Washington

September 22, 2000

U.S. Nuclear Regulatory Commission
Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
Mail Stop 0-6F18
Washington, DC 20555

Attn: Mr. Francis I. Young

Subject: Revision of ANSI/ANS 57.2 and ANSI/ANS 57.3

Reference: 1) Proposed ANSI/ANS-57.2, "Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants", 2000.

2) Proposed ANSI/ANS-57.3, "Design Requirements for New Fuel Storage Facilities at Light Water Reactor Plants", 2000.

3) "Draft Final Technical Study of Spent Fuel Pool Accident Risk At Decommissioning Nuclear Power Plants", NRC, Feb. 2000.

Dear Mr. Young:

Enclosed for your review and consideration, is the Table of Contents and Executive Summary for Reference 3), above.

It has been suggested by the US NRC to evaluate the above referenced Draft Final Technical Study and determine if or how it may impact the updating of the referenced ANS documents with regard to Spent Fuel Pool issues. Two members of the ANS 57.2/57.3 Working Group will be receiving complete copies of the study for their evaluation. Mr. Paul Reichert will be asked to evaluate spent fuel pool criticality issues and Dr. Stan Turner will be asked to evaluate spent fuel pool boiling concerns. If anyone else feels that the study may be relevant to their area of expertise, with regard to spent fuel storage, and desires a copy of the complete report, it can be viewed and/or downloaded from the NRC website at the following address:

http://www.nrc.gov/NRC/REACTOR/DECOMMISSIONING/SF/index.html

If you are unable to download the document, I can mail you a hardcopy upon your request. For those wishing to download the technical study, please note that the complete document is about 288 pages long and about 1.1 Megabytes (PDF format).

If you have any questions regarding this matter please contact me at (630) 829-2711.

Thank you for your support of this important ANS endeavor.

Very truly yours,

Donald A. Gardner, P.E.
Chairman
ANS Working Groups 57.2 and 57.3

Attach: as stated

Cc: J. Nevshemal, ANS, Denver
S. Coyne-Nalbach, ANS, Chicago

dm5574

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Draft Final Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants(Draft for Comment)

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Draft Report for Comment

Draft Final Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants

Date Published: February 2000

Technical Contributors

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MEMORANDUM TO: Those on the Attached List

FROM: Richard F. Dudley, Jr., Senior Project Manager /RA/
Decommissioning Section
Project Directorate IV & Decommissioning
Office of Nuclear Reactor Regulation

SUBJECT: Transmittal of Draft Final Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Plants And Federal Register Notice Requesting Public Comments On Technical Study

Attached is the "Draft Final Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Plants." Also provided, for your information, is a copy of the Federal Register notice requesting public comments on the subject report.

Project 689

Attachments: As stated (2)

CONTACT: Richard Dudley, DLPM/NRR
301-415-1116

Federal Register Notice

7590-01-P

NUCLEAR REGULATORY COMMISSION

Draft Final Technical Study of Spent Fuel Pool Accident Risk at
Decommissioning Nuclear Power Plants

AGENCY: Nuclear Regulatory Commission

ACTION: Request for public comments

SUMMARY: The Nuclear Regulatory Commission (NRC) is soliciting public comment on the "Draft Final Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants".

As the number of power reactors involved in the decommissioning process increases, the ability to address regulatory issues generically has become more important. After a nuclear power plant permanently shuts down and the reactor is defueled, the traditional accident sequences that dominate operating reactor risk are no longer applicable. The predominant source of risk remaining at permanently shutdown plants involves accidents associated with spent fuel stored in the spent fuel pool.

Following a Commission meeting held on March 17, 1999, the NRC staff formed a technical working group to evaluate spent fuel pool accident risk at decommissioning plants. The staff set out to develop a risk-informed technical basis that could be used to develop rulemaking and to establish a predictable method for reviewing future exemption requests and to identify the need for any research in areas of large uncertainty. The staff intends for this approach to meet the NRC outcome goals of maintaining safety, reducing unnecessary regulatory burden, increasing public confidence, and improving efficiency and effectiveness.

The NRC released a preliminary draft version of the technical basis study in June 1999 A public workshop to discuss the report was held in July 1999. Numerous comments and other input were received from the public and the nuclear industry. The NRC has revised the report to address the comments received and to incorporate needed changes based on the results of outside technical reviews. All comments received will be considered before the final report is published as the basis for initiation of rulemaking activities.

