From: Diane Jackson NLR
To: Glenn Kelly, Goutam Bagchi NLR
Date: Thursday, February 08, 2001 03:36 PM
Subject: Brian Sheron information for Commission meeting

Goutam and Glenn -

Brian Sheron has asked for more information on Robinson being a siesmic outlier.

From a conversation with Glenn (how talked with Goutam), I have put together a sheet on background information but it is incomplete. Please review the seismic page and add any additional or clarifying information that you can.

Goutam, in particular, can you add information on the other independent assessment that concluded that Robinson was a high seismic hazard? Who did it? when? is there a report, if so what is the name?

Glenn had mentioned that Robinson being an outlier may be influenced by the Charleston earthquake, however, why did EPRI not have the same influence?

Your thoughts and words would be appreciated.

Thanks -
Diane

CC: GTH

B/33

3.2 Characteristics of SFP Design and Operations for a Decommissioning Plant

Based on information gathered from the site visits and interactions with NEI and other stakeholders, the staff modeled the spent fuel pool cooling and cleaning (SFPC) system (see Figure 3.1).

- ☐ 2 redundent cooling pumps
- ☐ filtration subsystem
- ☐ ultimate heat sink is air
- ☐ manually operated makeup system (with a limited volumetric flow rate) supplements the small losses due to evaporation
- ☐ Back up makeup can use the firewater system, if needed. Two firewater pumps, one motor-driven (electric) and one diesel-driven, provide firewater in the SFP area. There is a firewater hose station in the SFP area. The firewater pumps are in a separate structure.

Based upon information obtained during the site visits and discussions with decommissioning
plant personnel during those visits, the staff also made the following assumptions that are
believed to be representative of a typical decommissioning facility:

- The SFP cooling design, including instrumentation, is at least as capable as that assumed in the risk assessment. Licensees have at least one motor-driven and one diesel-driven fire pump capable of delivering inventory to the SFP (SDA #1, Table 4.2-2).

- The makeup capacity (with respect to volumetric flow) is assumed to be as follows:

  Makeup pump: 20 – 30 gpm
  Firewater pump: 100 – 200 gpm
  Fire engine: 100 – 250 gpm (100 gpm, for hose: 1½-in., 250 gpm for 2 1/2-in. hose)

- For the larger loss-of-coolant-inventory accidents, water addition through the makeup pumps does not successfully mitigate the loss of the inventory event unless the location of inventory loss is isolated.

- The SFP fuel handlers perform walkdowns of the SFP area once per shift (8- to 12-hour shifts). A different crew member works the next shift. The SFP water is clear and the pool level is observable via a measuring stick in the pool to alert fuel handlers to level changes.

- Plants do not have drain paths in their SFPs that could lower the pool level (by draining, suction, or pumping) more that 15 feet below the normal pool operating level, and licensees must initiate recovery using offsite sources.

Based upon the results of the June 1999 preliminary risk analysis and the associated sensitivity
cases, it became clear that many of the risk sequences were quite sensitive to the performance
of the SFP operating staff in identifying and responding to off-normal conditions. This is because the remaining systems of the SFP are relatively simple, with manual rather than
automatic initiation of backups or realignments. Therefore, in scenarios such as loss of cooling
or inventory loss, the fuel handler's responses to diagnose the failures and bring any available
resources (public or private) to bear is fundamental for ensuring that the fuel assemblies remain
cooled and a zirconium fire is prevented.

As part of its technical evaluations, the staff assembled a small panel of experts to identify the
attributes necessary to achieving very high levels of human reliability for responding to potential accident scenarios in a decommissioning plant SFP. (These attributes and the human reliability analysis (HRA) methodology used are discussed in Section 3.2 of Appendix 2A.)

Upon considering the sensitivities identified in the staff's preliminary study and to reflect actual operating practices at decommissioning facilities, the nuclear industry, through NEI, made important commitments, which are reflected in the staff's updated risk assessment.

Additional important operational and design assumptions made by the staff in the risk estimates developed in this study are designated as SDAs and are discussed in later sections of this study.

Figure 3.1 Assumed Spent Fuel Pool Cooling System

Industry Decommissioning Commitments (IDCs)

IDC #1 Cask drop analyses will be performed or single failure-proof cranes will be in use for handling of heavy loads (i.e., phase II of NUREG-0612 will be implemented).

IDC #2 Procedures and training of personnel will be in place to ensure that onsite and offsite resources can be brought to bear during an event.

IDC #3 Procedures will be in place to establish communication between onsite and offsite organizations during severe weather and seismic events.

IDC #4 An offsite resource plan will be developed which will include access to portable pumps and emergency power to supplement onsite resources. The plan wouldprincipally identify organizations or suppliers where offsite resources could be obtained in a timely manner.

