4.0 Implications of Spent Fuel Pool Risk For Regulatory Requirements

An important motivation for performing the risk analysis contained in this report is to provide insight into the regulatory requirements that would be needed to control the risk of decommissioning plants. In order to do that, section 4.1 presents a brief summary of the risk results that are most pertinent to that end.

The analysis in chapter 3 explicitly examines the risk impact of specific design and operational characteristics. Some of these have been proposed by the Nuclear Energy Institute in a letter to the NRC dated November 12, 1999 [Ref. 1]. Others came to light as a result of the analysis itself. These characteristics are summarized in section 4.1. The NRC intends to make these the principle aspects of the risk-informed approach to oversight of decommissioning plants.

In addition, the industry and other stakeholders have proposed the use of risk-informed decision-making to assess regulatory requirements in three specific areas; namely, emergency preparedness, security and insurance. The technical results of this report might be used either to justify plant-specific exemptions from these requirements, or to determine how these areas will be treated in a risk-informed oversight process. Section 4.3 examines the implications of this technical results for those specific regulatory decisions.

4.1 Summary of the Technical Results

The thermal-hydraulic analysis presented in Appendix ___ demonstrates that the conditions necessary for a zirconium fire exist in spent fuel pools of decommissioning plants for a period of several years following shutdown. The analysis shows that the length of time over which the fuel is vulnerable depends on several factors, including fuel burnup and pool configuration. In some cases analyzed in Appendix __, the required decay time is ____ years. However, the time period for any specific plant will vary. Plant-specific analysis is needed to justify the use of shorter decay periods.

The consequence analysis presented in Appendix ___ demonstrates that the consequences of a zirconium fire in a decommissioning plant are very large. The integrated dose to the public is comparable to a large early release. Early fatalities are low compared to those from a large early release from an operating reactor accident, and are very sensitive to the effectiveness of evacuation.

For a decommissioning plant with about one year of decay time, the timing of radiological releases from zirconium fires is significantly slower than those from the most limiting reactor accident scenarios. This is due to the slow heatup time of the fuel. In addition, for many of the sequences leading to zirconium fires, there are very large delay times due to the long time required to boil off the spent fuel pool water inventory. Thus, while the consequences of zirconium fires are in some ways comparable to large early releases from reactor accidents, the timing is much slower.

The annual frequency of events leading to zirconium fires at decommissioning plants is estimated to be ______, for a plant that implements the design and operational characteristics discussed below. This estimate can be much higher for a plant that does not embody these characteristics. The most significant contributor to this risk is a seismic event which exceeds the design basis earthquake. Other contributors are _____. This overall frequency is within the

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acceptance guidelines for large early release frequency (LERF) in Regulatory Guide (RG) 1.174 [Ref. 2]. As noted above, zirconium fires are estimated to be similar to large early releases in some ways, but less severe in others.

4.2 Risk Impact of Specific Design and Operational Characteristics

4.3 Implications for Regulatory Requirements Related to Emergency Preparedness, Security and Insurance

The industry and other stakeholders have expressed interest in knowing the relevance of the results of this study to decisions regarding specific regulatory requirements. These decisions could be made in response to plant-specific exemption requests, or as part of the integrated rulemaking for decommissioning plants. Such decisions can be facilitated by a risk-informed examination of the both the deterministic and probabilistic aspects of decommissioning. Three examples of such regulatory decisions are presented in this section.

4.3.1 Emergency Preparedness

The requirements for emergency preparedness for are contained in 10CFR 50.47 [Ref. 3] and Appendix E [Ref. 4]. Further guidance on the basis for EP requirements is contained in NUREG-0396 [Ref. 5]. The general goal of EP requirements is to prevent early fatalities and to reduce offsite dose from accidents.

In the past, the NRC staff has granted exemptions from emergency planning requirements for decommissioning plants that could demonstrate that they were beyond the period in which a zirconium fire could occur. The rationale for those decisions was that, in the absence of a zirconium fire, a decommissioning plant had no appreciable scenarios for which the consequences justify the imposition of an EP requirement. The results of this technical study confirm that position (**but what about criticality?**).

In some cases, emergency preparedness exemptions have also been granted to plants which were still in the window of vulnerability for zirconium fire. In these cases, the justification was that enough time had elapsed since shutdown that the evolution of a zirconium fire accident would be slow enough to allow effective offsite protective actions on an ad hoc basis, without the need for emergency planning. The staff believes that the technical analysis discussed in chapter 3 and the decision criteria laid out in chapter 1 have direct bearing on how such exemption requests should be viewed in the future. In addition, this information has bearing on the need for, and the extent of, emergency preparedness requirements in the integrated rulemaking.

