

~~OFFICIAL USE ONLY~~

SANDIA REPORT

Revision 1
Draft

**Evaluation of a BWR Spent Fuel Pool Accident
Response to Loss-of-Coolant Inventory Scenarios
Using MELCOR 1.8.5**

Draft Completed: February 2004

Prepared by
KC Wagner
R. O. Gauntt

**Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-0748**

Information in this record was deleted
in accordance with the Freedom of Information
Act, exemptions 2 & 5
FOIA- 2004-0226

* Alion Science and Technology Corporation
6000 Uptown Boulevard, NE Suite 300
Albuquerque, NM 87110

Portions withheld - Ex 2 & Ex 5

[Handwritten signatures and markings]

[Handwritten signature and date 6/17]

~~OFFICIAL USE ONLY~~

EXECUTIVE SUMMARY

In 2001, United States Nuclear Regulatory Commission (NRC) staff performed an evaluation of the potential accident risk in a spent fuel pool (SFP) at decommissioning plants [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 at the time that some of the assumptions in the accident progression in NUREG-1738 were conservative in order to simplify the analyses, especially the estimation of the timing and extent of fuel damage. Furthermore, the NRC desired to expand the study to include accidents in the spent fuel pools of operating power plants. Recognizing the simplifying conservatisms in the earlier analyses, 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 a series of parametric calculations used to better understand the postulated accident behavior in a SFP.

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 phenomena expected during a spent fuel pool accident.

Ex.
5

Ex.
5

6.	SUMMARY	279
6.1	Complete Loss-of-Coolant Inventory Results	279
6.2	Complete Loss-of-Coolant Inventory Results	286
7.	REFERENCES.....	294

Table of Tables

Table 2.1.1	Summary of SFP Attributes.....	9
Table 2.1.2	Spent Fuel Pool Rack Data.	9
Table 2.2.1	Fuel Assembly Data.	10
Table 3.2.1	Summary of Regional Powers for SFP Calculations.	18
Table 3.2.2	Summary of MELCOR Modeling Parameters.	27
Table 3.2.3	Summary of MELCOR Sensitivity Coefficients.	28
Table 3.3.1	Summary of Complete Loss-of Coolant Inventory SFP Calculations.....	31
Table 3.3.2	Summary of the Partial Loss-of-Coolant SFP Calculations.	32
Table 4.1.1	Summary of Case C1 Specifications and Results.....	35
Table 4.2.1	Summary of Case C2 Specifications and Results.....	49
Table 4.3.1	Summary of Case C3 Specifications and Results.....	57
Table 4.4.1	Summary of Case C4 Specifications and Results.....	69
Table 4.5.1	Summary of Case C5 Specifications and Results.....	81
Table 4.6.1	Summary of Case C6 Specifications and Results.....	93
Table 4.7.1	Summary of Case C7 Specifications and Results.....	105
Table 4.8.1	Summary of Case C8 Specifications and Results.....	117
Table 4.9.1	Summary of Case C9 Specifications and Results.....	125
Table 4.10.1	Summary of Case C10 Specifications and Results.....	133
Table 4.11.1	Summary of Case C11 Specifications and Results.....	146
Table 5.1.1	Summary of Case P1 Specifications and Results.....	162
Table 5.2.1	Summary of Case P2 Specifications and Results.....	174
Table 5.3.1	Summary of Case P3 Specifications and Results.....	186
Table 5.4.1	Summary of Case P4 Specifications and Results.....	199
Table 5.5.1	Summary of Case P5 Specifications and Results.....	211
Table 5.6.1	Summary of Case P6 Specifications and Results.....	223
Table 5.7.1	Summary of Case P7 Specifications and Results.....	235
Table 5.8.1	Summary of Case P8 Specifications and Results.....	246
Table 5.9.1	Summary of Case P9 Specifications and Results.....	257
Table 5.10.1	Summary of Case P10 Specifications and Results.....	268
Table 6.1.1	Summary of Complete Loss-of-Coolant SFP Calculations.....	280

Table 6.2.1	Summary of the Partial Loss-of-Coolant SFP Calculations.	286
-------------	---	-----

