A New Basket for Transport/Storage Casks

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1 - INTRODUCTION

The heart of any cask concept is its basket :
Because the outer dimensions of a transport cask, or the weight at crane hook of a storage cask are frequently the limiting factors, one must aim at baskets that are as compact as feasible.

What does prevent from having a very tight array of LWR spent fuel assemblies inside a cask ?

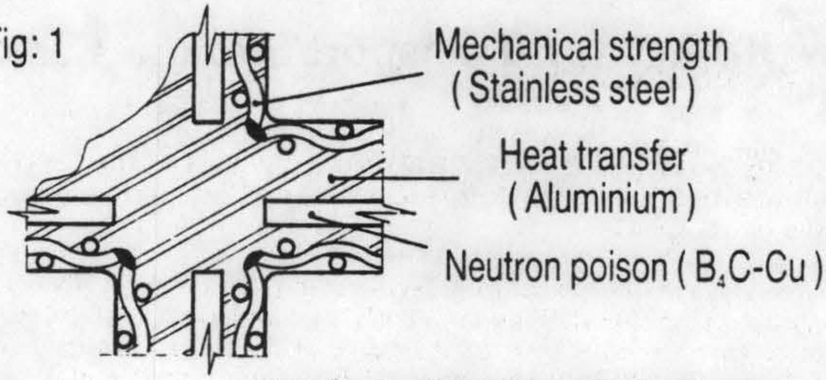
- criticality control that requires a minimum gap for neutron moderation and subsequent capture by neutron poison (one must remember that taking credit for burn up in the case of transport systems is onerous for operation).

- the resistance to mechanical loads that requires inertia : room must then be made for the structural members of partitions between assemblies so as to justify acceptable behaviour under accident conditions.

- thermal transfer that requires heat paths to the outside while maintaining acceptable temperatures both for fuel rod cladding and for the structure of the basket.

This paper will recall the solutions developed by TRANSNUCLEAIRE in coping with the above set of limits, the relative importance of which changes as new payload requirements appear. It will then explain the very last developments in our basket know-how, for short cooled and for long cooled fuel.

Fig: 1



Typical wall section: Early designs

Fig: 2

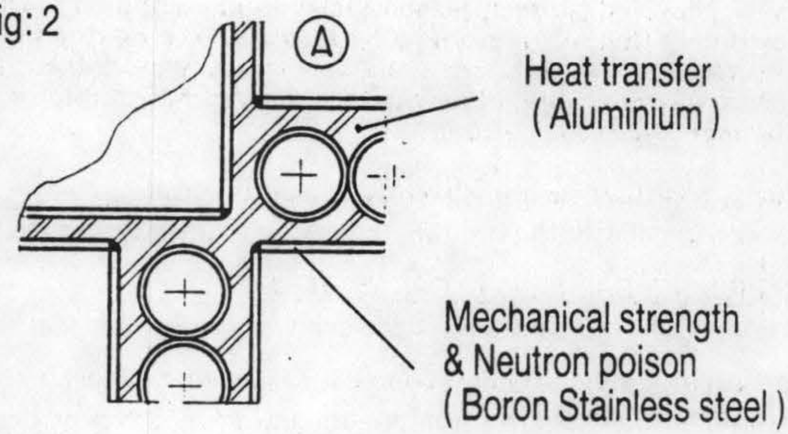
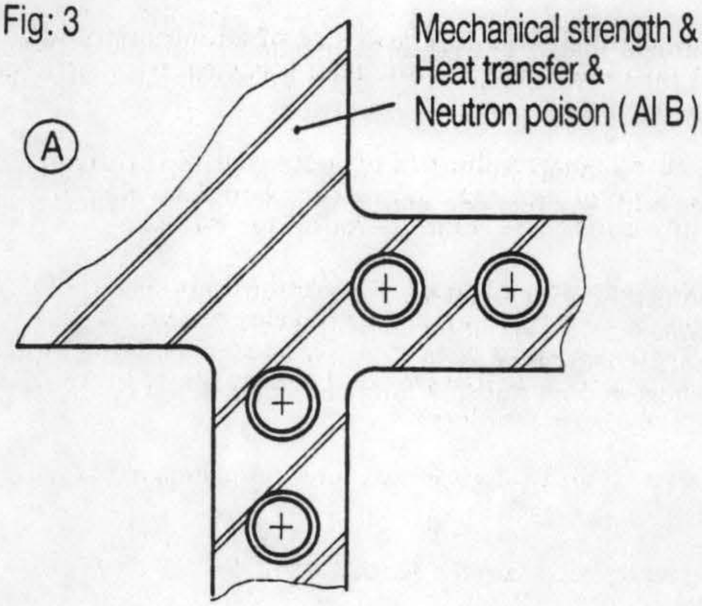


