CONCEPTUAL EVALUATION OF TYPE B(U) CASKS FOR THE NUCLEAR POWER PLANTS OF ARGENTINA

P.C. Florido, E.R. Isnardi

Comisión Nacional de Energía Atómica, Centro Atómic Bariloche, 8400 S.C. de Bariloche, Río Negro, Argentina

INTRODUCTION

In a conceptual evaluation of different designs of a type B(U) package, several engineering solutions must be studied. In this stage (conceptual design) small, easy and fast computer programs should be used. The principal issues that have to be fixed are shielding properties, thermal effects and mechanical behavior.

In conceptual evaluations, different boundary conditions correspond to different final choices: materials and geometry, total transported weight, burnup levels and decay times.

In Argentina two different nuclear power plants are in operation, Atucha I (PHWR-Siemens) and Embalse (PHWR-CANDU). Thus two very different fuel elements could be potentially transported. In order to optimize the research and development needed for the design and construction of the cask, the cost-benefit and flexibility of the engineering solutions are studied, for the two fuel elements.

The models and methods employed in the programs developed, are shortly discussed.

MODELS USED

a) Radioactive source:
For decay times greater than one year, the main gamma source are the fission and activation products. These nucleids are Sr90, Y90, Zr95, Nb95, Ru106 ,Rh106, Cs143, Cs137, Ce144, Pm147. Eu154, Ta182 and Co60, taking into account around 50 photon energies. The neutron source (spontaneus fissions and (α,n) reactions) is mainly produced by a few actinides, wich are Cm242, Cm244, Pu239, Pu240 and Am241.

Both sources were calculated in a multigroup formalism, with simple correlations for each radionucleide with different burnup-levels (7000 to 40000 MWd/THM), and decay times (1 to 40 years),with an error of 10%, compared with KORIGEN and ORIGEN calculations.

b) Dose and radiation transport [1]:
The fuel can be arranged in different geometries, and given the burnup-level and decay time, the radiation source is totally caracterized.

The gamma attenuation kernel was numerically integrated in the source volume. Multilayer shielding was used with appropriate attenuation coefficients for each material, computing the Build-up factors with the Taylor's model, and Berger's formalism. All the coeficients could be interpolated in a table, with different interpolation laws. The neutron transport was calculated using single removal or absorption cross sections, for fast neutrons (in presence of hydrogen). The final dose was calculated, using the flux-to-dose response function.

The final tool is good as long as the attenuation model with buildup-factor is good, and both models are usually used even for basic design. The designer could specify the target dosis, and the program, changing a specified dimension, reaches the specified dose rate. Finally the programs calculate the dimension and weight of the different materials used in the casks.

c) Thermal model [2]:
The principal heat source is mainly composed of the fission products (for short times) and actinides, and it was calculated by simple analytic expressions.

The heat transport, both between the fuel elements and inside the cluster itself, were calculated within a typical radiation model, by numeric integration of the view factor. The results of this model were checked with experimental data available in our country, and it was found that they were in good agreement.

The stationary and transient heat conduction for the walls of the cask, were modeled with a classic model of a one-dimensional finite difference, checked with exact (stationary case) and computational (transients models) solutions usually available. The outer boundary conditions allow to calculate a pool fire situation and natural convection in air.

d) Impact model [3]:
Usually available correlations are used for puncture test. For free-drop tests, in conceptual design, two different models were checked, the conventional Volumetric Displacement Method (VDM), and the Uniaxial Displacement Method (UDM), and the results were compared with experimental data and computer tests available in the bibliography. For the calculation of deformation length, both methods predict sufficiently accurate results, but for the calculation of the maximum acceleration, the results obtained with the UDM are better than those from VDM (the VDM is too

sensitive to the dynamic fluence strength, unlike the UDM).

e) Cost model:
The conceptual costs were calculated using the total weight for the materials used, fabrication costs, and the distance traveled. The costs program interpolate for different geometries, decay time and burnup level, for a given fuel element type and material used.

DESIGNS STUDIED
Different casks, for both types of existing fuel elements (Atucha I and Embalse), for different burnup-levels (regarding the advanced fuel cycle available), decay times, distances, and transported weight were studied. Three materials for shielding were used: uranium, lead and steel. Only transport by road was considered, due to the reduced availability of the train.

The total weight of the cask is a very important variable in a cask transported by road, so the absice in the following graphs represent the total weight of the cask (i.e. fuel elements and the cask itself).

The effects of the different weights transported are strongly dependent on the number of trips in wich the capital costs are recovered. This can be seen in figure 1, showing the effect of transportation, fabrication and total cost for the CANDU fuel element.

The effect for different materials can be seen in figures 2 and 3, for both fuel elements, and the effect of burnup-level in figure 4.

CONCLUSIONS
As a result of the evaluation, different options for the casks were founded, as well as the importance of different parameters and the effect of two different designs of fuel elements.

