recd 6/14/00
from T. Eaton

June 7, 2000

NOTE TO: Goutam Bagchi, Stu Richards, George Hubbard, John Hannon, Mark Rubin, Richard Emch, Jared Wermiel, Glenn Tracy, Cindy Carpenter, Faruok Eltawila

FROM: Tanya Eaton, John Lehning NRR/DSSA/SPLB

Background

On Feb. 15th, 2000, the "Draft Final Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Plants," was released for public comment. In a letter dated March 15, 2000, the Union of Concerned Scientists commented that the NRC staff solicited comments from the public, when it had no intention of addressing their comments. Therefore, to ensure that we address all stakeholder comments in the Final Technical Study, we have compiled a list of ALL comments which come from transcripts of meetings with the public, letters from the public, and emails received, from April 1999 until the present time.

In order to address each public comment, please review the comments assigned to your branch (located in Attachment A). Attachment A provides a summary of each documented public comment which must be addressed in the final report. A list of references that we reviewed, is contained at the end of Attachment A. Attachment B contains excerpts of the documents reviewed, which highlight the specific public comments shown for your branch. Thus, you do not have to retrieve all of the documents that we reviewed for public comments.

Also, there may be some comments identified in other branches which may require technical input from your branch. Comments where you may be asked to provide technical support are indicated throughout Attachment A with yellow tabs.

Final Writeup

If the public comment in your section was already addressed, please indicate "comment already addressed" in your final writeup and provide the location (example, Feb. 15th report, Section 2a, page 5).

If the public comment was not addressed, provide a written response to the comment.

If you find that you need to expand or modify statements already contained in the Draft report to address the public comment, contact Tanya Eaton so that she can electronically send you the portion of the file for modification. Or you can type it out again and indicate where it should be inserted within the final report.

All responses to public comments are due to George Hubbard by: July 7, 2000.

Forward any comments/question to Tanya Eaton at 415-3610 or TME@nrc.gov

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ATTACHMENT A

Summary of Public Comments/Staff Commitments

References are listed on the last page. The attachment highlights the exact location of the comments within each reference document.

DE (Contact: Goutam Bagchi)

1. Page 300,Shadis: Stresses on transfer tunnel [Ref. 1]
2. p 302, Atherton: Aging effect on qualification of equipment. **Rich Barrett assist if needed** [Ref. 1]
   Aging effects on SFP [Ref. 1]
   Irradiation effects on SFP [Ref. 1]
3. Page 306 and 447, Atherton: Aging effects on SFP: strengthening vs. Hardening of the concrete and the strength of the liner over time. [Ref. 1]
4. Page 13, Shadis statement: Seismic vulnerabilities of SFP transfer tubes must be assessed to properly determine the risk of draining SFP's. [Ref. 2]
5. Page 2, Atherton comment: The NRC should perform a more rigorous analysis of the effects of aging upon the SFP and its associated structures and equipment. [Ref. 7]
6. Page 2, Atherton comment: The NRC should identify all SFP's that were not initially designed to seismic criteria and explain their level of quantification, including SFP racks. [Ref. 7]
7. Page 2, Atherton comment: The NRC should perform a worst case analysis of the result of a seismic event which collapses the SFP building, and/or drains the pool and/or damages the spent fuel. [Ref. 7] **SRXB assist if needed**
8. Page 3, Atherton comment: The NRC should require that specific areas be inspected and that these areas be accessible. [Ref. 7]
9. Page 3, Atherton comment: The NRC should specify why it is not cost effective to perform a plant-specific seismic evaluation for each SFP and what impact this has on safety. [Ref. 7]

DLPM (Contact: Stu Richards)

1. Page 87, Lochbaum: It is difficult to figure out how this effort fits into the overall big picture of what the NRC is doing on decommissioning. [Ref. 1]
2. Page 262 Shadis: Look at all of the activities that happen during decommissioning when developing regulation, not just a narrow view of SFP. [Ref. 1]
3. Page 422, Shadis: Confused on the way Part 50 is being applied in place Part 72 might be more applicable. [Ref. 1]
4. Page 464, Cameron: Design basis accidents, address areas beyond the TWG study. [Ref. 1]
5. Page 64, Paul Blanch: SECY 99-168 doesn't cover all decommissioning issues. [Ref. 2]
6. Page 72, David Stewart-Smith: Consider a fire in the LLW storage area, including large amounts of LLW in case disposal capacity is lost mid-stream during decommissioning. [Ref. 2]
7. Page 97, R. Shadis: Wants an adjudicatory hearing and a prior NRC review/approval step at the onset of decomm. [Ref. 2]
8. Page 5, Shadis statement: Since more radioactive materials are being handled during decommissioning than during operation, why are resident inspectors removed or at least why does NRC not use contract radiation protection personnel? [Ref. 2]
9. Page 6, Shadis statement: NRC should hire a contractor to determine why/how 10 CFR Part 50 was contorted to fit decomm. reactors with the duct tape of 10 CFR 50.82 to avoid adjudicatory processes with potential regulatory handles. [Ref. 2]
10. Page 6, Shadis statement: Little of what operators or reactor inspectors have learned is applicable to decommissioning. NRC needs personnel specifically trained in and dedicated to decommissioning. [Ref. 2]
11. Page 8, Shadis statement and elsewhere: Untrained NRC public representatives frequently misinform the public, particularly about the opportunities for a hearing on reactor decommissioning. [Ref. 2]
12. Page 8-13, Shadis statement: Several specific examples of interactions with NRC staff that he feels demonstrate improper or inaccurate information provided by staff members. [Ref. 2]
13. Page 15, Shadis statement: The time delays experienced by licensees who must submit individual heatup analyses and applications for exemption from NRC regulations could be mitigated by preparation of such documentation well in advance of decommissioning. [Ref. 2]
14. Page 1, UCS comment: The NRC staff owes its stakeholders the courtesy of addressing their concerns, particularly when comments are solicited by the NRC staff. Otherwise, the NRC staff must stop actively soliciting public comment when it has no intention of considering. [Ref. 3]
15. Page 2, UCS comment: IDC #5 must be revised to require direct measurement of SFP temperature/water level. [Ref. 3] **SPLB/SPSB assist if needed**
16. Page 1, Atherton comment: Seeks another 3 months from date of memo to formally respond to draft. [Ref. 7]
17. Page 2, Atherton comment: The NRC should identify and address possible conflicts of interests, and differing professional opinions as to the use of PRA. For instance, Dr. Hanauer was quoted in a memo to say, "you can make probabilistic numbers prove anything, by which I mean that probabilistic numbers mean prove nothing." [Ref. 7] **Mark Rubin assist if needed**

18. Michele Kiddell email: Dr. Hanauer was quoted in a 1975 memo to say, "you can make probabilistic numbers prove anything, by which I mean that probabilistic numbers prove NOTHING." If a respected technical advisor has expressed doubts about the NRC's use of probabilistic numbers, how is the NRC going to use probabilities convincingly to protect health and safety? I feel that this is an invalid way of measuring safety, and should not be used. Each day these reactors stay opened you are poisoning the environment. This is unacceptable. [Ref. 12] **Mark Rubin assist if needed**
19. Page 1, Atherton comment: The NRC should make publically available references used in the study at no cost. [Ref. 7]
20. Page 4, Atherton comment: Interim regulations should be time-limited, to be reviewed again at some future date. [Ref. 7]
21. Page 3, Mats Sjöberg/ Ferenc Müller on report: Have you considered the "second" worst event at plants. For example waste handling. AT Barseback NPP, a fire in the bitumen storage is found to be the second worst case, although with limited off-site consequence. [Ref. 9]
22. Page 3, Mats Sjöberg/ Ferenc Müller on report: We would appreciate if an electronic copy via email of the following references: (Ask Dick Dudley if already complete) [Ref. 9]

    Sailor, et.al., "Severe Accidents In Spent Fuel Pools in Support of Generic Issue 82", NUREG/CR-4982.
    "A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants," NUREG/CR-6451, dated August 1997.