IDC #5 Spent fuel pool instrumentation will include readouts and alarms in the control room (or where personnel are stationed) for spent fuel pool temperature, water level, and area radiation levels.

IDC #6 Spent fuel pool seals that could cause leakage leading to fuel uncovery in the event of seal failure shall be self limiting to leakage or otherwise engineered so that drainage cannot occur.

IDC #7 Procedures or administrative controls to reduce the likelihood of rapid draindown events will include (1) prohibitions on the use of pumps that lack adequate siphon protection or (2) controls for pump suction and discharge points. The functionality of anti-siphon devices will be periodically verified.

IDC #8 An onsite restoration plan will be in place to provide repair of the spent fuel pool cooling systems or to provide access for makeup water to the spent fuel pool. The plan will provide for remote alignment of the makeup source to the spent fuel pool without requiring entry to the refuel floor.

IDC #9 Procedures will be in place to control spent fuel pool operations that have the potential to rapidly decrease spent fuel pool inventory. These administrative controls may require additional operations or management review, management physical presence for designated operations or administrative limitations such as restrictions on heavy load movements.

IDC #10 Routine testing of the alternative fuel pool makeup system components will be performed and administrative controls for equipment out of service will be implemented to provide added assurance that the components would be available, if needed.

Staff Decommissioning Assumptions (SDAs)

SDA #1 Licensee's SFP cooling design will be at least as capable as that assumed in the risk assessment, including instrumentation. Licensees will have at least one motor-driven and one diesel-driven fire pump capable of delivering inventory to the SFP.

SDA # 2 Walk-downs of SFP systems will be performed at least once per shift by the operators. Procedures will be developed for and employed by the operators to provide guidance on the capability and availability of onsite and offsite inventory makeup sources and time available to initiate these sources for various loss of cooling or inventory events.

SDA # 3 Control room instrumentation that monitors SFP temperature and water level will directly measure the parameters involved. Level instrumentation will provide alarms at levels associated with calling in offsite resources and with declaring a general emergency.

SDA # 4 Licensee determines that there are no drain paths in the SFP that could lower the pool level (by draining, suction, or pumping) more than 15 feet below the normal pool operating level and that licensee must initiate recovery using offsite sources.

SDA # 5 Load Drop consequence analyses will be performed for facilities with non-single failure-proof systems. The analyses and any mitigative actions necessary to preclude catastrophic damage to the SFP that would lead to a rapid pool draining would be sufficient to demonstrate that there is high confidence in the facilities ability to withstand a heavy load drop.

SDA # 6 Each decommissioning plant will successfully complete the seismic checklist provided in Appendix2B to this study. If the checklist cannot be successfully completed, the decommissioning plant will perform a plant specific seismic risk assessment of the SFP and demonstrate that SFP seismically induced structural failure and rapid loss of inventory is less than the generic bounding estimates provided in this study (<1x10 -5 per year including non-seismic events).

SDA # 7 Licensees will maintain a program to provide surveillance and monitoring of Boraflex in high-density spent fuel racks until such time as spent fuel is no longer stored in these high-density racks.

David Lochbaum / Union of Concerned Scientist comments and staff responses
in October 2000 report

<u>Comment #10</u>: Experience at nuclear power plants demonstrates that safety problems are not caused by workers making mistakes or by not following procedures. Problems are caused by bad management. [UCS; workshop; p 91]

<u>Response</u>: The staff agrees that utility safety culture and utility oversight/expectations in the day-to-day operations of a facility are important contributors to either a well run plant or a poorly run one. The staff decommissioning assumptions and industry commitments will help insure that proper attention is given to spent fuel pool status, procedures are developed that guide fuel handlers in the event of a spent fuel pool accident, communications are established between on-site and off-site organizations, and cask drop analyses are performed or a single failure

proof crane is used for handling very heavy loads. These staff assumptions and industry commitments are discussed in Sections 3 and 4.