Fig: 3



2 - INITIAL BASKET DESIGNS

The TN12 family casks (TN12, TN13, TN17) were designed in the Seventies for the international transport of LWR fuel assemblies . The specified decay duration was but 8 month.

A major concern was then evacuating decay heat (120 kW for a TN12) : this led to selecting aluminium for its high conductivity coupled with stainless steel wire mesh or plates as a structural material (figure 1&2). The criticality control was secured by Boron. For PWR fuel we selected B4C-Cu sintered plates that we had previously developed for the TN8 casks because of its high boron content (1 g/cc). For BWR baskets we used regular 0.15g/cc boron stainless steel.

Positioning water gaps, lodgements, poison plates in an aluminium structure remained to be done : this was performed by selection of a casting process of sectors.These sectors are then machined and mechanically assembled. Thus were cast among the largest ever aluminium castings, the reproducibility of which has been proved by more than 600 sectors.

More than ninety such baskets are currently in operation.

3 - CURRENT DESIGNS FOR SHORT COOLED FUEL

Since 1982, two incentives made us evolve a basket with higher performances for the TN12 family casks :

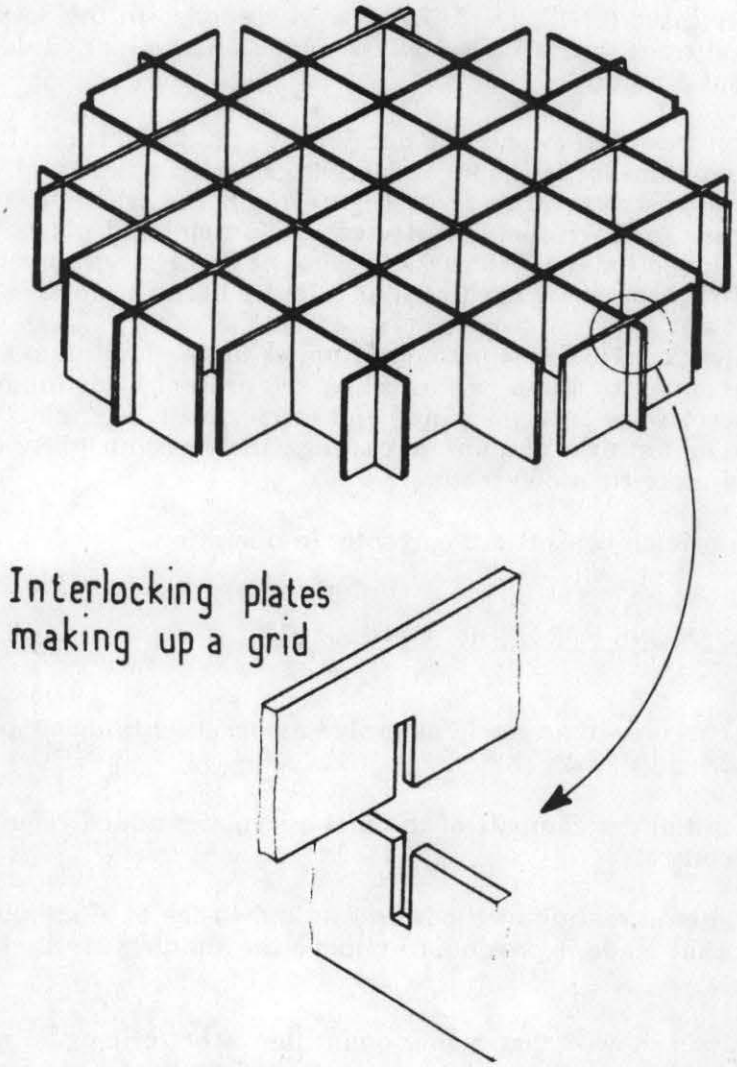
- increased initial enrichments of the fuel assemblies added requirements on criticality control
- improvements in casting methods and in knowledge of aluminium alloy behaviour that made it possible to remove the stainless steel wire structural support.

