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Ms. Tanya Eaton
Project Officer
U. S. Nuclear Regulatory Commission
Division of Systems Analysis
MS OWFN 11-A-11
Washington, DC 20555-0001

Subject: Review of "DRAFT Technical Study of Spent Fuel Pool Accidents for Decommissioning Plants" Contract No. NRC-03-95-026, Task Order No. 246.

Dear Ms. Eaton:

Attached are draft comments summarizing the evaluation of the report entitled "DRAFT Technical Study of Spent Fuel Pool Accidents for Decommissioning Plants," dated June 1999. Comments regarding the inadvertent criticality and fire protection portions of the draft report are attached for your review and comment.

Should you need any additional information, please do not hesitate to contact me at (301) 255-2279.

Sincerely,

Dr. Leonard W. Ward
Project Manager

Enclosure: As Stated

cc: D. Jackson, NRC, DSSA/SPLB
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QA File 1022

479

Review of DRAFT Technical Study of Spent Fuel Pool Accidents
for
Decommissioning Plants

INTRODUCTION

This report presents the results of the review of the NRC document entitled "DRAFT Technical Study of Spent Fuel Pool Accidents for Decommissioning Plants," dated June 1999. The subject report presents an interim assessment that evaluates the manner in which spent fuel pools would react to postulated severe accidents. The objective of the review contained herein is to provide an independent technical evaluation of the portions of the subject report that address the potential for inadvertent criticality and vulnerabilities to fires. Recommendations for improvements to the report are discussed.

DISCUSSION AND COMMENTS

This section presents the evaluation of the criticality and fire protection portions of the subject report. The comments pertaining to the potential for an inadvertant criticality are presented first followed by fire protection.

Inadvertant Criticality

Review of Section 2.3.1 Evaluation of the Potential for Criticality

1) Item 1. of this section specifically addresses the potential for criticality because of the closer (assembly) spacing resulting from the *removal of storage racks* from the pool. This additonal information presented below was not included in this item discussion.

   In some PWR storage racks a closer spacing between stored fuel assemblies could be achieved even without rack removal. These racks have spacers (~1 in. long) between cells. Typically, they are used for full core off-load and fresh fuel storage. Collapsed spacers would lead to a closer assembly spacing. **However, a sudden collapse of all spacers is not deemed** credible. Collapsing of a few spacers leading to some partial decrease in spacing between stored fuel assemblies would also not give rise to criticality because of the presence of a soluble absorber (boron). Thus, two contingencies would have to occur in order to possibly achieve criticality due to a closer fuel assembly spacing in this type of storage rack: collapse of spacers and removal of soluble boron. These both constitute highly unlikely events but the discussion is recommended for inclusion in the report for completeness.

2) Since Aluminum (1100) is used in some BWR spent fuel pools to cover Boral, it is recommended that the 3rd sentence of item 2. in the first paragraph be modified to read: "The absorber plates are generally enclosed by cover plates (stainless steel or aluminum alloy). The tolerances within a cover plate will tend to prevent any appreciable fragmentation and movement of the enclosed absorber material. "

Further, it is suggested that the last sentence of the first paragraph in item 2. be modified to: "The total loss of the welded cover plate is not considered feasible."

3) The draft report attempts to cover loss of fuel rod integrity without specifically addressing the conditions surrounding this event. However, the event conditions may greatly determine the extent of fuel damage and hence, the potential for criticality. For example, two bounding situations are identified here which are recommended for inclusion in the report.

If a loss of cladding integrity occurred, for example, because the cladding is brittle and could easily fail upon the impact from a foreign object (another assembly or fuel handling tool), it is highly unlikely that the damage would be very extensive. Thus, the number of fuel pellets available to form some unfavorable configuration is considered quite remote. In contrast, the complete pellet inventory of about 30 fuel rods would be needed for criticality in a quasi-spherical configuration. (This estimate is based on fresh 3.5 wt% U-235 fuel; see Ref. 1.) Typically, spent fuel contains fission product poison and a considerably smaller percentage of fissile material. Therefore, the combination of both the limited extent of the expected damage and the need for a large amount of the optimally configured fuel suggests the potential for criticality is negligible for this case.

