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SANDIA REPORT

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MELCOR 1.8.5 Separate Effect Analyses of Spent Fuel Pool Assembly Accident Response

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Executive Summary

In 2001, United State Nuclear Regulatory Commission (NRC) staff performed an evaluation of the potential accident risk in a spent fuel pool (SFP) at decommissioning plants in the United States [NUREG-1738]. The study was prepared to provide a technical basis for decommissioning rulemaking for permanently shutdown nuclear power plants. The study described a modeling approach of a typical decommissioning plant with design assumptions and industry commitments; the thermal-hydraulic analyses performed to evaluate spent fuel stored in the spent fuel pool at decommissioning plants; the risk assessment of spent fuel pool accidents; the consequence calculations; and the implications for decommissioning regulatory requirements. It was known that some of the assumptions in the accident progression in NUREG-1738 were necessarily conservative, especially the estimation of the fuel damage. Furthermore, the NRC desired to expand the study to include accidents in the spent fuel pools of operating power plants. Consequently, the NRC has continued spent fuel pool accident research by applying best-estimate computer codes to predict the severe accident progression following various postulated accident initiators. This report presents the results of separate effect calculations used to better understand the postulated accident behavior in SFPs.

Ex. 5

The MELCOR 1.8.5 severe accident computer code [Gauntt] was used to simulate the SFP accident response. MELCOR includes fuel degradation models for BWR and PWR fuel, radiation, convection, and conduction heat transfer models, air and steam oxidation models, hydrogen burn models, two-phase thermal-hydraulic models, and fission product release and transport models. Hence, it contains the basic models to address questions and phenomena expected during a spent fuel pool accident.

Ex. 5

Table E-1 summarizes the types of calculations that were performed. The types of calculations are divided into four parts; Part 1 – Decay heat evaluations, Part 2 – Separate Effect Air Cases, Part 3 - Separate Effect Water Cases, and Part 4 – Separate Effect Propagation Cases.

Table of Contents

Table of Tables

Ex. 5

Table of Figures

Ex. 5

Ex. 5

Ex. 5

Ex 5

Analysis of Spent Fuel Pool Flow Patterns Using Computational Fluid Dynamics: Part 1 -Air Cases

1 Background

In 2001, the NRC staff performed an evaluation of the potential accident risk in a SFP at decommissioning plants in the United States [NUREG-1738]. The study was prepared to provide a technical basis for decommissioning rulemaking for permanently shutdown nuclear power plants. The study described a modeling approach of a typical decommissioning plant with design assumptions and industry commitments; the thermal-hydraulic analyses performed to evaluate spent fuel stored in the spent fuel pool at decommissioning plants; the risk assessment of spent fuel pool accidents; the consequence calculations; and the implications for decommissioning regulatory requirements. It was known that some of the assumptions in the accident progression in NUREG-1738 were necessarily conservative, especially the estimation of the fuel damage. Furthermore, the NRC desired to expand the study to include accidents in the spent fuel pools of operating power plants. Consequently, the NRC has continued spent fuel pool accident research by applying best-estimate computer codes to predict the severe accident progression following various postulated accident initiators. The present report documents the use of separate effect models to develop a methodology to perform SFP accident analyses as well as to assess the importance of uncertain and variable parameters.

In Section 1.1, a description of the key phenomena expected in a SFP accident is presented. Two types of SFP accidents will be described, air cases and partial water cases. The present report examines the coolability of various assembly configurations to both complete and partial loss-of-coolant inventory accident (i.e., air and water cases, respectively). Next, Section 2 discusses the SFP geometry, the analysis methodology, and the MELCOR separate effects input model. Section 3 gives the results from the simulations. Finally, Section 4 gives the conclusions and Section 5 gives the references.

1.1 SFP Accident Scenarios

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2 ANALYSIS METHODOLOGY

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2.1 Description of the Spent Pool

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The general attributes of the spent fuel pool, the BWR fuel assemblies, and the spent fuel pool racks are described in Table 1, Table 2, and Table 3, respectively.

The high density SFP racks provide spent fuel storage at the bottom of the fuel pool. The fuel storage racks are normally covered with about 23 ft of water for radiation shielding. The SFP racks are freestanding, full length, top entry and are designed to maintain the spent fuel in a space geometry, which precludes the possibility of criticality under any condition.