DATES: The comment period expires April 7, 2000. Comments received after this date will be considered if practical to do so, but the staff is able to assure consideration only for comments received on or before this date.

ADDRESSES: Mail written comments to Chief, Rules and Directives Branch, Division of Administrative Services, Office of Administration, U S Nuclear Regulatory Commission, Washington, DC 20555-0001. Comments may also be sent electronically by completing the online comment form available on the NRC Internet web page at the address below. Comments may also be hand delivered to Room 6D59, Two White Flint North, 11555 Rockville Pike, Rockville, Maryland, between 7:30 am and 4:15 pm on Federal workdays. The report is available at the NRC Public Document Room, 2120 L Street NW, Washington, DC and through the NRC Agencywide Documents Access and Management System (ADAMS).

The report is also available via the Internet on the NRC web page at < http://wwwnrcgov/NRC/REACTOR/DECOMMISSIONING/SF/indexhtml > Requests for single copies may be made to Richard Dudley, U S Nuclear Regulatory Commission,Mail Stop O-11D19, Washington, DC 20555-0001 or by telephone at 301-415-1116 or email to rfd@nrcgov .

FOR FURTHER INFORMATION CONTACT: George Hubbard, U S NRC, Office of Nuclear Reactor Regulation, Mail Stop O-11A11, Washington, DC, 20555-0001; telephone 301-415- 2870; email: gth@nrcgov. Dated at Rockville, Maryland, this 15th day of February, 2000

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Stuart A Richards, Director
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

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Executive Summary

This report documents an evaluation of spent fuel pool (SFP) accident risks at decommissioning plants. It was done to provide an interim, risk-informed technical basis for reviewing exemption requests, and to provide a regulatory framework for integrated rulemaking. The application of this report is intended to eliminate to the extent practical, unnecessary regulatory burden, while maintaining safety and improving efficiency and effectiveness of the regulatory process. By establishing a consistent, predictable process fully open to public observation and comment, the agency intends to enhance public confidence in the regulatory process for decommissioning reactors. The report was initiated by the Commission when they asked the staff to consider whether the risk from decommissioning plants was low enough to justify generic regulatory relief in the areas of emergency planning, insurance indemnification and safeguards.

The current body of NRC regulations pertaining to light-water reactors (10 CFR 50) [Ref. 1] is primarily directed towards the safety of operating units. It is generally understood that this body of regulations is conservative when a plant transitions from an operating to a decommissioning status. In the past, decommissioning plants have requested exemptions to certain regulations as a result of their permanently defueled condition. When evaluating the acceptability of exemption requests from regulations for permanently shutdown plants, the staff has assessed the susceptibility of the spent fuel to a zirconium fire accident. To date, exemptions have been granted on a plant-specific basis, resulting in different analyses and criteria being used for the basis of the exemptions. In some cases, heat up evaluations of the spent fuel cooled only by air were requested. This criterion was used because of national laboratory studies that had identified the potential concern for a significant off-site radiological release from a zirconium fire which could occur when all water is lost from the spent fuel pool. A clad temperature of 565°C, based on the onset of clad swelling, was used as a limit to ensure no radiological release.

In March 1999, the staff formed a technical working group to evaluate spent fuel pool accident risks at decommissioning plants. A two month effort was launched to review the available technical information and methods and identify areas in need of further work. A substantial effort was made to involve public and industry representatives throughout the entire effort. A series of public meetings was held with stakeholders during and following the generation of a preliminary draft study that was published in June at the request of the Nuclear Energy Institute (NEI). The partially completed DRAFT report was released to facilitate a stakeholder/NRC two day workshop that was held in July 1999. Information gained at the workshop and through other stakeholder interactions was constructive in completing this report.

Estimates of the risk from heavy load handling accidents were revised and criticality concerns were addressed in response to stakeholder feedback. A checklist was developed to establish seismic capability of SFPs, and industry commitments were documented to address the vulnerabilities that had been identified by the June 1999 draft report. Independent technical quality reviews of controversial aspects of the report were initiated to bring in outside expert opinion on the details of the report. These experts evaluated several areas of the report, including the human reliability analysis, seismic considerations, thermal-hydraulic calculations, and probabilistic risk assessment (PRA) assumptions and treatment. The PRA results were re-quantified to take into account the industry commitments to reduce risk vulnerabilities.