Ex.
5

Ex.
5

Table of Figures

Figure 1.1.1	Reactor Building for a Boiling Water Reactor with the Spent Fuel Pool..	4
Figure 1.1.2	Spent Fuel Pool Rack with BWR Assemblies.....	5
Figure 2.1.1	Spent Fuel Pool Rack Layout.	8
Figure 3.1.1	SFP Assembly Decay Heat as a Function of Time.	12
Figure 3.2.1	Spent Fuel Location Colored by Year Discharged after the Last Discharge to the SFP.....	16
	19
Figure 3.2.4	MELCOR Axial Levels of Spent Fuel Assembly in Rack.	20
Figure 3.2.5	9x9 BWR Fuel Assembly [Boyd].	21
Figure 3.2.6	MELCOR Nodalization of SFP.	22
Figure 3.2.7	MELCOR Reactor Building Nodalization.....	25
Figure 3.2.8	MELCOR Nodalization of Refueling Elevation of the Reactor Building.	26
Figure 3.2.9	New Parabolic Reaction Kinetics for Zirconium-Air Oxidation.....	29
Figure 4.1.1	SFP Collapsed Water Level Response.	38

Ex
5

Ex5

Ex
5

Figure 4.1.10	Total Fission Product Release Fraction from the Fuel.....	43
Figure 4.1.12	Reactor Building Decontamination Factor.....	44

Ex5

Figure 4.1.13	RB Refueling Room Temperature Response.....	44	
Figure 4.1.14	Fuel Assembly Energy Balance.	45	
Figure 4.1.16	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	46	Ex 5
Figure 4.1.17	Average Assembly Oxygen Molar Fraction.	46	
Figure 4.1.18	UO ₂ Mass Distribution at the End of the Simulation.	47	
Figure 4.1.19	Debris/Cladding Temperature Distribution at the End of the Simulation.	47	Ex 5
Figure 4.1.20	Maximum Local Temperature Response (Intact Fuel/Debris) Near the Rack Base Plate Elevation.....	48	
Figure 4.2.1	SFP Collapsed Water Level Response.	51	
Figure 4.2.10	Total Fission Product Release Fraction from the Fuel.....	55	Ex 5
Figure 4.2.11	RB Refueling Room Temperature Response.....	56	
Figure 4.2.12	Fuel Assembly Energy Balance.	56	
Figure 4.3.1	SFP Collapsed Water Level Response.	59	
Figure 4.3.10	Total Fission Product Release Fraction from the Fuel.....	63	Ex 5
Figure 4.3.12	Reactor Building Decontamination Factor.....	64	
Figure 4.3.13	RB Refueling Room Temperature Response.....	65	
Figure 4.3.14	Fuel Assembly Energy Balance.	65	Ex 5
Figure 4.3.16	Overall SFP Zirconium and Zirconium-Oxide Mass.	66	
Figure 4.3.17	Average Assembly Oxygen Molar Fraction.	67	
Figure 4.3.18	UO ₂ Mass Distribution at the End of the Simulation.	67	Ex 5
Figure 4.4.1	SFP Collapsed Water Level Response.	71	

			Ex 5
Figure 4.4.10	Total Fission Product Release Fraction from the Fuel.....	75	Ex 5
Figure 4.4.12	Reactor Building Decontamination Factor.....	76	
Figure 4.4.13	RB Refueling Room Temperature Response.....	77	
Figure 4.4.14	Fuel Assembly Energy Balance.	77	
Figure 4.4.16	Overall SFP Zirconium and Zirconium-Oxide Mass.	78	Ex 5
Figure 4.4.17	Average Assembly Oxygen Molar Fraction.	79	
Figure 4.4.18	UO ₂ Mass Distribution at the End of the Simulation.	79	
		80	Ex 5
Figure 4.5.1	SFP Collapsed Water Level Response.	83	
			Ex 5
Figure 4.5.10	Total Fission Product Release Fraction from the Fuel.....	87	Ex 5
Figure 4.5.12	Reactor Building Decontamination Factor.....	88	
Figure 4.5.13	RB Refueling Room Temperature Response.....	89	
Figure 4.5.14	Fuel Assembly Energy Balance.	89	Ex 5
Figure 4.5.16	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	90	
Figure 4.5.17	Average Assembly Oxygen Molar Fraction.	91	
Figure 4.5.18	UO ₂ Mass Distribution at the End of the Simulation.	91	
			Ex 5
Figure 4.6.1	SFP Collapsed Water Level Response.	95	Ex 5

