CRITICALITY CONTROL OF BWR FUEL
DURING ROD CONSOLIDATION AND STORAGE

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Abstract

Criticality analyses of BWR fuel during rod consolidation operations were performed for both normal and abnormal operating conditions. The average fuel enrichment was 2.74 w/o U-235 with no credit for burnup. Results showed that subcriticality is assured under all conditions as the fuel is consolidated, and that consolidated fuel canisters may be stored safely in the spent fuel pool rack.

The reactivity of normally undermoderated BWR fuel assemblies may conceivably increase during the rod consolidation process due to the availability of additional moderator space as rods are placed in the canister. Fully loaded cans are less reactive than standard assemblies (k_{inf} of 1.20 versus 1.36) but partially-loaded cans could be more reactive (k_{inf} of up to 1.39) if the rods are assumed to be unconstrained in the canister and arranged at the optimum pitch and represent a potential critical configuration that must be evaluated.

A series of criticality analyses using the KENO program was performed. All fuel was treated as 2.74 w/o unirradiated rods with no credit taken for the burnup which would be expected in assemblies that are candidates for rod consolidation, and no Gadolinium burnable poison. The moderator and fuel are assumed to be at 70°F. The calculations for the loose rod (ungridded) canisters conservatively assumed that the rods were uniformly distributed within the canister to achieve the most reactive possible configuration. In reality, the rods will probably all rest against one side of the canister which is a more subcritical configuration than the one that was analyzed. The storage rack calculations assumed an infinite array to assure that no combination of events could exist which could create a more reactive configuration.

The disassembly elevator was analyzed with optimally moderated fuel rods in all containers as well as the assembly location, which overstates the amount and reactivity of fuel present. When the elevator is in its highest position, a fuel assembly or canister could hypothetically be brought alongside the elevator increasing the reactivity of the configuration, as shown in Fig. 1. The most reactive position for this assembly (or canister) was determined to be alongside the fuel assembly holding position in the elevator. This most reactive location was determined by KENO calculations at successive positions along the of the elevator. The results of these analyses are tabulated in Table I and show that subcriticality is maintained in all cases. These results include corrections for the bias and uncertainties of the calculations.

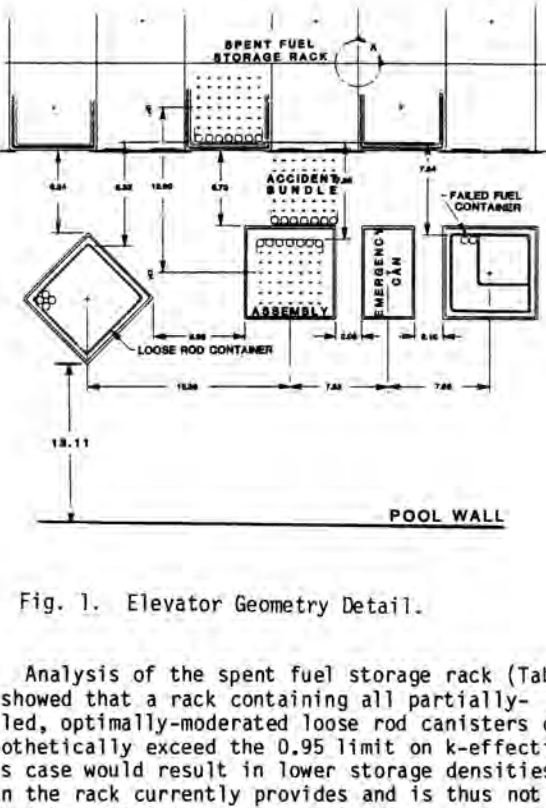

Fig. 1. Elevator Geometry Detail.

Analysis of the spent fuel storage rack (Table II) showed that a rack containing all partially-filled, optimally-moderated loose rod canisters could hypothetically exceed the 0.95 limit on k-effective. This case would result in lower storage densities than the rack currently provides and is thus not permitted by administrative controls that prevent storage of partially-filled containers in adjacent rack locations. This does not pose operational difficulties as the likelihood of more than one partially-loaded canister remaining at the end of a consolidation campaign is slight, and dummy fuel rods could be used, in most instances, to prevent the occurrence of a partially loaded canister.

The results of the storage rack analyses, tabulated in Table II, show that subcriticality is maintained.

Table I

Disassembly Elevator Criticality Safety Analysis

Normal Operation: Elevator in up position. Unrestricted number of rods in containers.	0.772	95/95 confidence level
Normal Operation: Elevator in lowest position next to the fuel assembly storage rack. Unrestricted number of rods in containers.	0.909	95/95 confidence level
Hypothetical Accident: Elevator in up position. Unrestricted number of rods in containers, with a 7x7 fuel assembly alongside.	0.851	95/95 confidence level
Hypothetical Accident: Elevator in up position. Unrestricted number of rods in containers, with a 100-rod gridded container alongside.	0.849	95/95 confidence level

The criticality safety analyses showed that the criticality control is possible for BWR fuel during rod consolidation and storage. The use of administrative controls and/or dummy fuel rods to maintain a minimum packing density (to exclude water moderator) is somewhat different from traditional methods for criticality control (to prevent the formation of a critical mass), but nonetheless effective.

Table II

Effective Multiplication Factor for the Various Storage Areas

Infinite array of 7x7 fuel assemblies	0.923	95/95 confidence level
Infinite array of gridded canisters (100 rods per canister).	0.937	95/95 confidence level
Infinite array of loose rod storage canisters. (111 rods per canister).	0.896	95/95 confidence level
Infinite array of failed rod storage canisters (32 rods per canister).	0.864	95/95 confidence level
Loose Rod storage canister (any number of rods) surrounded by 7x7 fuel assemblies	0.926	95/95 confidence level
Loose rod storage container (any number of rods), surrounded by 100 rod gridded containers.	0.943	95/95 confidence level
Loose rod storage container (any number of rods), surrounded by loose rod storage containers.	0.958	95/95 confidence level