SPLB (Contact: George Hubbard)

1. Page 256/7, Shadis: Heavy objects, such as crane rail or masonry wall, falling into the SFP or taking out electricity during decommissioning activities. [Ref. 1] **DE assist if needed**
2. Page 305, Atherton: Is SBO of SFP area acceptable? [Ref. 1] **SPSB assist if needed**
3. Page 14, Shadis statement: Could foreign materials with lower ignition temperatures enter a drained SFP and catch fire, thus raising the temperature of SF to the point of rapid zirconium oxidation? [Ref. 2] **SRXB assist if needed**
4. Page 14, Shadis statement: Since the National Severe Storm Center is predicting more frequent and more intense severe weather phenomena, shouldn't the size and velocity of wind-driven missiles and maximum height of storm surges be reassessed? [Ref. 2]
5. Page 14, Shadis statement: How can there be no SFP degradation issues if type 304 stainless steel employed in fuel racks and assemblies is known to exhibit stress-corrosion cracking in oxygenated or stagnant borated water? [Ref. 2] **DE assist if needed**
6. Page 2, UCS comment: The draft report should be revised to include credible hazards to plant workers at permanently closed plants. [Ref. 3] **SPSB assist if needed**
7. John Mcloughlin comment: All pools leak, dry storage is the only way for long term safety. The longer you think about it, the more reasons you have for no pools. [Ref. 5]
8. Page 3, Atherton comment: The NRC should identify all SFP's that leak. Degradation of the lines and concrete should be investigated. The leaks should be sealed. [Ref. 7]
9. Page 3, Atherton comment: The NRC should determine the qualifications and degradation of spent fuel racks. [Ref. 7] **DE assist if needed**
10. Page 3, Atherton comment: The NRC should determine the proper methods of extinguishing a possible zirconium fire. [Ref. 7]
11. Page 3, Atherton comment: What happened to the commitment verbally agreed up on through Mr. Meisner of Maine Yankee to install a single failure proof crane system using safety grade electrical equipment. [Ref. 7]
12. Page 3, Atherton comment: The draft report omitted acts of sabotage and vandalism. Emergency evacuation plans should be prepared with this consideration of terrorism. [Ref. 7] **SPLB coordinate with IOLB**
13. Page 4, Atherton comment: It is suggested that NRC err on the side of safety since terrorist acts can not be specifically addressed. [Ref. 7] **SPLB coordinate with IOLB**
14. Page 94, P. Blanch: What is SFP design basis during decomm? [Ref. 2]
15. Page 5, ACRS: Recommend putting rulemaking on hold until the inadequacies discussed herein are addressed by the staff. [Ref. 11] (Already addressed in GT dated May 22, 2000. Make reference to this in App. 8)
16. Page 1, Mats Sjöberg/ Ferenc Müller on report: Does IDC #3, also include means of communication? [Ref. 9]
17. Page 1, Mats Sjöberg/ Ferenc Müller on report: IDC #4, is there a new Tech. Spec (for shut down plants) in place. In that case, are the emergency diesels at the plant still operable? Or is this a higher expectation (than during operation of the plant) to provide electricity and water supply? [Ref. 9]

SPSB (Contact: Richard Emch acting for Richard Barrett)

1. Page 91, Lochbaum: Licensee plant management affecting human performance [Ref. 1]
2. Page 114, Gunter: human performance - multiple shifts can make same mistake; simple task of watching SFP can lead to tedium. [Ref. 1]
3. Page 124, Shadis: human performance lowers over time for tedious tasks - need to take a conservative view. [Ref. 1]
4. Page 162, Gunter: has common mode failure been evaluated. [Ref. 1]
5. Page 186, Lochbaum: Enforceable regulations for operator attentiveness - how often are operator rounds. [Ref. 1]
6. Page 303, Atherton: How to minimize the probability of failure of system to mitigate accidents. [Ref. 1]
7. Page 451, Atherton: relevancy of TMI, SBO [Ref. 1] (Rich Barrett)
8. Page 14, Shadis statement: The risk of SFP's to aircraft crashes should take into consideration changes in local air traffic as represented by flight control logs of local airports and military bases. [Ref. 2]
9. Page 2, UCS comment: What is the generic frequency of events leading to zirconium fires at decommissioning plants before the design and operational characteristics are implemented? [Ref. 3]
10. Page 2, UCS comment: What will the NRC do to protect plant workers and the public from SFP risks at permanently closed plants and operating plants before these design and operational characteristics being implemented? [Ref. 3] **SPLB assist if needed**
11. Shannon M. Rohrer comment: Found places in the report referring to "uncovering the core" when it was clear the authors meant "uncovering the fuel". [Ref. 6] (Tanya Eaton corrected throughout report).
12. Shannon M. Rohrer comment: PRA answers were off by an order of magnitude for some sequences. [Ref. 6] (Mike Cheok responded)
13. Page 2, Atherton comment: The probability of the happening of accidents as the event occurred should be calculated so that a more realistic probabilistic perspective is determined. [Ref. 7]
14. Page 3, Atherton comment: NRC should determine which failure rates used in the risk-informed process are reliable and which are not and the results should be included in the study. [Ref. 7]
15. Page 4, Atherton comment: The NRC should identify the number of operators assigned to each shift an how these operators are protected so that their availability is guaranteed in the event of an accident. [Ref. 7]
16. Page 4, Atherton comment: The NRC should address what measures are taken to minimize operator boredom and maintain alertness due to standing watch over a SFP "graveyard." [Ref. 7]
17. Page 4, Atherton comment: The NRC should address what measures are in play to minimize operator error in a postulated SFP accident. [Ref. 7]
18. Page 4, Atherton comment: The NRC should review the justification for containments in operating reactors and explain why a containment would/would not be advisable over a SFP. [Ref. 7] (Glenn)
19. Page 4, Atherton comment: To the extent possible, experimental validation of risk informed results should be addressed. [Ref. 7] (Glenn)

20. Page 2, Atherton comment: How has the NRC considered the availability of local resources as identified by ICD #2,3,and 4 should the local infrastructure be destroyed. [Ref. 7] **IOLB (EP) assist if needed**
21. Page 2, ACRS: The ruthenium inventory in spent fuel is substantial. If there are significant releases of ruthenium, the RG 1.174 LERF value may not be an appropriate surrogate for the prompt fatality quantitative health objectives (QHO). Because of the relatively long half-life of ruthenium-106, it is likely that the early fatality QHO would not longer be the controlling consequence. [Ref. 11] **RES assist if needed**
22. Page 4, ACRS: Risk-informed decisionmaking regarding the SFP fire issues should use realistic analysis, including an uncertainty analysis. The ACRS is concerned about the conservative treatment of seismic issues. [Ref. 11] **DE assist if needed**
23. Page 4, ACRS: Since the accident analysis is dominated by sequences involving human errors and seismic events which involve large uncertainties, the absence of an uncertainty analysis of the frequencies of accidents is unacceptable. The study is inadequate until there is a defensible uncertainty analysis. [Ref. 11]
24. Page 2, NEI: Seismic - There should be no SFP screening level distinctions based on plant SSE for the CEUS. For the WUS, it is reasonable to require that certain plants demonstrate a HCLPF of 2 X SEE. [Ref. 10] **DE assist if needed**
25. Page 5-7, NEI: Consequences: The consequence assessment provides a misleading conclusion that there is about a factor of 2 reduction in prompt fatalities if the accident occurs after 1 year instead of 30 days. [Ref. 10] **RES assist if needed**

    Page 5: The study does not note that the absolute value of fatalities is a couple of order of magnitudes below the numbers for operating plants. This is not surprising since it is the short-lived nuclides which drive this result. [Ref. 10]

    Page 5: The study does not highlight the fact that the most significant reduction in early fatalities occurs within the first 30 days. [Ref. 10]

    Page 5: By failing to emphasize the above, the staff's risk study lends misleading support to the idea that a 1 year waiting period is justified prior to reducing EP requirements. In fact the risk study does not support this conclusion. [Ref. 10]

    Page 6: The consequence analyses contained in Appendix A seems to contradict the staff's conclusion that 1 year is an appropriate waiting time for EP. [Ref. 10]