In the case of a zirconium fire (following a major loss of pool water), because of the assembly power peaking, a fire would initiate with cladding melt anticipated near the assembly midplane. The cladding temperature at the fuel bottom will be lower and the fuel rods are expected to remain intact in this region. Because of the closely packed fuel rods and the presence of grid spacers, there would be little room for fuel pellets to be expelled provided the wrapper (for BWR fuel) and/or rack canister remained intact. In this situation, rubble consisting of pellets and molten cladding would form on top of a spacer grid located below the assembly midplane. Since rubble would generate heat, it would eventually flow downwards slowed by the lower spacer grids. This rubble mass would be expected to grow, however, if not arrested by quenching from recovery actions. It is very likely that if not terminated at this stage, the rubble mass would melt the canister walls so that the fire could propagate towards the adjacent fuel assemblies. Thus, the amount of fuel debris material produced in a zirconium fire could easily exceed the 30 fuel rods, identified above, if early fire fighting recovery actions were not successful. Because of the low melting temperature and low density of Boraflex and Boral, it is likely that these would melt away early and collect below the rubble bed. Regardless of location, taking into account the potential for damaged fuel-moderator configurations to become more reactive than the original fuel lattice and given the uncertainty in poison effectiveness, subcriticality in the presence of unborated water addition cannot be fully assured. If a criticality accident is deemed an issue in this zirconium fire scenario, it appears that a most prudent measure would be to use borated water (~2000 ppm), for example, when extinguishing a pool firethat causes substantial fuel damage.

Review of Section 2.3.2 Evaluation of the Potential for Criticality from Personnel Actions in Reponse to an Accident

4) It is suggested that the 4th sentence in this section be modified to read: "...absorber material such as plates, brackets, and clips made out of stainless steel or aluminum is sufficient to...".

Editorial Comments

5) Section 2.3 covers criticality scenarios, mostly unrelated to "spent fuel heatup" (Section 2.0). It is recommended that this section be removed from Section 2.0 and placed elsewhere in a more appropriate section.

6) Section 2.3.1
Item 1, second sentence. Delete the first "could."

7) Appendix 3, 2nd paragraph, 2nd sentence: the "9x9" assembly is erroneously/incorrectly associated with a PWR bundle while the "17x17" assembly is associated with a BWR.

Fire Protection

The subject report analysis includes a risk assessment of fire events leading to a loss of fuel pool cooling with subsequent failure to provide adequate inventory make up in a timely manner. Comments are provided below specific to fire analysis.

8) It is recognized that the risk assessment provided to date is both preliminary and generic in nature and that significant judgement is involved in the assignment of event probabilities. As such, in order to provide a credible argument with respect to fire vulnerability it is would be extremely useful to clearly identify the systems, support systems and equipment (including main cable routes) required to maintain spent fuel pool cooling. Subsequently, the plant areas in which this equipment is located could be identified and the associated fire hazard determined with reference to generic data. For example, spent fuel pump/heat exchanger room, service/ component cooling water areas, switchgear rooms, control room and switchyard are possible candidate areas for the fire analysis. At present, the report provides very little information upon which to understand and judge the validity of the underlying assumptions which determine the fire hazards and associated impacts.

9) The fire analysis only addresses fire induced loss of fuel pool cooling. No mention is made regarding the possibility of fires leading to other initiators. While this is unlikely, an appropriate rational and statement excluding such events is recommended for inclusion in the report.

10) While a general reference is provided for the fire initiating event data (i.e. EPRI FIVE Methodology, EPRI TR-1000370s) used in the analysis, the report does not indicate

the basis upon which fire frequencies assigned in this study (8.9E-03/yr and 4.0E-02/yr) were derived. For example, how many specific pump and cabinet fires sources were included? Were any severity factors considered? It is recommended that some general arguments relating the generic fire data, pertinent ignition sources and targets of concern be provided in the report.

11) It is not clear why the fire event data pertaining to NPP operation is applicable during decommissioning activities. Will plant areas containing equipment and/or cable which is critical to fuel pool cooling be clearly identified and activities restricted or controlled in a manner similar to those imposed by current fire protection programs? Pertinent arguments are recommended for inclusion in the report in order to justify the use of NPP operational data. (It may in fact be more appropriate to use fire event data during NPP construction than the operational data used in the current study.) —ask Len

→ FIVE maybe

12) No basis is given for the probabilities for non-suppression applied in the fire event trees. For example, a FIRE screening value of 0.1 may be applied providing it can be demonstrated that sufficient time is available to detect and suppress the fire before the undesired damage occurs. Values lower than the reference screening value may be used provided appropriate qualitative arguments are used.