Figure 4.6.10	Total Fission Product Release Fraction from the Fuel.....	99
Figure 4.6.12	Reactor Building Decontamination Factor.....	100
Figure 4.6.13	RB Refueling Room Temperature Response.....	101
Figure 4.6.14	Fuel Assembly Energy Balance.	101
Figure 4.6.16	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	102
Figure 4.6.17	Average Assembly Oxygen Molar Fraction.	103
Figure 4.6.18	UO ₂ Mass Distribution at the End of the Simulation.	103
Figure 4.7.1	SFP Collapsed Water Level Response.	107
Figure 4.7.10	Total Fission Product Release Fraction from the Fuel.....	111
Figure 4.7.12	Reactor Building Decontamination Factor.....	112
Figure 4.7.13	RB Refueling Room Temperature Response.....	113
Figure 4.7.14	Fuel Assembly Energy Balance.	113
Figure 4.7.16	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	114
Figure 4.7.17	Average Assembly Oxygen Molar Fraction.	115
Figure 4.7.18	UO ₂ Mass Distribution at the End of the Simulation.	115
Figure 4.8.1	SFP Collapsed Water Level Response.	119

Figure 4.8.10	Total Fission Product Release Fraction from the Fuel.....	123
Figure 4.8.11	RB Refueling Room Temperature Response.....	124
Figure 4.8.12	Fuel Assembly Energy Balance.	124
Figure 4.9.1	SFP Collapsed Water Level Response.	127

Ex
5

Figure 4.9.10	Total Fission Product Release Fraction from the Fuel.....	131
Figure 4.9.11	RB Refueling Room Temperature Response.....	132
Figure 4.9.12	Fuel Assembly Energy Balance.	132
Figure 4.10.1	SFP Collapsed Water Level Response.	135

Ex
5

Figure 4.10.11	Total Fission Product Release from Fuel.....	140
Figure 4.10.13	Reactor Building Decontamination Factor.....	141
Figure 4.10.14	RB Refueling Room Temperature Response.....	141
Figure 4.10.15	Fuel Assembly Energy Balance.	142
Figure 4.10.17	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	143
Figure 4.10.18	Average Assembly Oxygen Molar Fraction.	143
Figure 4.10.19	UO ₂ Mass Distribution at the End of the Simulation.	144

Ex
5

Ex
5

Ex
5

Ex
5

Figure 4.11.1 SFP Collapsed Water Level Response. 149

Figure 4.11.11 Total Fission Product Release from Fuel..... 154

Figure 4.11.13 Reactor Building Decontamination Factor..... 155

Figure 4.11.14 RB Refueling Room Temperature Response..... 156

Figure 4.11.15 RB Refueling Room Gas Concentration..... 156

Figure 4.11.16 Fuel Assembly Energy Balance. 157

Figure 4.11.18 Summary of Zirconium and Zirconium-Oxide Masses in the SFP..... 158

Figure 4.11.19 Average Assembly Oxygen Molar Fraction. 158

Figure 4.11.20 UO₂ Mass Distribution at the End of the Simulation. 159

Figure 5.1.1 SFP Collapsed Water Level Response. 165

Figure 5.1.2 SFP Water Temperature at the Bottom of the Assembly. 166

Figure 5.1.4 Total Fission Product Release from Fuel..... 167

Figure 5.1.6 Reactor Building Decontamination Factor..... 168

Figure 5.1.7 RB Refueling Room Temperature Response..... 168

Figure 5.1.8 Fuel Assembly Energy Balance. 169

Figure 5.1.10 Summary of Zirconium and Zirconium-Oxide Masses in the SFP..... 170

Figure 5.1.11 Average Assembly Oxygen Molar Fraction. 170

Figure 5.1.12 UO₂ Mass Distribution at the End of the Simulation. 171

Figure 5.1.15 Integral Hydrogen Production. 172

Figure 5.2.1	SFP Collapsed Water Level Response.	177
Figure 5.2.2	SFP Water Temperature at the Bottom of the Assembly.	177
Figure 5.2.4	Total Fission Product Release from Fuel.....	178
Figure 5.2.6	Reactor Building Decontamination Factor.....	179
Figure 5.2.7	RB Refueling Room Temperature Response.....	180
Figure 5.2.8	Fuel Assembly Energy Balance.	180
Figure 5.2.10	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	181
Figure 5.2.11	Average Assembly Oxygen Molar Fraction.	182
Figure 5.2.12	UO ₂ Mass Distribution at the End of the Simulation.	182
Figure 5.2.15	Integral Hydrogen Production.	184
Figure 5.3.1	SFP Collapsed Water Level Response.	189
Figure 5.3.2	SFP Water Temperature at the Bottom of the Assembly.	189
Figure 5.3.4	Total Fission Product Release from Fuel.....	190
Figure 5.3.6	Reactor Building Decontamination Factor.....	191
Figure 5.3.7	RB Refueling Room Temperature Response.....	192
Figure 5.3.8	Fuel Assembly Energy Balance.	192
Figure 5.3.10	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	193
Figure 5.3.11	Average Assembly Oxygen Molar Fraction.	194
Figure 5.3.12	UO ₂ Mass Distribution at the End of the Simulation.	194
Figure 5.3.15	Integral Hydrogen Production.	196

