A PERSONAL COMPUTER PROGRAM FOR EVALUATING THE IMPACT OF PROPOSED CASK DESIGN SPECIFICATIONS*

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Shipments of spent fuel to the Monitored Retrievable Storage (MRS) facility may be minimized by developing a new generation of truck and rail casks. Specifications for such casks are now being prepared. While such specifications must be consistent with long-term economic, logistical and operational goals, they must not be overly restrictive. A new interactive program called CAPSIZE has therefore been written for the IBM-PC to rapidly determine the likely impact that proposed criteria might have on the size and capacity of casks designed to meet those criteria.

Given the burnup of the spent fuel, its cooling time, the thickness of the internal basket walls, the desired external dose rate and the nominal weight limit of the loaded cask, the CAPSIZE program will determine the maximum number of PWR fuel assemblies that may be shipped in a lead-, steel-, or uranium-shielded cask meeting those criteria. The necessary neutron and gamma shield thicknesses are determined by the program in each case. The calculational response time required for determining the capacities and shield thicknesses for all three types of casks totals approximately 2 or 3 seconds for small truck casks and approximately 8-12 seconds for large rail casks. The user may then interactively change one or more of the specified criteria and readily determine the impact of those changes on the projected capacities.

Neutron and gamma source terms, as well as the decay heat terms, are based on ORIGEN-S analyses of PWR fuel assemblies having exposures of 10, 20, 30, 40, 50, and 60 gigawatt days per metric tonne of initial heavy metal (GWD/MTIHM). In each case, values have been tabulated at 17 different decay times between 120 days and 25 years. The CAPSIZE program then performs a 2-D interpolation of this tabulated data to obtain the source terms and decay heat loads for the conditions specified. Based on comparisons with numerous 1-D transport calculations for different types of fuel, the neutron and gamma radiation levels impinging on the inner wall of a cask have been found to be proportional to $N^{0.75}$ and $N^{0.5}$, respectively, where N is the number of assemblies in the cask. These correlations are used in the CAPSIZE program to account for the spatial self-shielding by the fuel itself.

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* Only a summary is published here.

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One-group dose attenuation factors (i.e., cross sections) are used to determine the necessary shield thicknesses. This data, for the neutron and gamma shields and each of the stainless-steel shells used to build the cask(s), is dependent on the age of the spent fuel, the type of shield material (Pb, Fe, or U-metal) and the nominal thickness of the neutron and gamma shields. The one-group data library used in the CAPSIZE program has been distilled from the intermediate results of several hundred 1-D multigroup transport calculations for different types of casks containing different numbers of spent fuel assemblies with cooling times ranging from 1 to 10 years.

Other features of the CAPSIZE program include: (1) an automatic shielding optimization algorithm which determines the relative amounts of neutron and gamma shielding in such a way as to meet the specified external dose rate while simultaneously minimizing the overall weight of the loaded cask and (2) a steady-state heat transfer calculation which will minimize the size and weight of external cooling fins, if and when such fins are required.

The CAPSIZE program has proved useful in quickly evaluating the impact of many different proposed design constraints. Analyses have also been performed for standard 33 GWD/MTIHM PWR fuel assemblies with cooling times of 1, 2, 3, 5, 7 and 10 years. Comparisons with previously reported results[1] show that the CAPSIZE program can generally estimate the necessary neutron and gamma shield thicknesses to within 0.4 cm and 0.2 cm, respectively. The corresponding cask weights have generally been found to be within 1000 lbs (454 kg) of previously reported results.[1] While further comparisons would still be desirable for optimized casks carrying fuel at other exposures, the degree of accuracy demonstrated to date suggests that the CAPSIZE program will be a valuable desktop tool for evaluating the likely impact of proposed design specifications.

REFERENCE

1. J. A. Bucholz, "Scoping Design Analyses for Optimized Shipping Casks Containing 1-, 2-, 3-, 5-, 7-, or 10-Year-Old PWR Spent Fuel," ORNL/CSD/TM-149 (January 1983).