.

AREVA TN proposes a family of dual-purpose casks named the TN[®]24 which has been implemented worldwide. Over 300 casks of such type have been delivered and 400 have been ordered worldwide.

The design of this cask allows both storage and transport ability. These casks were designed for both storage and transport. Licensing is granted for both uses independently. Procedures are implemented to facilitate the transfer from the storage configuration to the transport configuration (Fitting of shock absorbers, change of seals...).



Figure 4. TN[®]24 BH

2.4. Fleet of transport means

In order to transport this fleet of casks, AREVA TN has developed, owns and operates several transport means.

2.4.1. Rail cars

The Q70 rail car was developed by AREVA TN for the transportation of the first generation of used fuel. Since the payload of the Q70 car is limited to 113t, the Q76 rail car was subsequently conceived for the next generation of heavier casks even though the Q70 will still be used in parallel for the transport of the lighter casks.

Canopies were specifically developed to allow the release of thermal power in accordance with the transport license and to limit the dose rate during transportation in the public environment.

AREVA TN owns more than 40 of such specialized rail cars. They are compliant with the French railway regulations and are adaptable to the railway systems in other European countries. These rail cars can also be easily decontaminated.



Figure 5. Q70 rail car

Although the rail cars have been specifically developed for the transportation of radioactive materials, the locomotive is owned by the French railway, as the authorities have not required any specificity concerning this equipment.

2.4.2. Heavy haul tractors and trailers

For road transportation of the heavy casks, AREVA TN has developed successively different types of tractors and trailers: the number of wheels has been adapted to comply with French road regulations for exceptional transportation and with the weight of the packages: the AREVA TN heavy haul tractor fleet is composed of the SR8, SR9 and SR10 with 8, 9 and 10 wheels respectively.

As with the rail cars, the tractors and trailers are easily decontaminated and are designed to protect the drivers from any irradiation during transport.



Figure 6. Heavy-haul trucks and trailers

2.5. Management of transport means fleet

AREVA TN manages the complete fleet of their transport means according to:

- the schedule based on the customer transport needs
- IAEA regulations which appear in the safety files of the casks as maintenance requirements (Frequency and/or duration, items to be changed, tests to be performed after the maintenance such as leak tightness tests, US control on the trunions...). When issuing the license approval of the cask, the Authorities approve the maintenance specifications.
- country-specific rules for handling in France and abroad: for example, casks from Germany are compliant with the KTA rules
- European regulations

The maintenance specifications can be broken down into two types of maintenance:

- Preventive maintenance for predictable maintenance as defined in the Safety files
- Corrective maintenance, which is the result of unexpected damage. In this case, the maintenance specifications are written, compliant with the safety of the packaging. Regular lessons learned meetings are held to determine whether corrective maintenance could be avoided by improved preventive maintenance.

The spare parts used for the replacement of used parts are supplied according to the manufacturing requirements issued from the Safety files of the package.

The maintenance of the transport means fleet is executed in a specific building and by trained operators. The maintenance of the casks is executed in the AMEC1 and AMEC2 facilities on the La Hague plant site. Located close to the unloading area of the package and storage area of the empty casks, these facilities contain all the equipment for the maintenance of contaminated casks: hot cells, radiological survey devices, decontamination boxes...

Since 1998, when rail cars were tested positive for contamination upon their arrival at La Hague, the cleaning program and process of the casks before shipment have been considerably improved and the number of verification tests and inspections has increased.

Although the railway cars are owned by AREVA TN, their maintenance is performed by suppliers certified by the French railway. However, AREVA TN does light maintenance of railway cars at the Valognes railway terminal. Its indoor facility provides a location for radiological inspections.

AREVA TN also does maintenance of the heavy trucks and trailers on the LMC site in Valognes near the railway terminal.



Figure 7. Railway Terminal at Valognes

Fleet management also includes the follow-up of licensing renewals and extensions. Indeed, to ensure continuous use for transport, licensing must be valid in every country in which the shipments are performed. To that end, AREVA TN keeps track of customer needs and updates the safety files of the packages, taking into account the latest requirements of the Authorities and the time necessary for the Authorities of all concerned countries to review the safety files and to grant the license. In France, the safety file review lasts 12 months. Once, certified by the French authorities, license approval from abroad could take between three months to one year longer.

3. ORGANIZATION OF WORLDWIDE SPENT FUEL TRANSPORTATION

With its 50 years of experience, AREVA TN has developed an integrated logistics model based on its collaboration with EDF.

First, AREVA TN identifies customer needs and proposes a transport process flow. This process is done in three different steps:

- Risk analysis
 - o implementation of the protocols and the safety data sheets
 - o identification of the transport emergency managers
 - o implementation of the regulatory surveillance
- Transport preparation
 - o identification of the flow
 - o preparation of the transport procedures
 - o qualification of the transport with the customers according to the prepared procedures
 - o scheduling of the shipments
 - o For EDF, a yearly schedule is prepared 4 months in advance which includes the transport means availability. This schedule is implemented before the beginning of the following year. In parallel a quarterly program is established

which is revised every month and which details the transport program for the first month.

- Transport
 - o make available the package (updated maintenance and licensing)
 - o put in place the inspections of the subcontractors
 - o put in place a surveillance program with inspection reports and audits
 - o update flow classification for any further risk analyses
 - o implement the real time tracking system
 - o issue the radiological prevention plan and associated instructions

As the transport is the weakest link in the delivery of spent fuel, AREVA TN has capitalized its experience by creating the Transport Risk Management® Initiative (TRM®). A key point of TRM® is the management of a crisis situation: in which doubts are raised about the safety of a transport and/or the physical protection of the material; with a potentially strong media impact; or a situation that interferes with the progress of the transport. The aim of crisis management is to provide a quick emergency response and the appropriate support to national organizations which are in charge of mitigation of the crisis, avoiding any consequences, ensuring the integrity of the nuclear industry reputation, and working with the many actors involved: public authorities, firemen, consignor, commissioning team, mayor...

CONCLUSION

With the knowledge gained from 50 years of spent fuel transportation around the world, AREVA TN has developed an integrated approach to the shipment of nuclear materials to the advantage of its customers.

The AREVA TN solution provides to nuclear stakeholders a comprehensive service with:

- An organization of the entire transport from A to Z
- All competencies to operate key logistic facilities or manage subcontractors
- All the necessary equipment for any transport operation (cask, transport means and tools)
- The technical assistance 24/24 - 7/7 for on-site operations
- A specific Transport Risk Management®, a real time tracking system and all emergency response plans

More than just a cask manufacturer, AREVA TN helps its customer to organize the shipments from the specification of needs to the actual operations. Many customers have expressed their satisfaction in AREVA TN support during operations. With such positive feedback, we now offer a new Advisory Service to help our customers make the best choices. You can trust AREVA TN to work in tandem with you and to assist you in your logistical decisions adapted to your specific circumstances and needs.