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Cleanliness of transportation cask cavities

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Abstract

Within the framework of spent fuel assemblies (SFA) shipments from French NPPs to the AREVA La Hague recycling plant, unexpected foreign objects have been observed in the cavities of TN®12/2, TN®13/2 and TN®112 casks.

The authorized contents of these casks are limited to spent fuel, with the basket and the spacers so any other content is therefore forbidden

In the event of the presence of any foreign materials in the cask cavities, the potential risks during transport are:

- damage to the basket or to the fuel assemblies in the case of solid objects,
- radiolysis in the case of organic material.

Any discovery or suspicion of a foreign material must be declared to the French Competent Authority by the consignor, accompanied by the appropriate safety analysis.

In 2010, EDF and AREVA set up a working group to identify the origin of these foreign materials and find solutions to improve the cleanliness of the cask cavities and thus transport safety.

This paper presents the objectives of the AREVA / EDF working group and will describe the different steps of the work performed and the processes followed in order to understand the foreign materials' origins. Main correctives actions are presented as well as the successful results of the implementation of these actions.

Introduction

With an excellent safety and security track record, for more than 40 years, transportation of used fuel to recycling facility has operated very smoothly. About 2,400 spent fuels are transported every year from EDF Nuclear Power Plants to the AREVA La Hague recycling facility, which represents about 200 transports per year in TN®12/2, TN®13/2 and TN®112 casks. Over the years, a significant amount of lessons learned have been used to strengthen the transportation program with root cause analysis and mitigation plan. This paper is describing one of the operational events that EDF and AREVA TN have been facing and actions put in place to resolve it. During the casks operations, mainly during the loading and unloading operations, foreign objects can fall into cask cavities. These foreign materials are not allowed by the certificate of approval; therefore, for each occurrence, the French Competent Authority must be informed, including the corresponding safety analysis.

As an example of lessons learned and continuous improvement, in 2010, EDF and AREVA set up a working group to identify the origin of these foreign materials and find solutions to improve the cleanliness of the cask cavities and thus transport safety.

EDF and AREVA TN have the most proven experience with used fuel shipments. Even after 40 years of operations, continuous improvement is a team objective.

Why reducing the number of foreign materials?

Definition of a foreign material

The allowable contents are prescribed in the certificate of approval. In the case of spent fuels transport, the only materials allowed are the fuel, the fuel holder when needed, the spacers and the basket, all others objects are not allowed and then called foreign materials.

Different kinds of foreign materials can be found in the cavity:

- rigid objects;
- flexible objects.

Some are organic components.

The foreign materials are not allowed by the certificate of approval. Therefore, when a foreign material in the cavity is detected or suspected, following transports cannot be performed without specific actions, as described hereafter.

Action plan when a foreign material is found in the cavity

There are two ways to find foreign materials, during exploitation operations or during maintenance.

During loading or unloading, it can occur that the operators detect (or only suspect, for example when the material falls in the pool and out of operators' sight or in the case of a missing gasket) a foreign material in the cavity or in the loading pool. In this case, as foreign materials are not allowed in the cask during transport, the operators have to make all the necessary operations to remove it, including, if possible, unloading the spent fuels from the cask in loading conditions. If unloading the fuels or removing the foreign material is not possible, information to the French Competent Authority, including a safety analysis, is needed before performing the transport. If the French Competent Authority agrees, following transports are performed and the foreign material is removed at the next maintenance (if confirmed in the case of a suspicion).

However, most of the foreign materials are detected and removed during maintenance operations because it is the only moment that allowed a full access to the cavity, including the bottom where the foreign materials can easily fall. As some transports have been done with foreign materials before to notice them, in this case, a declaration to the French Competent Authority is sent by the consignor. Indeed, for the previous configurations the transports are performed on the basis of the certificate of approval and the formal authorization sent by the French Competent Authority, whereas when the foreign materials are detected during maintenance operations, as we cannot determine when the foreign material fell into the cavity, we consider that all the transport performed since the last maintenance were not fully in compliance with the certificate of approval. Consequently, in this case, the French Competent Authority is informed of this non-compliance.

Safety impact of an organic foreign material (flexible or rigid)

The main safety impact of an organic foreign material in the cavity is the radiolysis analysis. Indeed, an organic foreign material can release hydrogen, especially in case of transport of high level activity contents, such as used fuels.

Consequently, a radiolysis analysis is performed to justify that, considering the total decomposition of the foreign components by radiolysis, the quantity of hydrogen produced remains below the lower limit of flammability determined in the safety analysis report.

For example, hereafter is detailed the analysis performed on a piece of duct tape found during maintenance operations in a TN®13/2 cavity:

Figure 1 Piece of duct tape

Considering a penalizing evaluation of the object dimensions, the mass of the foreign material is estimated to 3 grams. In a conservative way, it is considered that the material is made of polyethylene, which is the most hydrogenated material. All the hydrogen contains in 3grams of polyethylene is considered released in the cavity by radiolysis. It leads to a H_2 rate in the cavity equal to 0.69 %, which remains below the criteria of 1.5 % corresponding to the lower limit of flammability defined in the TN®13/2 certificate of approval <1> considering the maximum content temperature in accident fire conditions and the maximum thermal power allowed per spent fuel assembly.