The CANDU fuel element (for the nuclear power plant Embalse), could be transported in an economical range for different burnup-levels and decay times, due to its small dimensions and the gamma self absortion properties of the uranium in the fuel.

The Atucha fuel element (PHWR-Siemens) could be transported economically by casks of different materials only with the present burnup, and long decay time. For an advanced cycle (actually proposed), it could be economically transported in an uranium, or maybe lead, cask (limited by the thermal expansion of lead).

REFERENCES
[1]R.G.Jaeger,"Eng.Comp. on Rad. Shielding",Springer Verlag.

[2]W.H. Mc. Adams, "Heat Transmission", McGraw-Hill.
[3]L.B. Shappert, "Cask Designers Guide", ORNL-NSIC-68.

FIGURE 1: CANDU TRANSPORT COSTS
COST EFFECT COMPONENTS

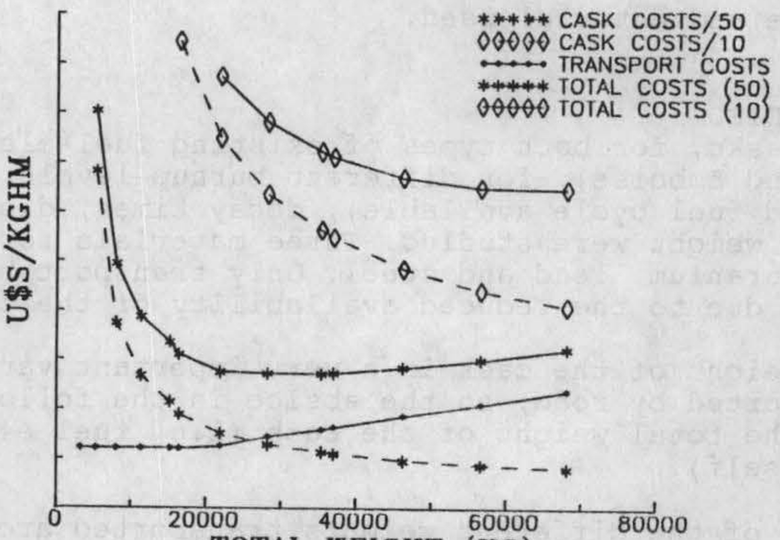

FIGURE 2: CANDU TRANSPORT COSTS
EFFECT OF MATERIALS USED

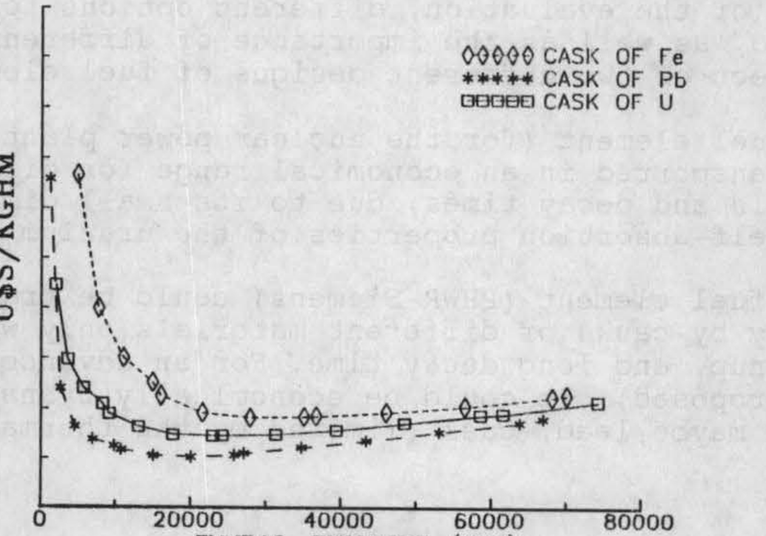

FIGURE 3: ATUCHA TRANSPORT COSTS
EFFECT OF MATERIALS USED

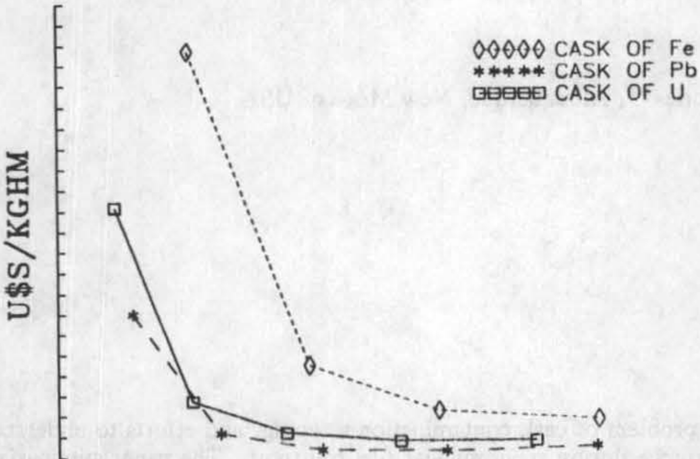

FIGURE 4: ATUCHA TRANSPORT COSTS
DIFFERENT BURNUP LEVEL