RATIONALIZING TRANSPORT OPERATIONS: THE TN 24 TRANSPORT STORAGE CASK APPROACH

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Abstract

The number of transports of spent fuel interim storage casks can be reduced by improved standardized cask design. Optimization of cask design is based on two main technological choices: shielding and spent fuel support basket design. The approaches to optimizing cask design to improve payload is described for the Transnucleaire TN24 family of dual purpose transport and storage casks.

1. INTRODUCTION

As last year’s events have clearly shown, the issue of transport of nuclear materials is all the more vulnerable to hasty judgements from the public as it takes place in the public domain. The constant concern of transport casks designers and operators is improving safety and keeping the roads open.

Many actions contribute to that goal, in the fields of choice of material, of transport equipment, of routes, of training and drafting procedures etc. The one very significant contributor to rationalizing the ground transport operations is finding ways to diminish the number of these operations, especially for spent fuel and vitrified high level waste.

The approach presented here should satisfy competent authorities as it diminishes impact on the environment and on public acceptance.

The present paper presents the application of this principle of reducing the number of transports of spent nuclear fuel interim storage casks. It shows how it has been implemented in the TN 24 family of dual purpose casks. It shows that, for that purpose, standardization is more effective in terms of technology used rather than in terms of products.

2. HOW CAN DIMINISHING THE NUMBER OF TRANSPORT OPERATIONS BE ACHIEVED?

We proceed here on the rational basis that civil use of nuclear energy is beneficial to mankind. We reject the contention that the only way to diminish transport operations is to put an end to nuclear generation altogether. In fact this would not change the rationale of what we propose here for whatever needs be transported.

- First comes the reduction of quantities of radioactive materials to be transported. Careful choice of conditioning and sorting of materials can make a first step in transport improvement. One clear way to achieve this is by going to higher fuel burnups so as to diminish the number of reloads. Connected to that is reprocessing, which actually allows a reduction of fuel handling operations, as it separates high level radioactive wastes and concentrates their volume. Transporting one glass canister avoids transport of approximately 80 spent fuel assemblies!

Most radioactive material producers and users are working steadily on these approaches.

- Second comes the increase of payloads of individual transport containers: doubling the payload of a container will halve the number of transport operations to perform, and will improve safety. This improvement stems from the fact that potential consequences from transport accidents or malevolent attacks are proportional to the number of kilometers on the road or railway but do not increase with the payload of a given container.

Why do they not increase?
The transport regulations are such that consequences of an accident are measured and limited with reference to the toxicity of the content, not with reference to the size of the content. In other words, if a given content has a toxicity index $A_2$, under the most severe accident condition, it may not release more than $A_2$ in one week. $A_2$ is a function of the isotopic composition of the material transported and not of the quantity of material transported. It follows that if a container contains ten times more than another one, this larger container may still release no more than the smaller one in case of accident.

Regarding radiation, the dose rate limits are as low for a large container as for a small one: it is therefore better to circulate larger containers less frequently, so that the accumulated dose en route is diminished.

3. THE EXAMPLE OF THE TN 24 CASKS FAMILY

It is this aspect that Transnucléaire has emphasized in the development of the TN 24 cask family of storage/transport casks listed below:

<table>
<thead>
<tr>
<th>CASK NAME</th>
<th>For transport and interim storage of</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN 24 P</td>
<td>24 PWR spent fuel assemblies</td>
</tr>
<tr>
<td>TN 24 B</td>
<td>52 BWR spent fuel assemblies</td>
</tr>
<tr>
<td>TN 24 D</td>
<td>28 PWR 900 spent fuel assemblies</td>
</tr>
<tr>
<td>TN 24 DH</td>
<td>28 PWR 900 spent fuel assemblies</td>
</tr>
<tr>
<td>TN 24 XL</td>
<td>24 PWR 1300 spent fuel assemblies</td>
</tr>
<tr>
<td>TN 24 XLH</td>
<td>24 PWR 1300 spent fuel assemblies</td>
</tr>
<tr>
<td>TN 24 SH</td>
<td>37 PWR spent fuel assemblies</td>
</tr>
<tr>
<td>TN 24 G</td>
<td>37 PWR spent fuel assemblies</td>
</tr>
<tr>
<td>TN 52 XL</td>
<td>52 BWR short cooled spent fuel assemblies</td>
</tr>
<tr>
<td>TN 97</td>
<td>97 BWR spent fuel assemblies</td>
</tr>
</tbody>
</table>

As one can see from the above table, the contents can vary in a proportion of more than 50% in case of PWR fuel and almost 50% in case of BWR fuel.

4. HOW IS OPTIMIZATION ACHIEVED?

By carefully integrating fuel assembly specification differences in terms of burnup, decay time, initial enrichment and geometry, it has been possible to maximize efficiently the casks payloads. This is based on two main technological choices [1-4]:

*Shielding*

Shielding is designed so as to be able to uncouple neutron shielding issues from gamma shielding issues.
The neutron sources increase very quickly with burnup and have a very slow decay versus time, whereas gamma sources decrease exponentially with time, as shown by the curve below.

![Graph showing dose rates](image)

**FIG.1. Surface dose rates on a cask.**

Uncoupling the shielding allows adapting readily to the actual need of the power plant and the set of fuel, and thus maximizes payload. In the TN 24 casks, the main gamma shielding is made of forged carbon steel, while neutron shielding is made from a neutron absorbing resin forming an outer layer on the gamma shielding. A steel outer shell protects the neutron shielding.

Because gamma radiation diminishes quickly with time, for a given initial global dose rate, a stronger neutron shielding will keep the global dose delivered lower than with a strong gamma shielding and a weak neutron shielding.

**Criticality control and mechanical support of fuel assemblies**

Baskets, that support the spent fuel and guarantee subcriticality, are basically boron aluminium structures.

This structure combines several advantages towards increasing the payload:

- Aluminium is a good heat conductor: less material is required to dissipate the decay heat while keeping low fuel cladding temperatures. The result is a smaller basket.
- Boron that captures moderated neutrons is distributed in the aluminium matrix at the best possible position for maximum efficiency. Furthermore, it cannot accidentally be separated from its aluminium matrix
- Aluminium alloys have a low specific density, hence the basket mass is minimal: this saves available weight for shielding purposes or for additional payload.
5. CONCLUSION

By aiming to improve the payload of transport/storage casks, a significant contribution is made to waste management.

This approach displayed here has been implemented steadfastly, and is being proven again by the current development of the TN 81 transport storage cask for high radioactive vitrified wastes that improves the capacity of such dual purposes casks by 40%.

These examples contribute in fact not only to limited handling and transport, but also to more compact interim storage facilities.

REFERENCES