Considering the complete disintegration of the organic foreign materials by radiolysis is a very conservative assumption as the objects are found intact in the cavity after a few transports.

Safety impact of a rigid foreign material (not organic one)

For the rigid objects, it must be demonstrated that the foreign material due to its location or geometry cannot damage the basket or the fuel assemblies.

Conclusion

Even if it has been justified the non-impact of the presence of the foreign materials found in the cavity on the safety of the cask transport, it is not satisfactory to find foreign materials in the casks cavity for the following reasons:

- foreign materials are not allowed in the certificate of approval;
- if the size or the numbers of foreign materials significantly increase, the non-impact on the safety will be difficult to justify.

Therefore, a working group between EDF and AREVA is actively working to determine the origins of these foreign materials and to find solutions to decrease or even eliminate the number of occurrence.

EDF and AREVA Working Group

As the number of foreign materials found in cask cavities was increasing, in 2010, EDF and AREVA set up a working group to identify the origin of these foreign materials and find solutions to improve the cleanliness of the cask cavities and thus transport safety.
The working group was constituted by the following entities:

- EDF – loading sites;
- AREVA NC - La Hague and AMEC3 – unloading and maintenance sites;
- AREVA MELOX – fresh fuel loading site (even fresh fuel transport is less concerned by the foreign materials, lower number of occurrences, it was still interesting to share experience with MELOX);
- AREVA TN – casks owner and certificate of approval applicant.

To identify the origins of these foreign materials and to understand how they end up in cask cavities, the working process was the following one:

- Meeting with the different participants to share the objectives and experiences;
- on-sites inspections of the operations;
- Analyses of the reports of inspection.

Understanding of the origins of the foreign materials

The first phase of the working group was to make an assessment of the foreign materials met in cavities to determine their origins.

In 2010, 22 foreign materials have been detected in 11 different casks. Among these items, 6 were rigid objects (small-sized spring, screw...) and 16 were flexible organic materials (gasket, duct tape, thin rope, colson collar...).

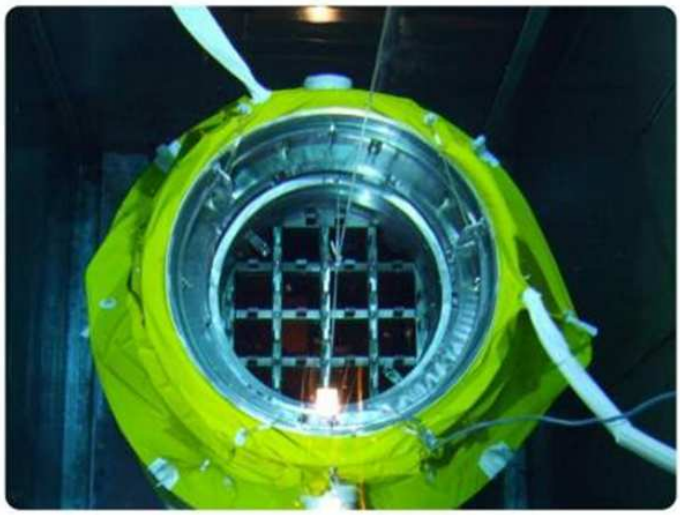

Figure 1 TN®112 cask during loading operations

The conclusion of this first phase is that the foreign materials are of different materials and various geometries and sizes. They can come from cask operations sites (maintenance, loading and unloading pools, etc…) or from the design of the cask itself. For example, with the previous design of the body orifices of the TN®12/2 and TN®13/2 casks, the gasket could be suck up in the cavity due to the difference of pressure between the connection tools and the cavity. Operators did not obtain leak tightness criteria and noticed the absence of gasket which had to be replaced before the transport.
Finally, the close environment of the casks operations areas is a high-risk area.

Action plan set up by the working group

The working group concluded in five types of recommendations implementes in the operation and maintenance facilities. These categories are:

- Work organization;
- Cleanliness of the installation;
- Cleanliness of the work areas;
- Specific actions on the casks;
- Visual checks.

In practical terms,

- The main improvement of the work organization is to reduce the time when the cask is opened in order to decrease the risk of fall of components in the cavity.
- By cleaning the installation in general, it can be repainting the wall or crane to prevent the fall of small pieces of paint for example. It can also consist in improving the cleanliness of the storage or loading pools.
- Cleaning the work areas and small racks prevents from involuntary falls of small tools or materials used for the casks operations.