Comment #11: Experience at nuclear power plants shows that multiple shifts can make the same error and not recognize it for a long time. With watching the pool being their major responsibility, a fuel handler's life would be very tedious and boredom would set in. This should result in a poorer response by the fuel handler in the event of an accident. An example of this is the recent Browns Ferry event. [GUNTER; workshop p 114; and UCS]

Response: The NRC, through the "Policy on Factors Causing Fatigue of Operating Personnel at Nuclear Reactors" provides guidelines on working hours that were consistent with the objective of ensuring that the mental alertness and decision-making abilities of plant staff were not significantly degraded by fatigue. The staff shares the commenter's concern that operator boredom and their ability to maintain alertness while standing watch may contribute to fatigue-induced impairment of personnel and thereby increase the likelihood of personnel errors. For this study, our modeling and quantification of SFP risk includes consideration of multiple shift turnovers and the chance that shift after shift makes the same mistake. However, for almost all postulated SFP accidents, there is a very long time available to the fuel handlers to discover and recover from the existence of a problem in the spent fuel pool or its support systems. The staff believes that the commitments made by the industry and the NRC's staff decommissioning assumptions provide a basis for reducing the chances of multiple shift errors to the point where they do not contribute significantly to the overall risk of spent fuel pool operation (See Sections 3 and 4). The rest of the accidents (i.e., seismic and heavy load drop), which progress rapidly, are assumed to proceed independent of operator intervention once the accident has occurred because the SFP is assumed to drain very rapidly.

Comment #14: NRC should set guidelines on how often fuel handlers make their rounds at decommissioning facilities. This would help assure operator attentiveness. [UCS; workshop p 186]

Response: The staff agrees that, if fuel handlers make the rounds of the SFP and its equipment on a frequent basis, the probability of the handlers detecting problems early is greatly enhanced. To this end, SDA #2 states in part that walk-downs of the SFP systems will be performed at least once per shift by the fuel handlers. The staff expects that these assumptions will be translated into requirements or industry guidance during the rulemaking process.

Comments #18 and 19: (A) What is the generic frequency of events leading to zirconium fires at decommissioning plants before the implementation of industry commitments and staff assumptions? (B) This question is relevant to operating plants. [UCS; 3/15/00 UCS letter p 2]

Response: The staff did not calculate a generic frequency of events without the implementation of industry commitments and staff assumptions. Risk assessments are performed as realistic as possible. As such, the analysis for this study reflects practices already in place. The staff visited four decommissioning sites as part of the preparation for developing the risk assessment of decommissioning spent fuel pools. The insights from those visits include that the facilities appeared to have been staffed by well trained and knowledgeable individuals with significant nuclear power plant experience. Procedures were in place for dealing with routine losses of inventory. Fuel handlers appeared to know whom to contact off-site if difficulties arose with the SFP. The staff recognized that these attributes were not required by NRC regulations nor suggested in NRC guidance for decommissioning sites. The IDCs and SDAs are an attempt to increase the assurance that plant personnel will continue to be knowledgeable of off-site resources and have good procedures available to them.

This study does not reflect the risk at operating plants. As with the practices discussed above, this study reflects the support systems and staffing generally found at decommissioning plants; which are different than at operating plants. For example, the spent fuel pool cooling and makeup systems at decommissioning plants are generally replaced smaller capacity systems to match the reduced decay heat level of the spent fuel. The staff believes that a direct comparison of this risk study on decommissioning plants can not be made to operating plants. However, the staff is sensitive to possible implications to operating plants.

Comment #43: A commenter stated that Industry Decommissioning Commitment #5 should be revised to require direct measurement of SFP temperature and water level. [UCS; 3/15/00 letter]

Response: The staff agrees; SDA #3 calls for direct measurement of SFP temperature and water level.

Comment #82: A commenter asked about calculations for radiation dose experienced by members of the fire brigade responding to resin fires. [UCS; 3/15/00 UCS letter]

Response: Existing regulatory requirements address the need for on-site worker radiation protection and emergency plans to consider protective actions and a means for controlling exposures in an emergency for emergency workers as well as the public. For example, the regulatory requirements for emergency worker protective actions and exposure control are found in 10 CFR 50.47(b)(10) and 10 CFR 50.47(b)(11). Each site has established procedures and training for the protection of workers responding to emergency situations. Generally, these procedures include the consideration of radiological conditions when responding to events. Calculations for occupational exposure for emergency workers would be consistent with the EPA Emergency Worker and Lifesaving Activity Protection Action Guide.

Comments #83 and 84: (A) Discuss protection of plant workers, particularly for less severe accidents such as pool uncovery without a zirconium fire. [IOLB; UCS; workshop p 91] (B) The draft report should be revised to include credible hazards to plant workers at permanently closed plants.[UCS; 3/15/00 UCS letter p 2]

Response: This technical study was limited to accidents involving the draining a decommissioning plant spent fuel pool. For on-site hazards, the staff believes that existing regulatory requirements adequately address the need for emergency plans to consider protective actions and a means for controlling exposures in an emergency for emergency workers. For example, 10 CFR Part 20 establishes standards for radiation protection for ons-ite workers and the public, and 10 CFR 50.47(b)(10) and 10 CFR 50.47(b)(11) establish protective actions and exposure control for emergency workers. Nuclear power plant licensees are also subject to regulations for byproduct material under 10 CFR Part 30. Emergency plans under Section 30.32 require identification of accidents and means for mitigation, include the protection of on-site workers. Additionally, OSHA and NRC regulations require safety training and education, including safe handling and use of poisons, caustics, flammable liquids, gases and toxic materials; radiation protection; and occupational safety.