The high-density SFP racks are of the "poison" type utilizing a neutron absorbing material to maintain a subcritical fuel array. The racks are rectilinear in shape

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Figure 2.1 Spent Fuel Pool Rack Layout.

Table 1. Spent Fuel Pool Data.

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Table 2. Fuel Assembly Data.

Assembly Characteristics	Description or Dimensions

Ex. 2

Table 3. Spent Fuel Pool Rack Data.

SFP Rack Characteristics	Description or Dimensions

Ex. 2

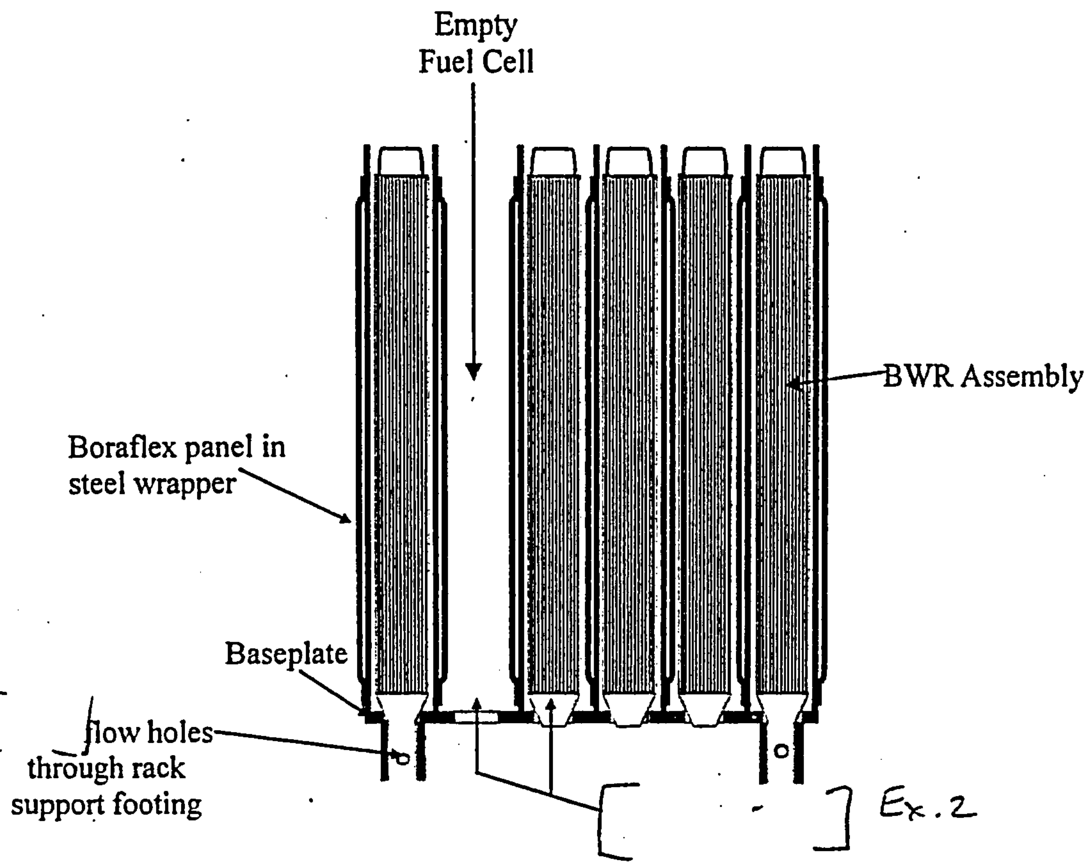

Figure 2.2 Typical Spent Fuel Pool Rack Cut-away Cross-section Showing the Fuel Assembly.

3 Separate Effect Calculations

The separate effect calculations are divided into four parts; Part 1 – Decay heat evaluations, Part 2 – Separate Effect Air Cases, Part 3 - Separate Effect Water Cases, and Part 4 – Separate Effect Propagation Cases and are described in Sections 3.1, 3.2, 3.3, and 3.4, respectively.

3.1 Part 1 - Decay Heat Calculations

[The decay heat power is calculated based on the discharge time and other parameters, such as the fuel burn-up and power history. Ex. 2

Ex. 2

Figure 3.1 shows the decay heat of various assemblies in the SFP.

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Ex. 2

Ex 2 portions

5 References

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