This report contains the results of these activities and includes three main outputs. The first is a discussion in Chapter 2 on how risk-informed decision making can be applied to decommissioning plants. The second is a summary in Chapter 3 of the risk assessment of SFPs at decommissioning plants. The third output or Chapter 4 provides the implications of SFP risks on regulatory requirements, and outlines where industry commitments in combination with additional staff assumptions may be useful in

improving spent fuel pool safety at decommissioning plants. Chapter 5 is a summary of the findings of the report.

After a period of one year following permanent shutdown, the results of this report estimated the generic frequency of events leading to zirconium fires at decommissioning plants to be less than $3x10^{-6}$ per year for a plant that implements the design and operational characteristics assumed in the risk assessment performed by the staff. This frequency was estimated based on the assumptions that the characteristics of the ten industry decommissioning commitments (IDCs) proposed by NEI (See Appendix 6) and the four staff decommissioning assumptions (SDAs) identified in Chapters 3 and 4 of the report would be implemented. This estimate could be much higher for a plant that does not implement these characteristics. The most significant contributor to this risk is a seismic event which exceeds the design basis earthquake. However, the overall frequency of this event is within the staff recommended pool performance guideline (PPG) identified in this report for large radiological releases due to a zirconium fire of $1x10^{-5}$ per year. As discussed below, zirconium fires are estimated to be similar to large early release accidents postulated for operating reactors in some ways, but less severe in others.

The thermal-hydraulic analysis presented in Appendix 1 demonstrates that the decay heat necessary for a zirconium fire exists in typical 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 burn-up and fuel storage configuration in the SFP. In some cases analyzed in Appendix 1, the required decay time to preclude a zirconium fire is 5 years(1). However, the exact time will be plant specific; therefore, plant-specific analysis would be needed to demonstrate shorter zirconium fire vulnerabilities.

The consequence analysis presented in Appendix 4 demonstrates that the consequences of a zirconium fire in a decommissioning plant can be very large. The integrated dose to the public is generally comparable to a large early release from an operating plant during a potential severe core damage accident and early fatalities are very sensitive to the effectiveness of evacuation. For a decommissioning plant with about one year of decay time, the onset of radiological releases from a zirconium fire is significantly delayed compared to those from the most limiting operating reactor accident scenarios. This is due to the relatively long heat up time of the fuel. 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 large spent fuel pool water inventory. Thus, while the consequences of zirconium fires are in some ways comparable to large early releases from postulated reactor accidents, the time of release occurs much later following initiation of the accident. Therefore, this analysis indicates that for the slowly evolving SFP accident scenarios at decommissioning plants, there is a large amount of time to initiate and implement protective actions, including public evacuation in comparison to operating reactor accident sequences.

In summary, the risk assessment shows low numerical risk results in combination with satisfaction of the safety principles as described in R.G. 1.174, such as defense-in-depth, maintaining safety margins, and performance monitoring. The staff concludes that under the assumptions of this study there is a low level of public risk from SFP accidents at decommissioning plants. In addition, the study shows that, after a period of one year following final shutdown, the low likelihood that a zirconium fire would occur, in combination with the long time frames available for taking off-site protective actions, provides a basis for relaxation of emergency planning requirements.

Chapters 4 also addresses the report's implications on security and insurance provisions at decommissioning plants. For security, the risk insights can be utilized to assess what target sets are important to protect against sabotage. However, any reduction in security provisions would be constrained by an effectiveness assessment of the safeguards provisions against a design basis threat. Therefore, the staff concludes that some level of security is required as long as the fuel in the SFP is exposed to a sabotage threat. For insurance, the reports points out that no definitive criteria exists that would allow relaxation on the basis of low event probability alone while the potential for a zirconium fire exists. Finally, inconsistencies were identified in current regulations regarding vehicle-borne bomb threats and insurance indemnification requirements for ISFSIs and decommissioning nuclear power plants. These inconsistencies should be revisited during the overall integration of rules for decommissioning plants.

In summary, the report provides a comprehensive treatment of SFP risks at decommissioning plants as it relates to emergency planning, insurance, and security requirements. The report systematically examines the differences between an operating reactor spent fuel pool configuration, and the typical SFP configuration in place at one year post-shutdown for a decommissioning plant. It provides the technical basis for determining the regulatory requirements for decommissioning plants using risk-informed decision making.