    Page 6: The study seems to establish the 1 year delay time based on providing sufficient time for operator response to upset conditions. A much shorter delay period supports the same conclusion..(Table 3.1, App. 2a). The total time available for operation action is 133 hours, as calculated. The same calculation for a 6 month period reveals 118 hours available for operator action. This is a substantial period of time, which allows the same conclusion....a 6 month period provides adequate decay time necessary to reduce the pool heat load to a level that would provide sufficient human response time. [Ref. 10]

    Page 6: The conclusion that should be drawn from the consequence analysis is that prompt fatalities are very small in comparison to operating reactor accidents,

and are sufficiently reduced in the first month after shutdown to support eliminating off site emergency preparedness. [Ref. 10]

Page 6: Most significant is the 1 rem offsite dose consequence (EPA PGA that distinguishes between offsite/onsite response. Below 1 rem, no offsite response is called for. [Ref. 10]

26. Comments on Appendix 2b, Seismic - [Ref. 10] **DE assist if needed**

Attachment A, NEI letter, Section 2:

Page 1: The comments on conservatisms associated with the design basis earthquake at licensed NPPs should be moved to a separate section. Furthermore the deterministic method should be contrasted with the probabilistic method. [Ref. 10]

Page 4: Use of the LLNL probabilistic estimates at high ground motions may not be credible. EPRI results are also likely to be overly conservative at high ground motions. [Ref. 10]

Attachment A, NEI letter, Section 3:

Page 3: The requirement that some plants with higher SSE values perform detailed HCLPF assessments of the SFP is not warranted. There should be no SFP screening level distinctions based on plant SSE for the CEUS. For the WUS, it is reasonable to require that certain plants demonstrate a HCLPF of 2 X SSE. [Ref. 10]

27. Page 2, Mats Sjöberg/ Ferenc Müller on report: An US earthquake response spectra 10-5 (0.5g) is considered as an 10-7 in Sweden. Does this justify exemption from further consideration, due to low yearly frequency for Zr-fire? The SFP at the Swedish plant is calculated with an earthquake of 0.1g, see response spectra Figure 1, and found to comply with the Swedish standard design standard. **DE assist if needed** [Ref. 9]

SRXB (Contact: J. Wermiel)

1. Page 256, Criticality due to chemical stripping of primary piping [Ref. 1] (Tony Ulses)
2. Page 451, Barrett: worst case draining of the SFP. [Ref. 1] (Joe Staud.)
3. Page 60, Ray Shadis: Concern about primary system chemical decon. and the potential for contaminated solution to go overboard into public waters or be flushed back into the SFP. [Ref. 2]
4. Page 14, Shadis statement: During primary system decontamination at decomm. reactors, is it possible to misalign the valves and send corrosive chemicals into the SFP? Could these chemicals precipitate boron from the SFP water? Is there a potential for criticality? Is there a potential for fuel damage? **EMCB assist if needed** [Ref. 2]
5. Page 15, Shadis statement: In a half-empty SFP, if a SFP liner presses racks together, or, if fuel racks or assemblies or boral plates fail, are localized heat and criticality issues to be considered? [Ref. 2]
6. Page 4, Atherton comment: NRC should identify the scenario where a steam explosion is possible because of a severe criticality event and the basis upon which the probability was determined to be "highly unlikely." [Ref. 7]
7. Page 4, Atherton comment: The NRC should identify all radioactivity in the SFP and that capable of being dispersed in an accident (beyond that on p A3-11 to A3-13). [Ref. 7] **RES assist if needed**
8. Orange County (OC) comment: Criticality accident analysis does not consider risk of a criticality accident that arises from placement of low-burnup fuel assemblies in a pool where the licensee relies on burnup credit to prevent criticality. [Ref. 8] (Tony Ulses)
9. OC comment: Study is deficient in that it ignores phenomenon associated with partial draindown of SFP that will suppress convective heat transfer by presence of residual water at the base of fuel assemblies. [Ref. 8]
10. OC comment: Study is deficient in that partial draindown will lead to a steam-zirc reaction producing hydrogen gas which could reach explosive concentrations in the atmosphere of the spent fuel building, potentially leading to a breach of that building. [Ref. 8]
11. Mats Sjöberg/ Ferenc Müller on report: [Ref. 9] Page A1-7 in the report says:

> "When zirconium reaches temperatures where air oxidation is significant, the heat source is dominated by oxidation. The energy of the reaction is 262 kcal per mole of zirconium. In air, the oxidation rate and the energy of the reaction is higher than zirconium-steam oxidation."
>
> We can transfer 262 kcal to other units:
> 262 kcal pel mol Zr = 1.1 MJ per mol Zr (1 mol Zr = 91.2 kg Zr) =
> 1.1E+06/91.2 = 1.2E+04 J/kg Zr. We can conclude that the air oxidaton energi according to the report is = 1.2E+04 J per kg Zr
>
> The corresponding values for Zr-steam reaktion in the Melcor manual = 6.43E+06 J/kg Zr (Ref. Bottom Head Package, Reference Manual, Table 3.6. Heats of reaction at 1,700 K) The Maap code uses 6.18E+08 J per mol Zr = 6.78E+06 J/kg Zr, for
> Zr-steam reaktion i.e. near the same as Melcor.

There is a factor 500 difference in the oxidaton energy and to the wrong direction.

12. Mats Sjöberg/ Ferenc Müller on report, Release Fractions, Page A4-5, Table A4-3. 100 % release is assumed for noble gases, iodine and cesium. We feel that this is too conservative. The latest estimates by the Swedish Radiation Protection Institute for the Tjernobyl case says that 100 % of the noble gases, 50-60 % of the iodine and 20-40% of the cesium were released at the accident. [Ref. 9]
13. Page 3, ACRS: The ACRS has difficulties with the time at which the risk of zirconium fires becomes negligible. Issues related with the formation of zirconium-hydride precipitates in the fuel cladding are spontaneously combustible in air. Spontaneous combustion of zirc-hydrides would render moot the issue of "ignition" temperature which is the focus of the staff analysis of air interactions with exposed cladding. The staff neglected the issue of hydrides and suggested that uncertainties in the critical decay heat times and the critical temperatures can be found by sensitivity analysis. Sensitivity analysis with models lacking essential physics and chemistry would be of little use in determining the real uncertainties. [Ref. 11]
14. Page 3, ACRS: The staff analysis of the interaction of air with cladding has relied heavily on geriatric work. New findings through a cooperative international program PHEBUS FP provide information relating to the well-known tendency for zirconium to undergo breakaway oxidation in air whereas no tendency is encountered in steam or in pure oxygen. Other findings relate to how nitrogen from air depleted of oxygen will interact exothermically with zircaloy cladding. The ACRS does not accept the staff's claim that it has performed "bounding" calculations of the heatup of Zircaloy clad fuel even when it neglects heat losses. [Ref. 11]
15. Page 4, ACRS: Since the staff has neglected any reaction with nitrogen and did not consider breakaway oxidation, it had not made an appropriate analysis to find this "ignition temperature". [Ref. 11]
16. Page 4, ACRS: The search for ignition temperature may be the wrong criterion for the analysis. The staff should be looking at the point at which cladding ruptures and fission products can be released. One arrives at a lower temperature criteria for concern over the release of radionuclides. [Ref. 11]
17. Page 4, ACRS: The staff focuses on eutectic formations when intermetallic reactions are more germane to the issues at hand. [Ref. 11] **RES assist if needed**
18. Page 4, NEI: T/H - Depending on fuel burnup/storage array details, the development of standard methods is needed for consistent application of regulations. [Ref. 10]
19. Page 1, Mats Sjöberg/ Ferenc Müller on report: Licensing limits of Zr-fire. It is very conservative to use 570 degrees C as a licensing limit (gap-release temperature). [Ref. 9]
20. Page 1, Mats Sjöberg/ Ferenc Müller on report: Fire propagation/radioactivity releases. We think it is probable that the Zr-fire, which starts in a fuel element with the highest burnup rate stays within that fuel element. It is very hard to conceive that this fire can propagate to the whole SFP, which also includes fuel from several years old fuel cycles. Limits on fire propagation will directly limit the possible radioactivity releases. [Ref. 9]

IOLB: (Contact: Glenn Tracy)