Ex
5

Ex
5

Ex
5

Ex
5

Ex
5

Ex
5

Ex
5

Ex
5

Ex
5

Ex
5

Ex
5

Ex
5

Figure 5.4.1	SFP Collapsed Water Level Response.	202	} Ex 5
Figure 5.4.2	SFP Water Temperature at the Bottom of the Assembly.	203	
Figure 5.4.4	Total Fission Product Release from Fuel.....	204	} Ex 5
Figure 5.4.6	Reactor Building Decontamination Factor.....	205	
Figure 5.4.7	RB Refueling Room Temperature Response.....	205	} Ex 5
Figure 5.4.8	Fuel Assembly Energy Balance.	206	
Figure 5.4.10	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	207	} Ex 5
Figure 5.4.11	Average Assembly Oxygen Molar Fraction.	207	
Figure 5.4.12	UO ₂ Mass Distribution at the End of the Simulation.	208	
Figure 5.4.15	Integral Hydrogen Production.	209	} Ex 5
Figure 5.5.1	SFP Collapsed Water Level Response.	214	
Figure 5.5.2	SFP Water Temperature at the Bottom of the Assembly.	214	} Ex 5
Figure 5.5.4	Total Fission Product Release from Fuel.....	215	
Figure 5.5.6	Reactor Building Decontamination Factor.....	216	} Ex 5
Figure 5.5.7	RB Refueling Room Temperature Response.....	217	
Figure 5.5.8	Fuel Assembly Energy Balance.	217	} Ex 5
Figure 5.5.10	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	218	
Figure 5.5.11	Average Assembly Oxygen Molar Fraction.	219	} Ex 5
Figure 5.5.12	UO ₂ Mass Distribution at the End of the Simulation.	219	
Figure 5.5.15	Integral Hydrogen Production.	221	} Ex 5
Figure 5.6.1	SFP Collapsed Water Level Response.	226	
Figure 5.6.2	SFP Water Temperature at the Bottom of the Assembly.	226	} Ex 5

Figure 5.6.4	Total Fission Product Release from Fuel.....	227	Ex 5
Figure 5.6.6	Reactor Building Decontamination Factor.....	228	
Figure 5.6.7	RB Refueling Room Temperature Response.....	229	Ex 5
Figure 5.6.8	Fuel Assembly Energy Balance.	229	
Figure 5.6.10	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	230	
Figure 5.6.11	Average Assembly Oxygen Molar Fraction.	231	Ex 5
Figure 5.6.12	UO ₂ Mass Distribution at the End of the Simulation.	231	
Figure 5.6.15	Integral Hydrogen Production.	233	
Figure 5.7.1	SFP Collapsed Water Level Response.	237	Ex 5
Figure 5.7.2	SFP Water Temperature at the Bottom of the Assembly.	238	
Figure 5.7.4	Total Fission Product Release from Fuel.....	239	Ex 5
Figure 5.7.6	Reactor Building Decontamination Factor.....	240	
Figure 5.7.7	RB Refueling Room Temperature Response.....	240	Ex 5
Figure 5.7.8	Fuel Assembly Energy Balance.	241	
Figure 5.7.10	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	242	
Figure 5.7.11	Average Assembly Oxygen Molar Fraction.	242	Ex 5
Figure 5.7.12	UO ₂ Mass Distribution at the End of the Simulation.	243	
Figure 5.7.15	Integral Hydrogen Production.	244	Ex 5
Figure 5.8.1	SFP Collapsed Water Level Response.	248	
Figure 5.8.2	SFP Water Temperature at the Bottom of the Assembly.	249	Ex 5
Figure 5.8.4	Total Fission Product Release from Fuel.....	250	
Figure 5.8.6	Reactor Building Decontamination Factor.....	251	Ex 5
Figure 5.8.7	RB Refueling Room Temperature Response.....	251	
Figure 5.8.8	Fuel Assembly Energy Balance.	252	