- The specific action on the cask is to design and set up a new plug for the orifice on TN®12/2 and TN®13/2 casks in order to prevent the orifice gasket loss in the cavity.
- Visual checks during loading or unloading operations allow detecting immediately if there is a foreign material in the cavity and, when it is possible, to remove it before closing the cask.

All the members of the working group participated in the writing of one common report in 2012 <2>, every action to be implemented is described in a specific data sheet.

Cleaning actions of the work areas and the installations as 5S or FME (Foreign Material Exclusion) methods and best practices were spread on every loading, unloading and maintenance site used for the transport casks.

These instructions of cleanliness were later deployed in the procedures of every installation.
The conclusions of this workgroup were presented and validated by French Competent Authority in 2012 and since 2011 the working group presents yearly a balance of the actions progress and a balance of the foreign materials found in the cavities of transport casks.

Beyond this actions plan, the recommendations of the working group are now used for all the activities that can bring directly or indirectly to foreign materials in the cask. For example, the specifications for the news tools used closed to the pools always have now a dedicated paragraph specific to FME and futures cask TN®G3 is designed to reduce the risk of sucked gasket.

Results

As shown in Table 1 and Figure 2 hereafter, the results of the working group actions are very satisfactory. Not only the number of the foreign materials found in cavity has significantly decreased, but their sizes decreased too. Awareness of the operators regarding this issue has been enhanced, and the detection of foreign materials is today much more effective than in 2010.

Table 1

Year	Number of casks concerned	Number of foreign materials
2010	11	22
2015	2	4

The new design of the plug of the orifices design have been implemented on the whole TN®12/2 and TN®13/2 fleet since end of June 2014. No orifice plug gasket has been found in casks cavities in 2015 but it can still be found a few residual gaskets until all the casks have passed their maintenance. However, from the end of 2016, it is expected to not meet this kind of foreign materials in cavity casks anymore.

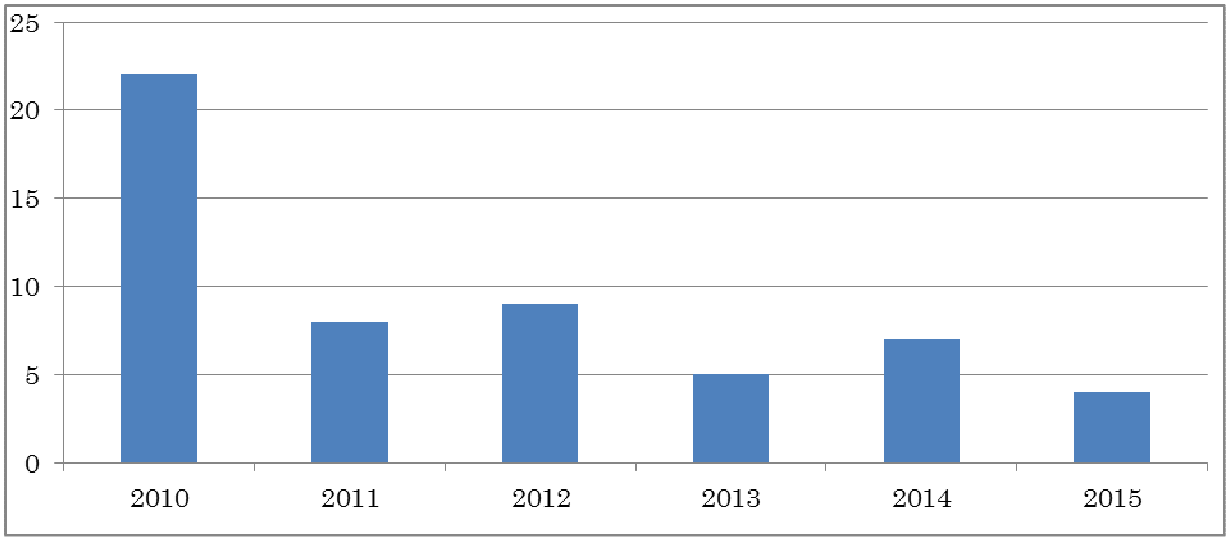

Figure 2 Evolution of the number of foreign materials found in the cavity per year

Conclusions

Individual assessments from EDF and AREVA were not productive to build of robust cause analyses allowing the resolution of foreign material matter.

Only the creation of this working group by the different actors of French nuclear led to exchange on best practices to be implemented and to find solutions in order to solve this operational issue.

The purpose of the working group was to eliminate the numbers of occurrences. The short term actions such as cleaning work areas and long term actions related to cask design already implemented allowed reducing significantly the number of foreign materials in casks cavities.

Furthermore, sharing the experiences is now a lot more frequent. At least after each spent fuel evacuation performed by AREVA on EDF power plants, a meeting is set up between all the participants to talk openly about improvements.

References

<1> TN®13/2 certificate of approval F/274/B(M)F-85T (Lad)
<2> Common report « Synthèse et conclusions du groupe de travail ‘propreté’ des emballages de transport de combustible usé et de mox frais »