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# 237- AREVA Solutions for Transport and Dry Interim Storage of Damaged Fuel

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## ABSTRACT

Part of the AREVA Group, TN International offers a complete range of transport and interim storage solutions for radioactive materials throughout the entire nuclear fuel cycle. A world leader in its sector, TN International has supported for 50 years the expansion of the nuclear industry.

The damaged spent fuel management is a major challenge for NPP operators in the case of shutdown.

The purpose of the paper is to describe solutions proposed by AREVA for transportation and dry interim storage of all type of damaged fuel.

1/ Transportation solutions

AREVA's Business Unit Logistic has already managed many transports in Europe of gas leaking spent fuel and various cask designs are already licensed for that purpose. The paper gives a description of these transports and the associated licensing methodology and also the new approach of the transportation of other damaged fuel.

2/ Dry Interim Storage solutions in US and Europe

- The storage of damaged fuel is implemented in the US for many years by AREVA, compliant with the United States safety authority's requirements. The damaged fuels are stored in designated basket location with top and bottom end caps.

- In Europe, following the recent shutdown of power plants in Germany, and the future shutdown of other NPP in Europe, AREVA has launched in 2012 the development of a new storage solution for damaged fuel based on European cask technologies and compliant with high level safety requirements.

  This solution is developed commonly by AREVA Fuel services Germany and AREVA TN International France.

  The technology is based on a new welded capsule technology and an associated specific approach of the licensing of the dry interim storage in casks. At the time of this abstract, the qualification process is on-going.

The paper describes these storage solutions in US and Europe.

*News : Since July 2013, AREVA BU Logistics is replaced by AREVA TN.*

## INTRODUCTION

One day or another, nuclear power plants worldwide must manage non-standard spent fuel.

AREVA TN International has been offering solutions for the transportation and interim storage of such particular spent fuel assemblies or rods for many years. The aim of this paper is to describe transport and interim storage solutions already available and recent developments of interim storage solution.

## AREVA TRANSPORT SOLUTIONS FOR NON-STANDARD USED FUEL

The easiest way to get rid of non-standard used fuel rods or assemblies is their treatment in a recycling plant such as the AREVA La Hague recycling plant. By the way with the treatment, nuclear operators have not to assess difficult subject such as the behaviour of these special spent fuel in an interim storage and further their behaviour in a final disposal facility.

Examples of gas-leaking fuel rod transportation

TN International has already managed many shipments in Europe of gas-leaking used fuel (no particle release, see Fig. 1), and various cask designs have already been licensed for this purpose.

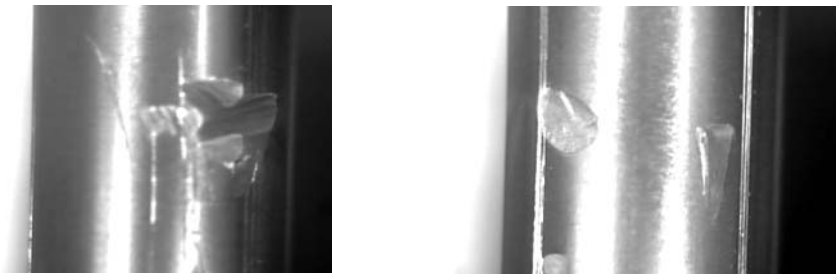

Figure1. Gas leaking used fuel, small cladding defects

For example, transport casks such as the TN12™ licensed in France or TN17/2™ licensed in France and Sweden are licensed for the transport of gas-leaking fuel rods (no release of particles).

The TN9/4™ was already used for the transport of gas leaking fuel rods from the Mühleberg NPP in Switzerland to the AREVA La Hague recycling plant.

Transportation of gas-leaking fuel rods to the AREVA La Hague recycling plant requires only an extension of the transport license and the application of the Hydrogen measurement method. These shipments do not require any preliminary encapsulation.

Licensing principles for the transport of gas-leaking fuel rods is as follows:

- sub-criticality calculations and containment safety case limit the number of gas leaking rods to be loaded per cask
- containment safety case limit the duration time of the transportation
- hydrogen explosion – due to the presence of residual water in the rod- risk analysis :

Transport duration is reduced at several months instead of one year, % H2 measurement in cavity cask is made at least two days after lid closure; extrapolation is made and permit to define a maximum time to reach the Lower Limit of Inflammability (LLI, near 3%); This duration with additional margins, defines a maximum time left between lid closure after loading and lid opening for unloading**.**

Examples of damaged fuel rods transportation

TN International has already managed transports in Europe of damaged used fuel (see fig. 2) and various cask designs are already licensed for that purpose.

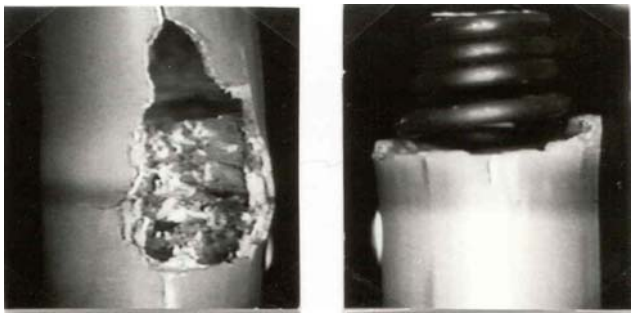

Figure 2. Damaged used fuel rods, with particle release

The AREVA TN 17/2 cask had already been used for the transport of gas-leaking fuel and damaged fuel from the Stade NPP in Germany to the La Hague recycling plant. All rods were encapsulated in the AREVA screwed particle-tight capsule (Fig. 3). The screwed capsule was put into a capsule canister (Fig. 4).