Figure 5.8.10	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	253	} Ex 5
Figure 5.8.11	Average Assembly Oxygen Molar Fraction.	253	
Figure 5.8.12	UO ₂ Mass Distribution at the End of the Simulation.	254	
Figure 5.8.15	Integral Hydrogen Production.	255	} Ex 5
Figure 5.9.1	SFP Collapsed Water Level Response.	259	
Figure 5.9.2	SFP Water Temperature at the Bottom of the Assembly.	260	} Ex 5
Figure 5.9.4	Total Fission Product Release from Fuel.....	261	
Figure 5.9.6	Reactor Building Decontamination Factor.....	262	} Ex 5
Figure 5.9.7	RB Refueling Room Temperature Response.....	262	
Figure 5.9.8	Fuel Assembly Energy Balance.	263	} Ex 5
Figure 5.9.10	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	264	
Figure 5.9.11	Average Assembly Oxygen Molar Fraction.	264	
Figure 5.9.12	UO ₂ Mass Distribution at the End of the Simulation.	265	} Ex 5
Figure 5.9.15	Integral Hydrogen Production.	266	
Figure 5.10.1	SFP Collapsed Water Level Response.	270	} Ex 5
Figure 5.10.2	SFP Water Temperature at the Bottom of the Assembly.	271	
Figure 5.10.4	Total Fission Product Release from Fuel.....	272	} Ex 5
Figure 5.10.6	Reactor Building Decontamination Factor.....	273	
Figure 5.10.7	RB Refueling Room Temperature Response.....	273	} Ex 5
Figure 5.10.8	Fuel Assembly Energy Balance.	274	
Figure 5.10.10	Summary of Zirconium and Zirconium-Oxide Masses in the SFP.....	275	} Ex 5
Figure 5.10.11	Average Assembly Oxygen Molar Fraction.	275	
Figure 5.10.12	UO ₂ Mass Distribution at the End of the Simulation.	276	

Figure 5.10.15 Integral Hydrogen Production. 277

Ex
5

Ex
5

Evaluation of a BWR Spent Fuel Pool Accident Response to Loss-of-Coolant Inventory Scenarios Using MELCOR 1.8.5

1. BACKGROUND

In 2001, NRC staff performed an evaluation of the potential accident risk in a spent fuel pool at decommissioning plants [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 at the time that some of the assumptions in the accident progression in NUREG-1738 were conservative in order to simplify the analyses, especially the estimation of the timing and extent of fuel damage. Furthermore, the NRC desired to expand the study to include accidents in the spent fuel pools of operating power plants. Recognizing the simplifying conservatisms in the earlier analyses, 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 scope of the present analysis is to describe the response of a reference Boiling Water Reactor (BWR) SFP to both partial and complete-loss-of-coolant inventory accidents.

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. The code contains the basic models to address questions and phenomena expected during a spent fuel pool accident.

Consequently, MELCOR separate effect [Wagner, 2003] and computational fluid dynamics (CFD) [Chiffelle, 2003, Ross, 2003, and Suo-Anttila, 2003]

calculations were performed to develop a modeling approach for whole SFP severe accident calculations. These analyses helped guide the development of the whole SFP MELCOR model as well as help characterize many of the uncertainties and variability in the accident response.

Section 1.1 summarizes the two types of SFP accidents considered in the present report. They consist of a complete loss-of-coolant inventory and a partial loss-of-coolant inventory. Due to the varying phenomena, the calculated responses are discussed separately. Then Section 1.2 summarizes the structure of the report.

1.1 SFP Accident Scenarios

Ex
5

Hence, there are competing effects of the lack of a strong convective flow versus the benefits of some steam cooling and axial conduction to the water. In summary, the scenarios with water include (a) two-phase boiling, (b) an assembly flow rate that is strongly affected by the amount of boiling below the water surface, and (c) an assembly inlet temperature that is limited to the boiling point of water (i.e., the air cases are not similarly constrained).

The rate of oxidation of the zirconium cladding is the second key difference expected in a partial loss-of-coolant inventory accident. In particular, the fluid next to the zirconium is steam rather than air. Steam also reacts exothermically with zirconium but at a slower rate than oxygen. Furthermore, the byproduct of the steam-zirconium reaction is hydrogen. The hydrogen will replace the steam and retard or stop the zirconium/steam reaction. Consequently, the reaction would become "steam starved" and controlled by the rate of steam production by boiling below the pool level, which is expected to be very low for aged spent fuel. If there is adequate steam when the zirconium reaches high temperatures (i.e., >1500 K), then the power from oxidation reactions can be one or more orders of magnitude larger than decay heat. Therefore, there are two competing effects on the rate of fuel degradation relative to the complete loss-of-inventory accident scenario (i.e., as described in Section 1.1.1), (1) a lower, controlled oxidation effect (i.e., due to steam starvation) and (2) a much lower convective cooling rate (i.e., because the bottom of the racks are "plugged" with water).