Careful analysis showed that higher quantities of better located neutron poison could solve the first point and that fabrication would be simplified by the second all the more if a substitute could be found for B4C-Cu.

We solved the two issues in one breakthrough : a standard aluminium alloy in which the boron is scattered in the matrix was developed and successfully tested in casting processes. Segregation of boron was mastered and kept at a minimum.Short term and long term behaviour of the alloy was proven by tests to be as good as that of classical alloys.

The results have enabled us to license the corresponding packagings for initial enrichments up to 4.3 % U5.

The first basket of this generation has been loaded at EDF-Blayais (France) power station in July 1985.



Section of new basket for storage/transport casks
Fig: 4

ADVANCED BASKET
FOR TRANSPORT AND STORAGE

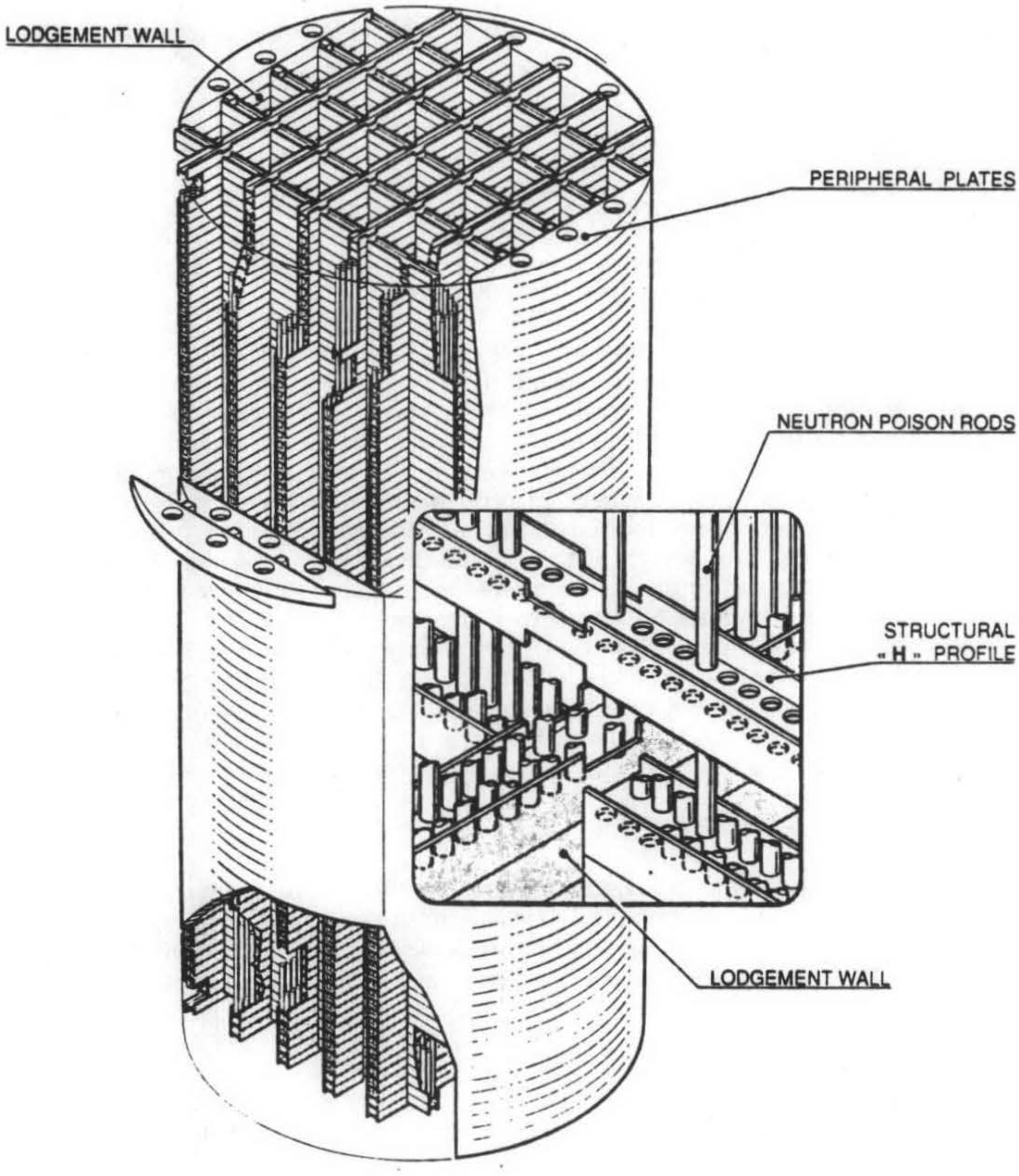


FIG : 5

Thirteen of these new baskets (figure 3) have now been delivered for Belgian, French, German, Japanese, Swedish (SKB) and Swiss spent fuel transports. The drying times have been dramatically shortened to 3 hours for a low decay heat (10 kW). More than 2000 fuel assemblies have been thus transported to date.

This basket design is now proven and can be installed in all existing TN12 family casks. To illustrate its versatility, we have recently been asked to design, license and supply, to this basic design, new baskets for a competitor's cask.

4 - DESIGNS FOR LONG COOLED FUEL

With the development of dual purpose storage and transport casks for 5 to 10 years cooled fuel, the design capacities went up while the major design issue shifted from thermal and mechanical to criticality issues.

Our paper at 1986 PATRAM presented a novel design which was based upon criticality control by insertion of boron aluminium rods in the guide thimbles of the assemblies, boron aluminium walls and no water gap ! (figure 4). This design is implemented in the TN24P dual purpose cask presently undergoing long term testing at INEL. It works perfectly well, and is extremely compact since it accomodates 24 assemblies where 21 only would fit without poison rods. Today its 24 lodgements are loaded with fuel rods consolidated from 48 PWR assemblies. However this design has the same disadvantage as resorting to burn-up credit : it puts an onus on the operator of the pool where the cask is loaded, since means must