Figure 3. Screwed capsule

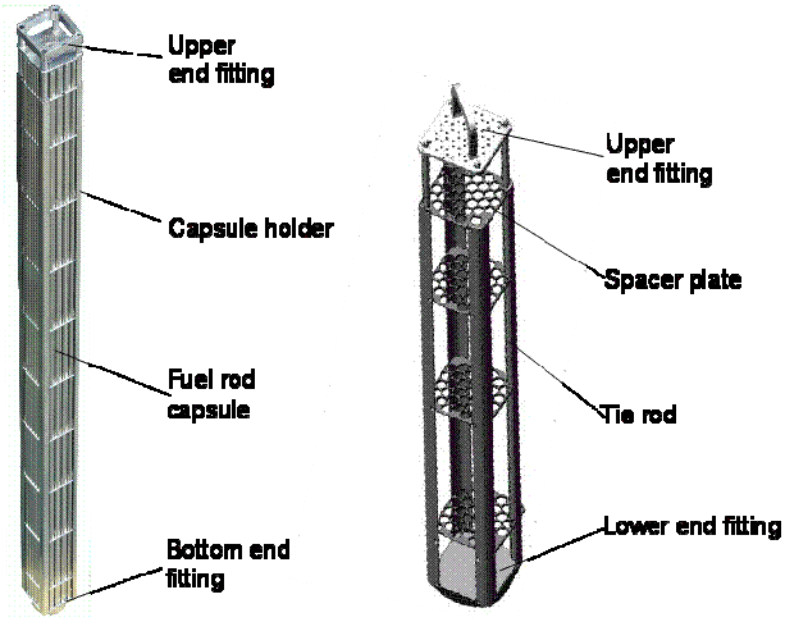


Figure 4. Capsule canister for PWR and BWR used fuel

These capsules and capsule canisters have been successfully transported and treated at the AREVA La Hague recycling facility.

## AREVA INTERIM STORAGE SOLUTIONS FOR NON-STANDARD SPENT FUEL IN THE US

The damaged fuel rods are defined as having known or suspected cladding defects greater than pinhole leaks or hairline cracks, and can be handled by normal means.

For several decades, TN Inc. as part of AREVA TN has been developing end implementing solutions for the dry storage of damaged fuel.

The principles of storage are the following:

- Top and bottom end caps
- Fuel debris are contained in the fuel compartment (broken rods, loose pellets and/or pieces of cladding)
- End caps fit snugly into the top and bottom of the fuel compartment
- Fuel Assemblies are held in place by: the fuel compartments, the inner bottom cover plate and the top shield plug during transfer and storage
- The end caps have multiple holes to permit unrestricted flooding and draining of the fuel cells
- Containment boundaries for the damaged fuel are the same as for intact fuel except the fuel cladding
- Damaged fuel assemblies are placed in designated basket locations with top and bottom end caps


Figure 5. Example of damaged fuel rods storage license in Nuhoms® 32 PTH

## AREVA INTERIM STORAGE SOLUTIONS FOR NON-STANDARD SPENT FUEL IN EUROPE – ZOOM ON GERMANY

In Europe, following the recent shutdown of power plants in Germany, and the future shutdown of other NPP in Europe, AREVA has launched in 2012 the development of a new storage solution for damaged fuel based on European cask technologies and compliant with high level safety requirements.

The technology is based on a new welded capsule technology and an associated specific approach of the licensing of the dry interim storage and transport casks for PWR and BWR used fuel.

The principles of storage are the following:

- Preparation and pretreatment of the damaged fuel rod
- Transfer of the rod into the fuel rod capsule in the pool
- Dewatering of the capsule
- Drying of the fuel rod with hot gas
- Gas-tight enclosure of the fuel rod capsule by welding
- Non-destructive testing
- Transfer of Fuel Rod Capsule into the Capsule Canister
- Resetting of the top nozzle of the Capsule Canister and screwing
- Handling and transfer of the loaded Capsule Canister to the cask
- Storage of the loaded capsule canister with standard used fuel assembly in the same cask
- All these operations are managed in the reactor pool, but they can also be implemented in a hot cell for specific customers needs

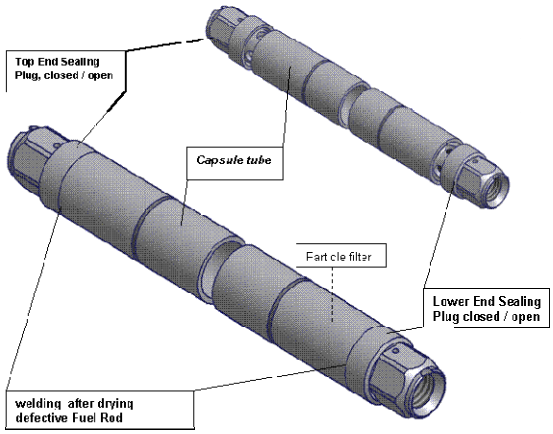


Figure 6. AREVA capsule

The technology and the approach developed by AREVA is the most efficient technology in terms of final quantity of residual water in the capsule (<< 1 g of water per capsule) and robustness of the safety demonstration, which guarantee the granting of the associated license of transport and storage of the AREVA dual-purpose TN24™ family cask.

The same technology is currently proposed in Belgium and Switzerland.

## CONCLUSION

The easiest way to get rid of any non-standard used fuel rods or assemblies is the treatment in a recycling plant as the AREVA La Hague recycling plant. By the way with the treatment, nuclear operators have not to assess difficult subject such as the behaviour of these special spent fuel in an interim storage and further their behaviour in a final disposal facility.

AREVA TN proposes a strong and approved solution for the transport of any type of damaged fuel rod to recycling facility.
For interim storage of damaged fuel rod, AREVA also proposes robust solutions based on available competences and experience, compliant with all AREVA type of casks worldwide.