13) The assignment of a non-suppression probability in the model generally implies some form of automatic fire detection is in place, particularly for Cases 1 and 3 where occupancy levels may be low. It is recommended that the assumption regarding the presence of automatic fire detection in key areas be clearly stated.

14) In the analysis of case 2 it is assumed that the probability of non-suppression will be lower than case 1 and 3 since, in this scenario, the last fuel was transferred from the reactor one month ago and consequently the occupancy levels will be higher. In fact, case 2 appears to represent the period of one month to one year after the transfer of fuel to the pool. (One month is merely a bounding assumption used in assessing the decay heat level.) As such, it is not clear that occupancy levels at the end of one year are sufficient to justify a reduced non-suppression probability and an explanation is therefore recommended.

15) Fire suppression probabilities assigned in the fire event trees (5E-02, 1.0E-02, and 0.1 are inconsistent with the write up provided on page 28 which indicates frequencies should be 0.1, 0.05 and 0.2, respectively.

16) As a result of comment 9, the total frequency of fuel uncovery shown in the event trees is inconsistent with the text on page 28. (It appears that the latest event trees were omitted from the draft report)

17) The event trees for cases 1 and 2 credit both "fire suppression" and "make up using the diesel driven fire pump." It is recommended that an explanation as to why these events can be treated as independent failures be included in the report.

Other None Fire Related Review Comments

18) It is not clear that the analysis recognizes that recovery of the normal spent fuel pool cooling system may not be possible once the pool begins to boil (or at even lower heated temperatures) due to inadequate NPSH considerations. Thus, recovery options may be more limited than currently assumed in the analysis.

19) The report contains good technical information on the conditions for fuel failure, zirconium fire potential, and criticality, for example. The report contains this detailed information through out many sections, making it a little difficult to follow. The Staff may want to consider re-organizing the report and focusing on the major issues at hand in each section without including detailed discussions of other issues in any given section. This would make the document easier to read and less confusing to understand. For example, stand alone sections on the subjects of the thermal hydraulic scenario, fuel heat-up, fuel failures, zirconium fire potential, criticality, thermal hydraulic analysis codes/methodologies, and fire protection that discusses only these issues would improve the report structure.

20) Since the fuel can remain at elevated temperatures, although below the metal-water reaction threshold, these low temperatures if sustained for extended periods of time could result in the oxidation of large portions of the fuel cladding. This could produce challenges to fuel rod integrity, and as such the fuel rods may not then be able to withstand the quenching of the rods during recovery causing fuel failures. It may be prudent to recommend a time-at-temperature or a time frame within which recovery must be performed to preclude these low rate heat oxidation processes from challenging fuel rod integrity. This emphasizes the need for one to clearly state the recovery actions and timing for such actions that are considered important considerations. It would also be prudent to consider an evaluation of the recovery operations and a discussion of the important issues to assure the accident acceptance criteria are maintained during this phase of the scenario.

SUMMARY AND CONCLUSION

A review of the draft subject report regarding the potential for inadvertent criticality and fire protection issues was performed. The review included recommendations to address the concerns. Of particular importance is the need to recognize the potential for criticality and the subsequent actions to mitigate the accident consequences when unborated water is used following a zirconium fire. As mentioned above, when taking into account the potential for damaged fuel-moderator configurations to become more reactive than the original fuel lattice given the uncertainty in poison effectiveness, subcriticality in the presence of unborated water addition cannot be fully assured. If a criticality accident is deemed an issue in this zirconium fire scenario, it appears that a most prudent measure would be to use borated water (~2000 ppm), for example, when extinguishing a pool fire when some some major fuel damage has occured. It is

recommended that these discussions and mitigative actions be included in the draft report.

In regard to fire protect, it is recognized that the risk assessment provided to date is both preliminary and generic in nature and that significant judgement is involved in the assignment of event probabilities. However, it is recommended that the report clearly identify the systems, support systems and equipment (including main cable routes) required to maintain spent fuel pool cooling. Subsequently, the plant areas in which this equipment is located could be identified and the associated fire hazard determined with reference to generic data. For example, spent fuel pump/heat exchanger room, service/ component cooling water areas, switchgear rooms, control room and switchyard are possible candidate areas for the fire analysis. At present, the report provides very little information upon which to understand and judge the validity of the underlying assumptions which determine the fire hazards and associated impacts. This information is recommended for inclusion to support the technical basis for the fire protection event probabilities cited in the report.

REFERENCES

1. Thomas, J. T., Nuclear Safety Guide, TID-7016, Rev.2, NUREG/CR-0095, June 1978.