be found to guarantee that the fuel elements being loaded are indeed poisoned (just as guarantee that the burn-up is effective must be given to take credit for it). We did develop a system that prevents handling of the fuel assembly for loading if it is not poisoned : therefore a simple equipment fully solves the issue. It remains a difficulty for transport because acceptance by the consignee (reprocessing or storage facility) must be secured.

This is why we developed a basket (figure 5) that provides a new answer to storage and transport with high capacity casks without resorting to burn-up credit nor to the insertion of poison rods in thimbles. It was made possible by the development of a new poison material with a high boron content.

It features :

- standard aluminium alloy profiles for structural strength and heat transfer. The H shaped profiles are mechanically assembled and make up wall partitions,

- poison rods permanently inserted into holes drilled into the profiles for criticality control.

Because the "water content" of the partitions is high, we get an excellent criticality control inside a small cavity :

Today we are able to accommodate, within usual power plants handling limits (125 US tons) and for 10 year cooled fuel, at least 32 PWR assemblies 3.5 % enriched in a steel storage-transport cask . For 5 year cooled fuel, 28 assemblies can be loaded. Because this design does not resort to burn-up credit, the licensing process and implementation are simplified for the users. Of course, this design also works well for smaller capacity casks such as TN12 for shorter cooled fuel.

Because the strength is based upon standard structural material, and because of the simplicity of the concept, licensing of this basket which we have patented should be straightforward.

5 - CONCLUSION

Be it for short or long cooled fuel, we have developed a range of baskets for transport and storage casks that meets all currently expressed needs without resorting to burn-up credit nor to any additional operational constraints on cask and pool operators. Optional burnup credit is also forseeable thus further enhancing the baskets high performances within the same allocated size limitations.

6 - REFERENCES

Meyer P. & al, Progress in designing the internal arrangements of packagings for LWR spent fuel, IAEA-SM-286/202P, PATRAM 86.

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Transport Experience/ Exposures