The consequence analysis presented in appendix __ demonstrates that the offsite consequences of a zirconium are comparable to those from operating reactor severe accidents. Further, the analysis demonstrates that timely evacuation can significantly reduce the number of early fatalities due to a zirconium fire. The thermal-hydraulic analysis presented in appendix

__ confirms our earlier conclusion that zirconium fire events evolve slowly, even for initiating events that result in a catastrophic loss of fuel pool coolant. The results in chapter 3 also show that the frequency of zirconium fires is low when compared with the risk guidelines from RG 1.174. Thus the risk associated with early fatalities from these scenarios is low. Based on this combination of low risk and slow evolution, the Commission might decide to reduce or eliminate EP requirements for decommissioning plants.

One important safety principle of RG 1.174 is consistency with the defense in depth philosophy. In the rationalist approach, defense in depth is included in a plant design to account for uncertainties in the analysis or operational data. The spent fuel pools at operating reactors and decommissioning facilities do not exhibit the defense in depth accorded to the reactor. As discussed in chapter 1, this difference is justified in light of the considerably greater margin of safety of the SFP compared with reactors. For SFP at operating reactors, defense in depth consists mainly of the mitigating effect of emergency preparedness. The Commission might consider retaining a baseline level of EP requirements for decommissioning plants as a defense in depth measure. This might be justified in view of the uncertainties associated with the risk analysis presented herein. The staff has not attempted to assess what level of emergency preparedness might be needed to provide this defense in depth. However, given the slow nature of these accidents, we believe it would be substantially lower than what is currently required for operating reactors.

4.3.2 Security

The risk estimates contained in this report are based on accidents initiated by random equipment failures, human errors or external events. PRA practitioners have developed and used dependable methods for estimating the frequency of such random events. By contrast, this analysis, and PRA analyses in general, do not include events due to sabotage. No method exists for estimating the likelihood of a sabotage event. Nor is there a method for analyzing the effect of security provisions on that likelihood.

The technical information contained in this report shows that the consequences of a zirconium fire would be high enough to justify provisions to prevent sabotage. Moreover, the details of the risk analyses could be used effectively to assist in determining priorities for, and details of, a security capability at a plant. However, there is no information in the analysis that bears on the level of security necessary to limit the risk from potential sabotage events. Those decisions will continue to be made based on a deterministic assessment of the level of threat and the difficulty of protecting the facility.

4.3.3 Insurance

In accordance with 10 CFR 140 [Ref. 6], each 10 CFR 50 licensee is required to maintain public liability coverage in the form of primary and secondary financial protection. This coverage is required to be in place from the time unirradiated fuel is brought onto the facility site until all the radioactive material has been removed from the site, unless the Commission terminates the Part 50 license or otherwise modifies the financial protection requirements. The industry has asked the NRC to consider whether the likelihood of large scale radiological releases from decommissioning plants is low enough to justify modification of the financial protection requirements once the plant is permanently shutdown and prior to complete removal of all radioactive material from the site.

In the past, licensees have been granted exemptions from financial protection requirements on the basis of deterministic analyses showing that a zirconium fire could no longer occur. The analysis in this report supports continuation of this practice in the interim, and would support a revised regulatory framework for decommissioning plants that eliminates the need for insurance protection when a plant-specific thermal-hydraulic analysis demonstrates that a zirconium fire can no longer occur.

The NRC staff has considered whether the risk analysis in this report justifies relief from this requirement for decommissioning plants during the period when they are vulnerable to zirconium fires. As part of this effort, the staff determined that an analogy can be drawn between a SFP at a decommissioning plant and a wet (as opposed to dry) independent spent fuel storage installation (ISFSI) licensed under 10 CFR 72 [Ref. 7] for which no indemnification requirement currently exists. Spent reactor fuel aged for one year can be stored in a wet or dry ISFSI. The risk analysis in this report predicts high consequences for a zirconium fire, and identifies a generic window of vulnerability out to 5 years. In the staff requirements memorandum (SRM) for SECY-93-127 [Ref. 8] the Commission suggested that insurance coverage is required unless a large scale radiological release is deemed incredible. Further, they instructed the staff to determine more precisely the appropriate spent fuel cooling period after plant shut down, and to determine the need for primary financial protection for ISFSIs.

Since the consequences are high, frequency of a zirconium fire occurring in a wet ISFSI or a decommissioning reactor SFP would have to be acceptably low to justify no regulatory requirement for indemnification protection. A dry ISFSI is not under consideration since the fuel is already air cooled and no threat of zirconium fire exists. The zirconium fire frequencies presented in Chapter 3 for a decommissioning reactor SFP do not fit the category of incredible. They are comparable to the frequencies of large releases from some operating reactors. The staff is not aware of any basis for concluding that the frequency of a zirconium fire occurring in a wet ISFSI would be significantly different than those presented in Chapter 3, and thus would conclude that indemnification should be required for operation of a wet ISFSI to be consistent with a decommissioning reactor SFP and provide for coherency in the regulations.

The staff knows of no frequency criterion which could be cited to justify reduction or elimination of the insurance requirement while a vulnerability to zirconium fire exists. Defining or applying such a criterion would be inconsistent with Commission direction provided in SECY-93-127.

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