UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 31, 2016

MEMORANDUM TO: Brian E. Holian, Director
Office of Nuclear Security and Incident Response

FROM: Michael F. Weber ***/RA/***
Director of Nuclear Regulatory Research

SUBJECT: TRANSMITTAL OF REPORTS TO INFORM DECOMMISSIONING PLANT RULEMAKING FOR USER NEED REQUEST NSIR-2015-001

For your information, enclosed are technical reports intended to inform the ongoing rulemaking for decommissioning plants. This memo and the enclosures are in response to user need request NSIR 2015-001, available in the Agencywide Documents Access and Management System (ADAMS), under Accession No. ML15168B073. This memo closes the user need request.

In that request, dated September 4, 2015, the Office of Nuclear Security and Incident Response (NSIR) requested the Office of Nuclear Regulatory Research (RES) to perform applied research to support an ongoing rulemaking for decommissioning reactors. The request asked RES to support three applied research efforts: (1) perform a task analysis that includes a timeline of responder actions at representative spent fuel pool configurations to mitigate a drain down event and, if possible, determine the likelihood of success of these actions in preventing a radiological release; (2) perform analyses of representative spent fuel to determine the decay time necessary for the fuel to remain below temperatures associated with runaway clad oxidation for at least 10 hours assuming adiabatic heat up condition; and (3) perform an analysis of the offsite dose rate from radionuclides released during a hypothetical spent fuel pool zirconium fire. In an October 5, 2015 memorandum, RES accepted this user need request, which was designated as NSIR-2015-001 (ADAMS Accession No. ML15271A303).

The three requested analyses are documented in the enclosures to this memorandum.

The analyses focused on decommissioning plants where there is not another unit on-site that is continuing to operate. Overall, this work demonstrates:

- For many initiating events at decommissioning reactors, mitigative actions have a high likelihood of preventing an uncontrolled spent fuel heatup.
- In cases where an uncontrolled heatup is not prevented, the heatup is relatively slow, providing significant time before a radiological release.
- In the case of a radiological release, dose rates are low enough such that significant additional time is available to take offsite actions to protect the public.

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Task 1: Task Analysis of Mitigation Actions

The purpose of this task was to perform two analyses, one for a Boiling Water Reactor (BWR) and one for a Pressurized Water Reactor (PWR), to (i) determine the time the representative licensee's on-shift decommissioning organization would take to implement procedures to mitigate a spent fuel pool drain down event, and (ii) estimate the likelihood of successful deployment of the mitigation measures to prevent fuel overheating. The analysis results aim to be generally applicable to all decommissioning nuclear power plants. The report uses the Vermont Yankee Nuclear Power Station and the San Onofre Nuclear Generation Station as the BWR and PWR reference plants, respectively, to perform the task analyses. The task analyses are based on the various NRC-conducted or –sponsored studies related to the safety of the spent fuel in the spent fuel pools and plant-specific information collected before, during, and after the two plant visits conducted for the study.

The task analyses were performed against the nine initiating events identified in NUREG-1738, "Technical Study of SFP Accident Risk at Decommissioning Nuclear Power Plant." The results show that the plant staff and offsite support can reliably implement the mitigation strategies to prevent spent fuel heat-up damage. This study identified that only the events causing a rapid spent fuel pool (SFP) water draindown (e.g., extreme earthquake and large aircraft impact) would challenge the successful mitigation of fuel heatup.

Task 2: Spent Fuel Decay Time

The purpose of this analysis was to provide information on fuel heatup time and onset of zirconium fire as a function of cooling time for both PWR and BWR assemblies. The analysis is mainly based on the assumption of adiabatic heatup for a generally limiting condition wherein the benefit of radiative and convective heat transfer is not realized. This is the case when the most recently discharged fuel is surrounded by similar assemblies without the benefit of radial heat transfer and the spent fuel pool leak elevation and/or debris blockage prevents natural circulation air cooling. Adiabatic heatup times are calculated for a variety of burnups using both average and hottest assemblies. The spent fuel decay time corresponding to the 10-hour heatup time can vary by as much as 28% for the hottest BWR assembly (24% for PWR) compared to the average assembly for a typical burnup of 60 GWd/HTHM.

The report includes an analysis of the effects of the degree of benefit that could be achieved by relaxing the adiabatic heatup assumption based on realistic benefits gained from including radiative heat transfer to surrounding colder assemblies and the presence of the racks in the adiabatic calculation. The results show that including the mass of the racks in the adiabatic calculation can decrease the required fuel decay time by 50% and 20% for the BWR and PWR assemblies, respectively. Additionally, if the hot fuel is placed in a favorable fuel loading pattern where the hottest assemblies are next to assemblies from the previous offload in a checkerboard pattern, the heatup time is increased by an additional factor of 1.3 early in the cooling time (≤ 1 year) to about 1.1 at 3 years.

Task 3: Dose Rate of Accidental Radiological Release from Spent Fuel Pool

The purpose of this analysis was to examine offsite doses and dose rates for potential spent fuel pool accidents using spent fuel pool source terms developed for the consequence study in NUREG-2161, "Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor." RES staff conducted an analysis of these source terms using MACCS to evaluate cumulative early phase acute doses to organs of interest for early health effects (red bone marrow, stomach, and lungs) as well as effective

doses from early phase exposures as a function of both time and distance from the point of release.

This information indicates how much time is available before offsite exposures become excessive as a result of a zirconium fire. The results indicate that acute fatal effects offsite appear to be unlikely from either source term evaluated provided that individuals can be relocated within a reasonably short time after plume arrival. Meanwhile, regarding exceedance of protective action guidelines (PAGs), for the larger source term studied, the PAG guidelines would be exceeded within the first hour of release inside 0.3 miles. Outside of 5 miles, PAG limits would be expected to be exceeded 8 hours after release.

The Office of Nuclear Regulatory Research has established an online quality survey to collect feedback from user offices on the usefulness of RES products and services. This survey can be found online at the hyperlink: http://www.internal.nrc.gov/RES/now/res-product-survey/01-Update-suggested-language-for-request-to-complete-the-survey.html Please have the responsible manager or supervisor complete this short—about 5 minutes—survey within the next 10 working days to present your office's views of the delivered RES product.

Further, my staff has evaluated these deliverables and determined that they do not meet the criteria for Highly Influential Scientific Assessment or Influential Scientific Information as discussed in Management Directive 3.17.

Enclosures:
1. Task 1: Human Reliability Analysis of Decommissioning Nuclear Power Plants
2. Task 2: Spent Fuel Assembly Heat Up Calculations
3. Task 3: Offsite Dose Accumulation Rates Following a Hypothetical Spent Fuel Pool Accident

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