CRITICALITY ANALYSIS OF ANO-1

FRESH FUEL RACK

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Introduction

This report describes the criticality safety analysis for the Arkansas Nuclear One, Unit 1 (ANO-1) Fresh Fuel Storage Rack (FFSR) loaded with 4.1 weight percent U-235 fuel.

In order to meet the NRC acceptance criterion of 0.98 for the neutron mutiplication factor at conditions of optimum moderation, it is necessary to preclude the placement of assemblies in ten interior rack locations. A conservative analysis then confirms that the partially loaded ANO-1 FFSR can safely accommodate 4.1 weight percent U-235 fuel.

Methodology

AMPX-KENO was used in the criticality analysis of the fresh fuel storage racks. Originally developed by the Oak Ridge National Laboratory for criticality safety analyses, AMPX uses the 123 group SCALE cross-section library and the NITAWL routine to derive weighted cross-sections for U-238 in the resonance region with the Nordheim resonance integral treatment. SCALE is an acronym for <u>S</u>tandard <u>C</u>omputer <u>A</u>nalysis for <u>L</u>icensing <u>E</u>valuations. Output from NITAWL is supplied to the KENO program, a three-dimensional Monte Carlo neutron tracking code that calculates the system multiplication factor, k-effective.

Even though the AMPEX/KENO methodology has been extensively benchmarked by the nuclear industry, critical experiment benchmarks were performed using Entergy Operations' specific methodology in order to determine the calculational uncertainty associated with Entergy Operations' specific applications.

For the assembly design used in this application, the reactivity effects of a $\pm$ 1.5 percent variation in pellet density and a $\pm$ 0.05 weight percent variation in U-235 enrichment were determined using CASMO. CASMO is a multigroup two-dimemsional transport theory code for burnup calculations on BWR and PWR assemblies.

Fuel Assembly Design Model

The fuel bundle for ANO-1 is the B&W supplied MK-B8. This bundle consists of a 15 by 15 array of fuel rods containing UO2 in zircalloy cladding. The rods have a 141.8 inch active fuel height. An enrichment of 4.1 weight percent U-235 is assumed in all fuel. Nominal pin pitch is 0.568 inches. However, as a conservatism, the minimum average pin pitch was used in the KENO model. The stack density is calculated using the active

fuel height and the stack weight. No credit was taken for neutron absorption in the upper or lower end fittings or grids in the assemblies, rebar in the concrete or structural support steel in the racks. No burnable poison, control element assembly, or other fixed poisons were modeled as part of the fuel assembly. The reactivity increase due to the variation in pellet theoretical density was calculated using an infinite CASMO model. This very conservative method effectively increased the amount of uranium in the rack by more than 1.5 percent.

Storage Rack Model

The ANO-1 FFSR consists of a nine by eight array of storage cells on nominal twenty one inch centers. The KENO storage rack model consists of a four by four and one-half array of full-height assemblies. The array is reflected at the +x and +y faces to form an explicit model of the entire rack. Ten assembly locations were left empty of fuel (c.f. Figure 1). Concrete two feet thick was modeled on the bottom and all four sides. A maximal water reflector (30 cm. thick, density 1 gm/cc) was modeled above the active fuel and below the concrete bottom.

Previous studies by Entergy Operations have shown that eccentric placement of assemblies reduces the multiplication factor in optimum moderator analyses. The assemblies, therefore, were modeled as centered in the cells. The model used the minimum average assembly pitch. Since the moderator number density is optimized for maximum neutron multiplication, the effect of temperature is negligible.

The case of a dropped or misloaded assembly was analyzed by modeling an extra assembly in the quarter core model at a continuous pin pitch spacing from the rack. Additionally, there were no assemblies missing from the rack. After reflection, this model is equivalent to placing a total of four additional assemblies beside a fully loaded rack, an extremely conservative model of the accident. No moderator was modeled in this case.

Results

NUREG-800, Section 9.1.1 requires that the fresh fuel rack have a maximum multiplication factor of 0.98 with optimum moderation and 0.95 under normal conditions. The 95/95 k-effective obtained for the ANO-1 fresh fuel rack loaded as shown in Figure 1 is 0.96957 under conditions of optimum moderation. An assembly dropped or misloaded in a maximum reactivity

configuration beside the dry rack results in a 95/95 k-effective of 0.546718

It is concluded that the fresh fuel rack at ANO-1 can safely store sixty two 4.1 weight percent U235 enriched fuel assemblies in the pattern shown in Figure 1.

FIGURE 1: ANO-1 FFSR Loading Pattern

<----- North

		NO			NO		
			NO	NO			
			NO	NO			
			NO	NO			
		NO			NO		

"NO" indicates a location in which fuel loading is prohibited.