1. Michael Holmes comment: Section 4.3.2, "Security" of the draft report casks a shadow on the entire 10 CFR 73.51 rulemaking and needs to clarify the scope of the safety issues. He recommended that the last paragraph in Section 4.3.2 be clear and completely identify the scope and basis of the ISFSI safety concerns from the radiological sabotage and theft identified in 10 CFR 73.1. He also stated that this paragraph appears to contradict the May 15, 1998, NRC rulemaking on Physical Protection for Spent Nuclear Fuel and High-Level Radioactive Waste, Federal Register Vol. 63, No. 94 Pages 26955 - 26963. See email for further detail [Ref. 4] **Skip Young reviewing now.**
2. Page 420, Shadis: With new personnel and decommissioning personnel - how to instill/ ensure the same "safety culture" as during operation? [Ref. 1] (David Trimble)
3. Page 3, NEI: Sabotage - NEI disagrees with the staff's conclusion that there is no methodology currently available to assess probabilities of terrorist activity or behavior which might culminate in attempted sabotage of spent fuel. In fact, SNL, has applied a probabilistic approach to security in decommissioning on the Maine Yankee docket. NEI encourages the staff to review this report. [Ref. 10]
4. Page 3, NEI: EP - The decommissioning rule should specify that the licensee is excused from 10 CFR 50.47 off-site EP requirements after the short lived nuclides important to dose have undergone substantial decay resulting in off-site dose consequences due to license basis accidents of less than 1 rem (the EPA protective action guideline). [Ref. 10]
5. Page 3, Mats Sjöberg/ Ferenc Müller on report: What does "reducing unnecessary regulatory burden" mean in practice when it comes to emergency planning? What kind of reductions are foreseen for the following: manpower onsite/offsite, emergency equipment, communication means, alarm means, notification of personnel/public, EP, plans, KI, EPZ radius? [Ref. 9]
6 Page 30, Gunter: What about Security/bomb threat/intentional events [Ref.1]
7. Page 37/38, Shadis: fire scenarios - resin container fire; fire in a waste storage building; fire in a container vehicle with waste stored in it that could trigger emergency response mechanisms. [Ref. 1]
8. Page 91, Lochbaum: Protection of plant workers, particularly less severe accidents such as pool uncovery without a zirc fire. [Ref. 1] **DRIP assist if needed**
9. Page 2, UCS comment: Asked about calculations for radiation dose experienced by members of the fire brigade responding to resin fires. [Ref. 3] **DRIP assist if needed**

RGEB (Contact: Cindy Carpenter)

1. Pages 3-4, NEI: Insurance - The obligation for decommissioning plants to participate in the secondary financial protection should be reviewed in light of the low public risk posed for SFP's for decommissioned plants. Industry does not believe that the risk justifies requiring participation. (The majority of the 3 in 1 million risk of significant offsite consequences comes from an upper bound determination of the risk posed by seismic events, not on a best estimate of the seismic risk). [Ref. 10] Insurance

   Page 3: If it is determined that participation will be required during the short time that decommissioning plants pose a none-zero risk, then the level of participation should be in proportion to a best estimate of the risk posed relative to the risk posed by operating plants. [Ref. 10]

   Page 4: If any participation is required, it should be only for the short period that clad surface temperatures greater than 570 degrees C can occur in a loss of water configuration. The calculation of this temperature should be by an approved methodology. [Ref. 10]

   Page 4: The capacity required for primary financial protection should be eliminated for consideration of any potential for accidents with significant offsite consequences. NEI proposes that for other events with offsite consequences, onsite coverage be reduced to $25M for the period when spent fuel remains in the pool and offsite coverage be reduced to $5-10M. [Ref. 10]

   Page 4: When fuel has been removed offsite or placed in an offsite ISFSI, we recommend onsite coverage be reduced to $25M while the site still contains significant sources of radioactive material. Onsite coverage could be reduced to zero when there are no sources exceeding 1000 gallons of fluid. Offsite coverage should be reduced to $5-10M for plants with fuel offsite or in an onsite ISFSI. [Ref. 10]

RES (Contact: Faruok Eltawila)

1. Page 2, ACRS: The staff made additional MACCS calculations which assumed 100% release of the ruthenium inventory. For a 1 year decay time with no evacuation, the prompt fatalities increase by 2 orders of magnitude over those in the draft report which did not include ruthenium release. The societal dose doubled, and the cancer fatalities increased four-fold. [Ref. 11]
2. Page 2, ACRS: The ACRS is concerned about the appropriateness of the source term used in the study. The staff did consider the possibility that "fuel fines" could be released from fuel with ruptured cladding (as a result of decrepitation). It did not, believe these fuel fines could escape from the plant site. Evidence suggest that fuel fines could be entrained in the vigorous natural convection flows produced in a SFP accident. Nevertheless, the staff considered the effect of 6×10^{-6} release fraction of fines. This minuscule release fraction did not affect the calculated findings. There is no reason to think that such a low release fraction would be encountered with decrepitating fuel. [Ref. 11]
3. Page 3, ACRS: The uncertainties associated with many of the critical features of the MACCS code do not seem to have been considered in the analyses of the SFP accident. [Ref. 11] **Also SPSB assist if needed**

   -One of the uncertainties is that the spread of the radioactive plume from a power plant site is much larger than what is taken as the default spread in the MACCS calculations.
   - The initial plume energy assumed in the MACCS calculations, which determines the extent of plume rise, was taken to be the same as that of a reactor accident rather than one appropriate for a zirconium fire.
   -The consequences found by the staff tend to overestimate prompt fatalities and underestimate latent fatalities just because of the narrow plume used in the MACCS calculations and the assumed default plume energy.
4. Page 3, ACRS: The staff needs to review the air oxidation fission products release data from Oak Ridge National Lab. and from Canada that found large releases of cesium, tellurium, and ruthenium at temperatures lower than 1000°C. Based on these release values for ruthenium, and incorporating uncertainties in the MACCS plume dispersal models, the consequence analysis should be redone. [Ref. 11]
5. Page 3, Mats Sjöberg/ Ferenc Müller on report, [Ref. 9]: Is a gap release considered to give moderate off-site consequences at the time when Zr-fire is no longer a threat? **SPSB assist if needed**

Policy Issues on consequences/risk (who addresses?):

1. OC comment: Draft study does not address where people who have been relocated from uninhabitable land will reside while the land recover from radioactive contamination. Furthermore, the study does not explain the regulatory basis for using 4 rem over 5 years as the threshold dose for relocation **(Jason of RES to address)**. Finally, the study fails to address the social and economic implications of losing the use of thousands of square kilometers of land for several generations. [Ref. 8]

References:

1. Public Concerns Raised At the Decommissioning Workshop on July 15-16, 1999.
2. Public Comments/Staff Commitments, November 8, 1999 Commission Meeting.
3. UCS Letter dated March 15, 2000.
4. Michael H. Holmes, email dated March 7, 2000.
5. John McLoughlin email dated February 23, 2000.
6. Shannon M. Rohrer email dated March 15, 2000.
7. Peter James Atherton letter dated April 10, 2000.
8. Orange County Response to Shearon Harris Board.
9. Mats Sjöberg/ Ferenc Müller email to Dick Dudley dated April 25, 2000.
10. NEI Public comments, dated May 2, 2000
11. ACRS Letter dated April 13, 2000 from Dana A. Powers to Chairman Meserve
12. Email from Michele Kiddell - SAFE Legacy dated April 7, 2000.

Attachment B

Ref. 8

From Projects

Orange County Response to Shearon Harris Board

1. (p. 3) Draft study does not consider relationship between degraded-core accidents and potential for severe accidents in spent fuel pools during the period after a core damage accident when areas of the plant are inaccessible due to high radiation levels. Appx F Question 10

2. (p. 3) Criticality accident analyses in draft study does not consider risk of a criticality accident that arises from placement of low-burnup fuel assemblies in a pool where the licensee relies on burnup credit to prevent criticality. — Tony Ulses

3. (p. 2 & p. 4) Draft study is deficient in that it ignores phenomena associated with partial draindown of spent fuel pools that will suppress convective heat transfer by presence of residual water at the base of the fuel assemblies.