Finally, a third new difference in the partial loss-of-coolant inventory accident is the behavior of the hydrogen. As hydrogen is produced during the fuel degradation, the hydrogen will rise and mix with oxygen in the air above the pool. Given the appropriate conditions, the hydrogen could ignite and possibly cause structural damage to the reactor building. Any damage or enhanced leakage caused by the pressurization from the hydrogen burn could increase the release of fission products and their associated adverse consequences.

1.2 Report Structure

In Section 2, a summary discussion is given on the reference BWR SFP. The modeling approach using MELCOR 1.8.5 is given in Section 3. Section 3 also includes a discussion of the decay heat modeling, the radial thermal coupling schemes, the reactor building model, the SFP nodalization, and the code model settings and sensitivity coefficients. The results of complete loss-of-coolant calculations are given in Section 4. The results from the partial loss-of-coolant cases are given in Section 5. An overall summary of their results is given in the Section 6. Finally, the references are provided in Section 7.

complete Ex 5
partial Ex 5

2. SFP GEOMETRY

2.1 SFP Geometry



Ex
2



Figure 2.1.1 Spent Fuel Pool Rack Layout.⁴

⁴ All dimensions are in inches.

Table 2.1.1 Summary of SFP Attributes.

SFP Pool Characteristics	Description or Dimensions
Ex 2	

Table 2.1.2 Spent Fuel Pool Rack Data.

SFP Rack Characteristics	Description or Dimensions
Ex 2	

2.2 SFP Assembly Geometry

Ex 2	
---------	--

Ex 5

[illegible]Ex
2

3. ANALYSIS METHODOLOGY

The analysis methodology is described in the following subsections.

Section 3.1 describes the decay heat calculations made for the various decay timings. The MELCOR SFP model is described in Section 3.2. Finally, Section 3.3 describes the various SFP calculations.

3.1 Decay Heat Calculations

The SFP contains fuel assemblies from separate fuel offloads from the reference BWR reactor. Within a particular offload, variations in the assembly burnup and initial uranium loading are also present. The variations in these parameters lead to different levels of fission product decay heating. However, as the fuel ages, the heat produced by the fission product decay decreases.

Ex
5

Ex
2

Ex
5

Ex
5

7. REFERENCES

ANSI/ANS ANSI/ANS-5.1-1994, "Decay Heat Power in Light Water Reactors," ANS Standard, 1994.

Boyd, C., "Predictions of Spent Fuel Heatup after a Complete Loss of-Coolant Accident," NUREG-1726, July 2000.

Chiffelle, R., et al., "Analysis of Spent Fuel Pool Flow Patterns Using Computational Fluid Dynamics: Part 1 – Air Cases," Sandia National Laboratories, Informal Report, April 2003.

Collins, T. E., and Hubbard, G., "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants," NUREG-1738, February, 2001.

Gauntt, R. O., et al, "MELCOR Computer Code Manuals, Reference Manual, Version 1.8.5, Vol. 2, Rev. 2", Sandia National Laboratories, NUREG/CR-6119, SAND2000-2417/1.

Ross, K. W., et al., "Analysis of Spent Fuel Pool Flow Patterns Using Computational Fluid Dynamics: Part 2 – Partial Water Cases," Sandia National Laboratories, Informal Report, April 2003.

Suo-Anttila, A. J., Wagner, K. C., Gauntt, R. O., "Analysis of Spent Fuel Pool Flow Patterns Using Computational Fluid Dynamics: Supplement - Thermal Plume Response," Sandia National Laboratories, Informal Report, July 2003.

Wagner, K. C., et al., "Evaluation of Spent Fuel Pool Accident Response to a Complete Loss-of-Coolant Inventory Using MELCOR 1.8.5," Sandia National Laboratories, Informal Report, January 2003 [2003a].

Wagner, K. C., et al., "MELCOR 1.8.5 Separate Effect Analyses of Spent Fuel Pool Assembly Accident Response," Sandia National Laboratories, Informal Report, June 2003 [2003b].

Release