1.0 Introduction

The current body of Nuclear Regulatory Commission (NRC) regulations pertaining to light-water reactors (10 CFR 50) [Ref. 1] is primarily directed towards the safety of operating units. As some reactors have reached permanent shutdown condition and

entered decommissioning status, the NRC has been faced with establishing the appropriate requirements and regulatory oversight necessary to provide adequate protection to the public. For decommissioning plants, the potential public risk is due primarily to the possibility of a zirconium fire associated with the spent fuel rod cladding. Due to the decay heat generated by the spent fuel, it must be continuously cooled and remain covered by water after removal from the reactor. A postulated event could occur if the systems which provide heat removal from the fuel pool fail, causing the cooling water to boil off from the pool until the fuel is uncovered. Alternatively, a leak in the pool could occur, that if not corrected, could also result in the spent reactor fuel becoming uncovered. For either scenario, the uncovered and uncooled spent fuel could heat up causing a fire of its zirconium cladding and releasing large quantities of radionuclides.

Decommissioning plants have requested exemptions to certain regulations as a result of their permanently defueled condition. While the current Part 50 regulatory requirements (developed for operating reactors) ensure safety at the decommissioning facility, some of these requirements may be excessive and not substantially contributing to public safety. Areas where regulatory relief has been requested in the past include exemptions from off-site emergency planning (EP), insurance, and safeguards requirements. Requests for consideration of changes in regulatory requirements are appropriate since the traditional accident sequences that dominate operating reactor risk are no longer applicable. For a defueled reactor in decommissioning status, public risk is predominantly from potential accidents involving spent fuel. Spent fuel can be stored in the spent fuel pool (SFP) for considerable periods of time, as remaining portions of the plant continue through decommissioning and disassembly. To date, exemptions have been requested and granted on a plant-specific basis. This has resulted in some lack of consistency and uniformity in the scope of evaluations conducted and acceptance criteria applied in processing the exemption requests.

To improve regulatory consistency and predictability, the NRC has undertaken this effort to improve the regulatory framework applicable to decommissioning plants. This framework will utilize risk-informed approaches to identify the design and operational features necessary to ensure that risks to the public from these shutdown facilities are sufficiently small. This framework will form the foundation upon which regulatory changes will be developed, as well as the basis for requesting and approving exemption requests in the interim, until the necessary rulemaking is completed.

In support of this objective, the NRC staff has completed a draft assessment of spent fuel pool risks. This assessment utilized probabilistic risk assessment (PRA) methods and was developed from analytical studies in the areas of thermal hydraulics, core physics, systems analysis, human reliability analysis, seismic and structural analysis, external hazards assessment, and off-site radiological consequences. The focus of the risk assessment was to identify potential severe accident scenarios at decommissioning plants, and to estimate the likelihood and consequences of these scenarios. Of primary concern are events that lead to loss of spent fuel pool water inventory or loss of cooling to the spent fuel assemblies, and events that result in fuel configurations that could lead to criticality conditions. For some period after reactor shutdown and after sustained loss of inventory or cooling, it is possible for the fuel to heat up to the point where rapid oxidation and burning of the zirconium fuel cladding occurs leading to significant releases of radionuclides.

A preliminary version of this draft report was issued for public comment and technical review in June 1999. Comments received from stakeholders and other technical reviewers have been considered in preparing this assessment. Quality assessment of the staff's preliminary analysis has been aided by a small panel of human reliability analysis (HRA) experts who evaluated the human performance analysis assumptions, methods and modeling, as well as a broad quality review carried out at the Idaho National Engineering & Environmental Laboratory (INEEL).

The conclusions and findings of the study provide guidance for the design and operation of spent fuel pool cooling and inventory make-up systems as well as practices and procedures necessary to ensure high levels of operator performance during off-normal conditions. This report concludes that, with the fulfillment of industry commitments and satisfaction of a number of additional staff assumptions, the risks from spent fuel pools will be sufficiently small to justify exemptions from selected current regulatory requirements and to form the basis for related rulemaking.

This report is divided into three main parts. The first is a discussion in Chapter 2 on how risk-informed decision making can be applied to decommissioning plants. The second is a summary in Chapter 3 of the risk assessment of SFPs at decommissioning plants. The third in Chapter 4 provides the implications of SFP risk on regulatory requirements, and outlines where industry commitments in combination with additional staff assumptions may be useful in improving spent fuel pool safety.

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1. In the area of dry storage, it is noted that currently certified casks may be loaded with spent fuel with a minimum of five years

cooling. The risk of a zirconium fire in dry cask storage is largely eliminated by limiting the maximum fuel cladding temperature and minimizing the oxygen available. The temperature is explicitly modeled using bounding fuel characteristics. The maximum clad temperature occurs during vacuum drying when little oxygen is available and the fuel is in an inert environment for storage.