4. (p. 4) Draft study is deficient in that partial drainage will lead to a steam-zirconium reaction producing hydrogen gas which could reach explosive concentrations in th atmosphere of the spent fuel building, potentially leading to a breach of that building.

5. (p. 5) Draft study is inaccurate with respect to its discussion of spent fuel pool accident consequences: (A) Study does not address where people who have been relocated from uninhabitable land will live while the land recovers from radioactive contamination. (B) Study does not explain regulatory basis for using 4 rem over 5 years as the threshold dose for relocation. (C) Study fails to address social and economic implications of losing the use of thousands of square kilometers of land for several generations.

Policy

Policy

Why not Risk issue

Jason

Ref. 9

From: <Richard.Olsson@ski.se>
To: OWFN_DO.owf4_po(RFD)
Date: Thu, Apr 27, 2000 5:21 AM
Subject: VB: Draft Final Technical Study SFP Risks at Decom NPPs

Dear mr Dudley,

Please find below our first email. Concerning time aspects we appreciate if it is possible to have a response within 2 weeks if possible. However this is not critical.

Can You also say something about the high lights of the public comments and a few words about next step for the draft document ? Best regards

Richard Olsson

> -----Ursprungligt meddelande-----
> Från: Olsson, Richard > Skickat: den 5 april 2000 13:20
> Till: 'RFD@nrc.gov'
> Kopia: Sandervåg, Oddbjörn; Viktorsson, Christer
> Ämne: Draft Final Technical Study SFP Risks at Decom NPPs
> > Dear Mr Dudley,
> > First of all we would like to express our sincere appreciation of the
> extensive draft study. It will be used as basis for our national study on
> emergency planning for decommissioning NPPs. We are currently working
> intensively in order to have a report ready by the end of April and the
> NRC draft report has really been a valuable contribution to our work.
> > Moreover we are very grateful for Your kind response to our fax of
> February 25th, where we propose a liaison with the small group working
> with this in Sweden. > > In Sweden a group of SKI consultants has scrutinized Your report, from the
> emergency preparedness point of view, and confirmed SKIs initially very
> positive impressions of the quality and usefulness of Your draft report.
> > We had a meeting with the consultant group yesterday and listed our brief
> and informal comments to Your report. In attached list we have a few
> questions and furthermore some references listed.
> > We would be very grateful if You could oblige us with a response to the
> questions and if it would be possible to obtain the references listed
> (preferably by email, considering the time pressure we have).
> > Your co-operation on this issue would be highly appreciated.
> > > Best regards
> > Richard Olsson
> Co-ordinator Emergency Preparedness
> SKI
> > <<Questions_comments to NRC.doc>> > >

CC: GATED.nrcsmtp("mats@eskonsult.se")

ES-konsult
ENERGI OCH SÄKERHET AB

Memorandum

Date
2000-04-05

Page
1(1)

Client

Project

Subject

To

Copy

Issued by
Mats Sjöberg/ Ferenc Müller

Viewed by

Approved by

Questions/Comments on the NRC "Draft final technical study of spent fuel accidents risk at decommissioning nuclear power plants", 7590-01-P.

Dear Mr Dudley,

We have studied your report with great interest. It covers exactly the issues we are dealing with.

Below we have some thoughts that came to our minds during the reading and would appreciate if you can comment on the numbered ones:

The main report is well structured and the conclusions seem to be well grounded.

1. IDC #3, also include means of communication?

2. IDC #4, is there a new Technical Specification (for shut down plants) in place. In that case are the emergency diesels at the plant still operable? Or is this a higher expectation (than during operation of the plant) to provide electricity and water supply.

3. Licensing limits of Zr-fire.
   Very conservative to use 570°C as a licensing limit (gap-release temperature)

4. Fire Propagation and radioactivity releases
   We think that it is probable that the Zr-fire, which starts in a fuel element with the highest burnup rate stays within that fuel element. It is very hard to conceive that this fire can propagate to the whole SFP, which also includes fuel from several years old fuel cycles.

   Limits on fire propagation will directly limit the possible radioactivity releases and fatalities e.t.c.

5. An US earthquake response spectra 10^{-5}/year (0.5g) is considered as a 10^{-7} in Sweden. Does this justify exemption from further consideration, due to low yearly frequency for Zr-fire? The SFP at the Swedish plant is calculated with an earthquake 0.1g, see response spectra Figure 1, and found to compily with the Swedish standard design standard (Boverkets Konstruktionsregler 94, BKR94.

6. Have you considered the "second" worst event at plants? (Second to SFP accidents) For example waste handling. At Barsebäck NPP a fire in the bitumen storage is found to be second worst case, although with limited off-site consequence.

(5) 7. Is a gap release considered to give moderate off-site consequences at the time when Zr-fire is no longer a threat?

8. What does "reducing unnecessary regulating burden" mean in practice when it comes to emergency planning ? What kind of reductions are foreseen:

- Man-power on-site and off-site?
- Emergency equipment?
- Communication means?
- Alarm means; notification of personnel and the public?
- Emergency preparedness, plans, KI, EPZ radius ?

9. We also would appreciate if you could send us an electronic copy via E-mail of the following documents from the references:

Sailor, et al., "Severe Accidents in Spent Fuel Pools in Support of Generic Issue 82", NUREG/CR-4982.

"A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants," NUREG/CR-6451, dated August 1997.

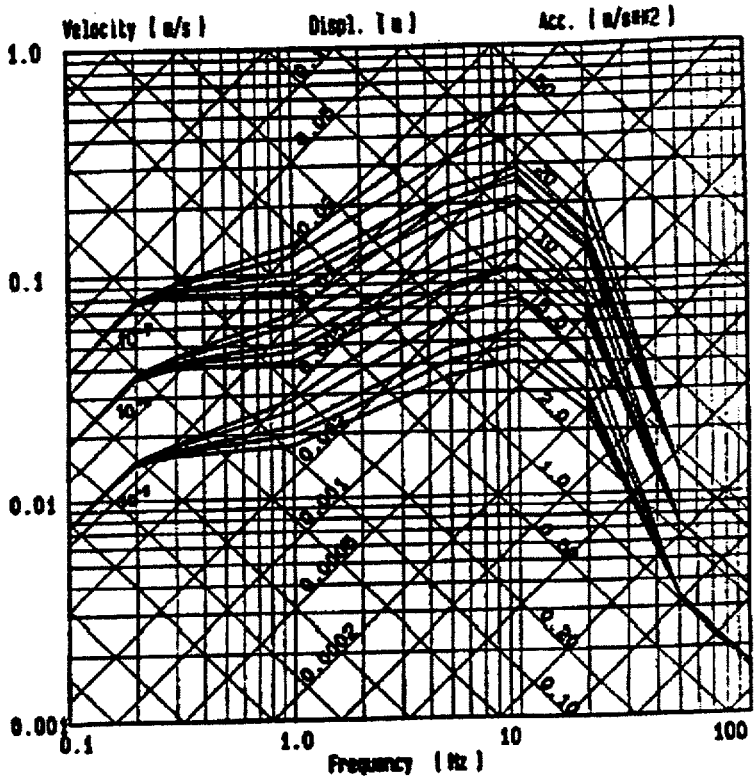

FIGURE 1: Envelope Ground Response Spectra for a (principal) horizontal GM direction, relating to exceedance frequencies 10^{-5}, 10^{-6} and 10^{-7} annual events per site and damping ratios 0.005, 0.02, 0.05, 0.07 and 0.10.

Ref. 10
NEI Public Comments

2. Risk Assessment

a. Methodology: *No Comments*

b. Structural Integrity - Seismic Loads: (see Attachment A).

c. Structural Integrity - Heavy loads

In Section 3.3.6 and footnote 7, the staff mischaracterize the risk of heavy load drops for licensees choosing to do load drop analyses. A successful load drop analysis, by definition, demonstrates that off-site dose consequences are acceptable. Therefore, the risk associated with a heavy load drop that has been analyzed is negligible– i.e., it is not considered for events resulting in consequences that propagate to either a complete loss of inventory (and potential zircalloy fire), or, in license basis terms, fuel pin damage resulting in consequences in excess of Part 100.

Action SPSB

Therefore, for purposes of a risk study, the only heavy loads component of risk is that contributed by a single failure proof crane approach.

d. Structural Integrity - Aircraft Crashes: *No Comments*

e. Structural Integrity – Tornadoes: *No Comments*

3. Criticality

No Comments

4. Consequences Assessment from Zirconium Fire

possible supporting issues

The Consequence Assessment for Zirconium Fires in the NRC draft final study provides the misleading conclusion that there is "about a factor of two reduction in prompt fatalities if the accident occurs after 1 year instead of thirty days." What the study does not note is that the absolute value of fatalities is a couple of orders of magnitude below the numbers for an operating plant. This is not surprising since it is the short-lived nuclides that drive this result. In addition the study does not highlight the fact that the most significant reduction in early fatalities occurs within the first thirty days. Although there is an additional factor of two reductions over the next 11 months, the more significant reduction is in the first month, again since the short-lived nuclides have largely decayed off in this period.

By failing to emphasize the above, the staff's risk study lends misleading support to the idea that a one year waiting period is justified prior to reducing emergency planning requirements. In fact, the risk study does not support this conclusion.

The consequence analyses contained in Appendix A also seem to contradict the staff's conclusion that one year is an appropriate waiting time for emergency planning. Presumably, the primary benefit of off-site emergency preparedness is to reduce prompt fatalities through evacuation. Yet, Case 1 in Appendix 4 which apparently was intended to support that assumption, contradicts this assumption. While there is not sufficient information in Appendix 4 to clearly understand the consequence analyses, Case 1 appears to indicate that evacuation provides no benefit in reducing prompt fatalities.

possible supporting issues

Finally, the staff's study seems to establish the one year delay time based on providing sufficient time for operator response to upset conditions. For instance, in Section 4.3.1, page 34, the staff notes: "This study indicates that a one-year period provides adequate decay time necessary to reduce the pool heat load to a level that would provide sufficient human response time for anticipated transients, and minimize any potential gap release." A true, but again, misleading statement.

Actually, a much shorter delay period supports the same conclusion. For instance, referring to Table 3.1 and subsequent text in Appendix 2, we see that one year after shutdown, the total time available for operator action (time to bulk boiling plus time to boil down) is 133 hours. Performing the same calculation for a six-month delay period (which the staff does not do in the report) reveals 118 hours available for operator action. This is a substantial period of time, which allows the same conclusion that i.e. this study indicates that a six-month period provides adequate decay time necessary to reduce the pool heat load to a level that would provide sufficient human response time.

Thus the risk-informed conclusion that should be drawn from the Consequence Analysis is that the prompt fatalities are very small in comparison to operating reactor accidents, and are sufficiently reduced in the first month after shutdown to support eliminating off-site emergency preparedness. Furthermore, even after a relatively short delay time, there is substantial time for operator action to respond to upset conditions.

On the other hand, there are restrictions on reducing off-site emergency preparedness that are part of the pre-existing license basis of the facility, that have little to do with decommissioning or the risk study, but nonetheless must be satisfied by a licensee in transitioning from operations to decommissioning. Most significant is the one rem off-site dose consequence (the so-called EPA protective action

guideline) that distinguishes between off-site and on-site response. Below one rem, no off-site response is called for.

Independent of spent fuel pool events, there are accidents within a plant's license basis that can generate off-site doses during decommissioning. The dominant event is a fuel handling accident (e.g., dropping a fuel bundle that breeches the integrity of some fuel rods, thereby releases radioactivity). Examination of this event shows that the vast majority of off-site dose is due to iodine, which fairly rapidly decays following fuel offload. In fact, it is straightforward to reanalyze a fuel handling accident to determine the point following shutdown at which the accident offsite dose drops below one rem, thereby establishing the point at which off-site emergency response capability can be eliminated.

5. Seismic Checklist

As a result of stakeholder interactions with NRC in 1999, it was concluded that, in general, spent fuel pools possess substantial capacity beyond their design basis but that variations in seismic capacity existed due to plant specific details. The industry developed a seismic screening checklist to identify and evaluate specific seismic characteristics. The checklist has been incorporated into the bases for the NRC evaluation. Successful application of the revised seismic checklist provides a high degree of assurance that the Spent Fuel Pool (SFP), High Confidence Low Probability of Failure (HCLPF) is 0.5g or greater. In no Central or Eastern United States licensing proceeding has there been compelling data to require design to an earthquake of a magnitude which would challenge the seismic capacity of an SFP that satisfies the seismic checklist. The industry is committed to completion of the requirements of the checklist, including a thorough spent fuel pool walkdown.

6. NEI Commitment Letter.

NEI reiterates that the industry will perform decommissioning with the same high level of commitment to safety as during operation of the plants. To that end, industry has made several commitments for procedures and equipment, which would reduce the probability, and consequence of spent fuel pool events during decommissioning. These commitments have been incorporated into the bases for the NRC evaluation and the industry stands ready to fulfill them.

Hubbard
Assignment copy

4/12/00 0245 PM

April 10, 2000
Ser. # PJA - 9

From: Peter James Atherton
P.O. Box 2337
D.C. 20013
Pgr. # 202-424-2000

To: R. Dudley for
Office of Amin
U.S.N.R.C.

Subj. Comments on "Draft Final Technical Study of SFP Accident Risk at Decommissioned NPP's"

These informal and incomplete comments are provided to NRC for NRC's review and consideration. The time period of the 2/22/00 release date to the 4/7/00 due date for comments is suggested to be insufficient time for complete comments, especially when I am unable to devote a full time effort to the review.

Projects Accordingly, I respectfully seek another three (3) months from this date to more formal and completely respond.

However, I provide my comments without access to any of the references in the study. The additional time requested permits me the opportunity to obtain and/or review the references.

My involvement during the 1970's as an NRC employee with the Maine Yankee NPP and more recently with the allegation review process and followup investigations by the OIG has required me to stay with Maine Yankee during the decommissioning process both for personal reasons and at the request of stakeholders. I attended most of the meetings. These are my first written comments. However, much of what I have said was transcribed from the meetings.

Among the many issues that I talked abut were seismic concerns; criticality concerns and aging questions. Although earthquake and fuel reactivity issues are addressed from an engineering investigative perspective, aging has not been.

Comments on Policy.

Projects 1. It is suggested that references used in a study seeking public comment be made available to to those interested members of the public at no cost. Some members of the public wanting to comment do not have these references readily available, especially when the public is located out of state.

Projects 2. Possible conflict of interests by the NRC should be identified and addressed. For example, when Nuclear PP owners sue DOE on fuel storage matters, NRC (being part of the same govt. as DOE) might appear to have a motivation to rule SFP matters in a manner to minimize the lawsuits' impact at the expense of public safety.

Projects SPSB

3. The NRC should identify differing professional opinions expressed and their resolution as it affects this study. For instance, on 5/6/75, Dr. S. H. Hanauer in a memo to G. Arlotto is quoted to say "you can make probabilistic numbers prove anything, by which I mean that probabilistic numbers 'prove' nothing." Barrett Rubin

4. The basis for the heavy reliance upon a risk informed approach to this study fails to account for realistic probabilistic numbers. The probability of the happening of accidents as the event occurred should be calculated so that a more realistic probabilistic perspective is determined. For example, what is the probability that the TMI-2 and Chernobyl accidents would have occurred. This number properly calculated could form a more realistic figure from which to apply "highly unlikely" and "not credible" terminology. At this time the RG 1.174 criteria of 1 x 10^{-5}/yr frequency used for a zirc fire has no documented experimental basis or actual happening to support its use for zirc fires. FG 1.174 was not in part written for decommissioned nuclear power plants. Its application is for operating reactors, which have a more conservative defense in depth strategy than the design of SFPs

SPSB

5. The NRC should perform rigorous engineering analysis of the effects of aging*[1] upon the spent fuel pool and its associated structures and equipment. Most SFPs were never designed to be quasi-permanent fuel storage facilities. Because there is as-yet no permanent place to store used fuel, SFPs have had to accept more fuel than they were original designed to hold. To allow SFPS to continue to store spent fuel for as yet an undetermined period of time requires, I suggest, a comprehensive look at aging.

DE

Comments on Seismic Designs.

DE

1. A significant seismic event which damages and drains the SFP is also likely to wreak havoc upon the local infrastructure. How has NRC considered the availability of local resources as identified by IDC #2, #3, and #4? Should the local infrastructure be destroyed?

2. To my knowledge, not every spent fuel pool was designed to the seismic criteria in use today. The use of works like "robust" does not necessarily address seismic qualifications. The NRC should identify all spent fuel pools that were not initially designed to seismic criteria and explain their level of qualification, including the SF racks.

3. Not all PWR building housing spent fuel are seismically qualified. The NRC should perform a worst case analysis of the result of a seismic event which collapses the spent fuel pool building, and/or drains the pool and/or damages the spent fuel. Both criticality and zirc fires are of concerns. The nine initiating events listed at p. 11 which could occur concurrent with the earthquake should also be considered if the events contribute to the worst case scenario.

4. The NEI seismic checklist requires a seismic engineer to review drawings in addition to conducting a walkdown of the SFP. It has been my experience that many electrical drawings of NAP's do not reflect the existing plant electrical installation. How is the seismic

[1] * Aging could include degradation, failure, etc. of structures & equipment.

engineer going to verify drawings to the existing S&P building and pool if much of the pool is inaccessible? For instance, how does he verify concrete degradation under the steel liner? The NRC should require that specific areas be inspected and that these areas be accessible. If these areas are not accessible, then the checklist is not complete and susceptibility to sumac activity remains a concern.

5. The NRC should specify why it is not cost effective to perform a plant-specific seismic evaluation for each spent fuel pool and what impact this has on safety. Because there are so many differently designed spent fuel pools, it is difficult to perceive how a generic approach could be acceptable without assembling a list of similar &/or identical designs and performing a seismic evaluation of the various groups which are assembled. Specific seismic evaluations for each plant or groups of similar/identical plants should be considered

Comments on spent Fuel Pools (SFPs).

SPLB

1. The NRC should identify all spent fuel pools that leak. Degradation of the lines and concrete should be investigated. The leaks should be sealed.

2. The NRC should determine the qualifications and degradation of spent fuel racks.

3. The proper methods of extinguishing a possible zirconium fire needs to be addressed.

Comments on Failure Rates.

SPSB
Glenn
Gareth
Mike

It is possible to obtain reliable failure rates for safety-related equipment. However non-safety related equipment failure rate information is not as simple for the NRC to obtain. Standards for manufacture, quality assurance, etc. may not be known. Requirements to report non-safety related failures of equipment may not be properly documented. Hence non-safety-related equipment failure rates may not be accurate. Inputs of failure rates of non-safety related equipment to a risk-informed PRA could adversely affect accuracy. NRC should determine which failure rates used in the risk-informed process are reliable and which are not and the results should be included in the study. I am not aware of any older NPPs that have safety related equipment in the SFP cooling, instrumentation or other areas. Reliable failure rates are questionable.

SPLB

My recollection of the 7/16/99 work/study group meeting between the NRC and industry is that industry verbally agreed through Mr. Meisner of Maine Yankee to install a single failure proof crane system using safety grade electrical equipment. What happened to this commitment?

Comments on Terrorism.

SPLB
Safeguards

This draft report omitted terrorist acts of sabotage and vandalism. A successful terror-ist event could endanger public health and safety. Emergency evacuation plans should be prepared with this consideration of terrorism.

Safeguards SPLB coordinator

Comments on Criticality.

SRXB 1. NRC should identify the scenario where a steam explosion is possible because of a severe criticality event and the basis upon which the probability was determined to be "highly unlikely."

SRXB 2. A recent telephone conference call on criticality has been the basis of a request for access to various reference documents. In conclusion with policy comment #1, NRC should permit free and easy access to references. I do not anticipate a flood of requests for technical references. The subject matter should be of interest to technically educated people.

possible expanding issue

RES/ SRXB Load 3. ~~The NRC should identify all radioactivity in the spent fuel pool and that capable of being dispersed in an accident~~ (beyond that on p. A3-11 to A3-13).

Comments on Operator Action.

SPSB Glenn 1. Because spent fuel pool accidents require operator manual action the NRC should identify the number of operators assigned to each shift and how these operators are protected so that their availability is "guaranteed" in the event of an accident.

Gareth 2. Standing watch over a SFP "graveyard" cannot be the most exciting job available. What measures are taken to minimize boredom and maintain alertness?

3. Accidents in operating reactors are designed to be mitigated by automatic safety systems. Operator error has aggravated many of these accidents. What measures are in play to minimize operator error in a postulated spent fuel pool accident?

General Comments.

Glenn 1. Spent fuel pools in PWRs do not have a containment. Yet the worst case accident scenario parallels that of an operating reactor with respect to both people and property damage. The NRC should review the justification for containments in operating reactors and explain why a containment would or would not be advisable over a SFP.

Glenn 2. To the extent possible, experimental validation of risk informed results should be addressed.

~~SPSB~~ S. Fraguards 3. Because terrorist acts are not specifically addressed, it is suggested that any approach towards safety that NRC adopts should err on the side of safety wherever there is a choice.

Projects 4. It is suggested that these interim regul-ations be time limited, to be reviewed again at some future date.

PJA

FAX to 301-415-2002
alt fax #.

Ref. 11

Consequences
Criteria
Fires
Fire
Seismic
uncertainties

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555-0001

April 13, 2000

The Honorable Richard A. Meserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Chairman Meserve:

SUBJECT: DRAFT FINAL TECHNICAL STUDY OF SPENT FUEL POOL ACCIDENT RISK AT DECOMMISSIONING NUCLEAR POWER PLANTS

During the 471st meeting of the Advisory Committee on Reactor Safeguards, April 5-7, 2000, we met with representatives of the NRC staff and discussed the subject document. We also had the benefit of the documents referenced, which include the available stakeholders comments. This report is in response to the Commission's request in the Staff Requirements Memorandum dated December 21, 1999, that the ACRS perform a technical review of the validity of the draft study and risk objectives.

BACKGROUND

Decommissioning plants are subject to many of the same regulatory requirements as operating nuclear plants. Because of the expectation that the risk will be lower at decommissioning plants, particularly as time progresses to allow additional decay of fission products, some of these requirements may be inappropriate. Exemptions from the regulations are frequently requested by licensees after a nuclear power plant is permanently shut down. To increase the efficiency and effectiveness of decommissioning regulations, the staff has engaged in rulemaking activities that would reduce the need to routinely process exemptions. The staff has undertaken the technical study and risk analysis discussed here to provide a firm technical basis for rulemaking concerning several exemption issues.

In the draft study the staff has concluded that, provided certain industry decommissioning commitments are implemented at the plants, after one year of decay time the risk associated with spent fuel pool fires is sufficiently low that emergency planning requirements can be significantly reduced. It also concluded that after five years the risk of zirconium fires is negligible even if the fuel is uncovered and that requirements intended to ensure spent fuel cooling can be reduced.

RECOMMENDATIONS

1. The integrated rulemaking on decommissioning should be put on hold until the staff provides technical justification for the proposed acceptance criterion for fuel uncovery frequency. In particular, the staff needs to incorporate the effects of enhanced release of ruthenium under air-oxidation conditions and the impact of the MELCOR Accident

Consequence Code System (MACCS) code assumptions on plume-related parameters in view of the results of expert elicitation.

2. The technical basis underlying the zirconium-air interactions and the criteria for ignition needs to be strengthened. In particular, the potential impact of zirconium-hydrides in high burnup fuel and the susceptibility of the clad to breakaway oxidation need to be addressed.

3. Uncertainties in the risk assessment need to be quantified and made part of the decisionmaking process.

DISCUSSION

The staff's conclusion that the risk after one year of decay time is sufficiently low that emergency planning requirements can be reduced is based partially on the assessed value of fuel uncovery frequency (3.4×10^{-6}/yr) being less than the Regulatory Guide 1.174 large, early release frequency (LERF) acceptance value (1×10^{-5}/yr). This LERF risk-acceptance value was derived to be a surrogate for the Safety Goal early fatality quantitative health objectives (QHO) *for operating reactors.* The derivation from the QHO is based, however, on the fission product releases that occur under severe accident conditions which are driven by steam oxidation of the zircaloy and the fuel. These releases include only insignificant amounts of ruthenium. Under air-oxidation conditions of spent fuel fires, significant data indicate much enhanced releases of ruthenium as the very volatile oxide. Indications are that, under air oxidation conditions, the release fractions of ruthenium may be equivalent to those for iodine and cesium. In the accident at Chernobyl significant releases of ruthenium were observed and attributed to the interactions of fuel with air.

possible supporting issue

These findings have significant implications. The ruthenium inventory in spent fuel is substantial. Ruthenium has a biological effectiveness equivalent to that of iodine-131 and has a relatively long half-life. If there are significant releases of ruthenium, the Regulatory Guide 1.174 LERF value may not be an appropriate surrogate for the prompt fatality QHO. In addition, because of the relatively long half-life of ruthenium-106, it is likely that the early fatality QHO would no longer be the controlling consequence.

(1) In response to our concerns about the effects of substantial ruthenium release, the staff has made additional MACCS calculations in which it assumed 100 percent release of the ruthenium inventory. For a one-year decay time with no evacuation, the prompt fatalities increased by two orders of magnitude over those in the report which did not include ruthenium release, the societal dose doubled and the cancer fatalities increased four-fold.

(2) Our concern is not just with ruthenium. We are concerned with the appropriateness of the entire source term used in the study. There is a known tendency for uranium dioxide in air to decrepitate into fine particles. The decrepitation is caused by lattice strains produced as the dioxide reacts to form U_3O_8. This decrepitation is a bane of thermogravimetric studies of air oxidation of uranium dioxide since it can cause fine particles to be entrained in the flowing air of the apparatus. This suggests that decrepitating fuel would be readily entrained in vigorous natural convection flows produced in an accident at a spent fuel pool. The decrepitation process provides a low-temperature, mechanical, release mechanism for even very refractory

(2) radionuclides. The staff did consider the possibility that fuel fines could be released from fuel with ruptured cladding. It did not, however, believe these fuel fines could escape the plant site. Nevertheless, the staff considered the effect of a 6x10^{-6} release fraction of fines. This minuscule release fraction did not significantly affect the calculated findings. There is no reason to think that such a low release fraction would be encountered with decrepitating fuel.

(3) Consequences of accidents involving a spent fuel pool were analyzed using the MACCS code. The staff has completed an expert opinion elicitation regarding the uncertainties associated with many of the critical features of the MACCS code. The findings of this elicitation seem not to have been considered in the analyses of the spent fuel pool accident. One of the uncertainties in MACCS identified by the experts is associated with the spread of the radioactive plume from a power plant site. The spread expected by the experts is much larger than what is taken as the default spread in the MACCS calculations. There is no indication that the staff took this finding into account in preparing the consequence analyses. In addition, the initial plume energy assumed in the MACCS calculations, which determines the extent of plume rise, was taken to be the same as that of a reactor accident rather than one appropriate for a zirconium fire. We suspect, therefore, that the consequences found by the staff tend to overestimate prompt fatalities and underestimate land contamination and latent fatalities just because of the narrow plume used in the MACCS calculations and the assumed default plume energy.

(4) The staff needs to review the air oxidation fission products release data from Oak Ridge National Laboratory and from Canada that found large releases of cesium, tellurium, and ruthenium at temperatures lower than 1000 °C. Based on these release values for ruthenium, and incorporating uncertainties in the MACCS plume dispersal models, the consequence analyses should be redone.

Based on the results of this reevaluation of the consequences, the staff should determine an appropriate LERF for spent fuel fires that properly reflects the prompt fatality QHO and the potential for land contamination and latent fatalities associated with spent fuel pool fires.

In developing risk-acceptance criteria associated with spent fuel fires, the staff should also keep in mind such factors as the relatively small number of decommissioning plants to be expected at any given time and the short time at which they are vulnerable to a spent fuel pool fire.

We also have difficulties with the analysis performed to determine the time at which the risk of zirconium fires becomes negligible. In previous interactions with the staff on this study, we indicated that there were issues associated with the formation of zirconium-hydride precipitates in the cladding of fuel especially when that fuel has been taken to high burnups. Many metal hydrides are spontaneously combustible in air. Spontaneous combustion of zirconium-hydrides would render moot the issue of "ignition" temperature that is the focus of the staff analysis of air interactions with exposed cladding. The staff has neglected the issue of hydrides and suggested that uncertainties in the critical decay heat times and the critical temperatures can be found by sensitivity analyses. Sensitivity analyses with models lacking essential physics and chemistry would be of little use in determining the real uncertainties.

The staff analysis of the interaction of air with cladding has relied on relatively geriatric work. Much more is known now about air interactions with cladding. This greater knowledge has come in no small part from studies being performed as part of a cooperative international

program (PHEBUS FP) in which NRC is a partner. Among the findings of this work is that nitrogen from air depleted of oxygen will interact exothermically with zircaloy cladding. The reaction of zirconium with nitrogen is exothermic by about 86,000 calories per mole of zirconium reacted. Because the heat required to raise zirconium from room temperature to melting is only about 18,000 calories per mole, the reaction enthalpy with nitrogen is ample. In air-starved conditions, the reaction of air with zirconium produces a duplex film in which the outer layer is zirconium dioxide (ZrO_2) and the inner layer is the crystallographically different compound zirconium nitride (ZrN). The microscopic strains within this duplex layer can lead to exfoliation of the protective oxide layer and reaction rates that deviate from parabolic rates. These findings may well explain the well-known tendency for zirconium to undergo breakaway oxidation in air whereas no such tendency is encountered in either steam or in pure oxygen. Because of these findings, we do not accept the staff's claim that it has performed "bounding" calculations of the heatup of Zircaloy clad fuel even when it neglects heat losses.

The staff focuses its analysis of the reactions of gases with fuel cladding on a quantity they call an "ignition temperature." The claim is that this is the temperature of self-sustained reaction of gas with the clad. Gases will react with the cladding at all temperatures. In fact, at temperatures well below the "conservative ignition temperature" identified by the staff, air and oxygen will react with the cladding quite smoothly and at rates sufficient to measure. Data in these temperature ranges well below the "ignition" temperature form much of the basis for the correlations of parabolic reaction rates with temperature. We believe that the staff should look for a condition such that the increase with temperature of the heat liberation rate by the reaction of gas with the clad exceeds the increase with temperature of the rate of heat losses by radiation and convection. Finding this condition requires that there be high quality analyses of the heat losses and that the heat of reaction be properly calculated. Since staff has neglected any reaction with nitrogen and did not consider breakaway oxidation (causes for the deviations from parabolic reaction rates), it has not made an appropriate analysis to find this "ignition temperature."

In fact, the search for the ignition temperature may be the wrong criterion for the analysis. The staff should also be looking for the point at which cladding ruptures and fission products can be released. Some fraction of the cladding may be ruptured before any exposure of the fuel to air occurs. Even discounting this, one still arrives at much lower temperature criteria for concern over the possible release of radionuclides.

There are other flaws in the material interactions analyses performed as part of the study. For instance, in examining the effects of aluminum melting, the staff seems to not recognize that there is a very exothermic intermetallic reaction between molten aluminum and stainless steel. Compound formation in the Al-Zr system suggests a strong intermetallic reaction of molten aluminum with fuel cladding as well. The staff focuses on eutectic formations when, in fact, intermetallic reactions are more germane to the issues at hand.

We are concerned about the conservative treatment of seismic issues. Risk-informed decisionmaking regarding the spent fuel pool fire issues should use realistic analysis, including an uncertainty assessment.

Because the accident analysis is dominated by sequences involving human errors and seismic events which involve large uncertainties, the absence of an uncertainty analysis of the

frequencies of accidents is unacceptable. The study is inadequate until there is a defensible uncertainty analysis.

The risk posed by fuel uncovery in spent fuel pools for decommissioning plants may indeed be low, however, the technical shortcomings of this study are significant and sufficient for us to recommend that rulemaking be put on hold until the inadequacies discussed herein are addressed by the staff.

Sincerely

Dana A. Powers
Chairman

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