Although this study does not directly assess accidents or hazards that could occur to plant personnel, measures for worker safety were included. For example, IDC #8 calls for remote alignment of the water makeup source to the SFP without requiring entry to the refueling floor, which prevents workers and other accident responders from entering a potential radiation area.

Comment #85: What will the NRC staff do to protect plant workers and the public from spent fuel pool risks at permanently closed plants and operating plants before the industry commitments and staff assumptions are implemented? [UCS; 3/15/00 UCS letter p 2]

Response: The analysis for this study reflects practices already in place. The staff visited four decommissioning sites as part of the preparation for developing the risk assessment of decommissioning spent fuel pools. The insights from those visits include that the facilities appeared to have been staffed by well trained and knowledgeable individuals with significant nuclear power plant experience. Procedures were in place for dealing with routine losses of inventory. Fuel handlers appeared to know whom to contact off-site if difficulties arose with the SFP. The staff recognized that these attributes were not required by any NRC regulations nor suggested in any NRC guidance for decommissioning sites. The IDCs and SDAs are an attempt to increase the assurance that plant personnel will continue to be knowledgeable of off-site resources and have good procedures available to them.

The staff believes that current worker safety regulations adequately protect workers. The regulations for the protection of workers are the same at decommissioning plants as at operating plants, such as 10 CFR 20 for standards for protection against radiation. Several other comments in this appendix also address worker safety regulations.

Comments #92 and 93: (A) It is difficult to figure out how this effort fits into the overall big picture of what the NRC is doing on decommissioning. [LOCHBAUM/UCS; workshop p 87] (B) A commenter asked the staff to "look at all of the activities that happen during decommissioning when developing regulations, not just a narrow view of the spent fuel pool." [SHADIS; workshop p 262]

Response: The focus of the decommissioning spent fuel pool risk study was intentionally limited to address potential severe accidents associated only with spent fuel. An additional rulemaking effort, termed the regulatory improvement initiative, is planned by the NRC and will include a comprehensive look at all decommissioning regulations to determine if any additional changes are required. An overall assessment of decommissioning issues and other activities that take place at decommissioning sites will be addressed during this subsequent effort.

Comment #105: In a letter to the NRC, a commenter stated that 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. [UCS; 3/15/00 letter p 1]

Response: At the July 15-16, 1999 public workshop on decommissioning spent fuel pool risk, the public stakeholder raised a concern that the NRC evaluate potential hazards that decommissioning accidents could impose upon plant workers. When the NRC issued its final draft report, the stakeholder's issue was not specifically addressed in the comment evaluation section. However, the NRC had received an industry decommissioning commitment that licensees would provide a remote method of adding water to spent fuel pools that would reduce potential risk to plant workers and which resulted from the issue the stakeholder had raised. The NRC seriously considers public comments received on all issues within its jurisdiction. In this case, the staff regrets the appearance that a public comment had been ignored. In order to ensure that proper consideration was given to all stakeholder comments, the NRC staff reviewed written comments received and examined transcripts of public meetings to ensure that all issues had been addressed.

High Density and Low Density spent fuel racks:

<u>Low Density racks</u>:
- criticality control is provided by spacing between assemblies
- example, 21-inch center-to-center spacing, PWR
- PWR: walls of the SF racks are open lattice, however some could have solid walls
- BWRs: channel boxes are kept around assemblies in SFP

<u>High Density racks</u>:
- criticality control is provided by neutron shielding plates (e.g., boraflex)
- walls of the SF racks are solid and form boxes around the assemblies
- example, 6 - 14 inch center-to-center spacing
- ~5 inch diameter hole in bottom of rack for water or air flow

- Older high density racks have spaces between the boxes around the assemblies
- Current high density racks have no space between boxes and actually share a wall with the next assembly

Generic Issue - 82:

GI-82 examined SFP storage accidents for 2 reasons:
(1) New use of high density spent fuel storage racks because of decision not to reprocess fuel
(2) Laboratory studies identified possibility of zirconium fire

Concluded to take "no action" option for several reasons:
(1) did not pass the backfit test (could not identify any cost benefit options)
(2) risk met safety goals
(3) reducing risk from SFP would still leave a comparable risk from the reactor

Changes in spent fuel storage since GI-82 resolved:
(1) higher burnup fuel / higher decay heat levels
  GI-82: 30-40 GWD/MTU
  Now: 60 GWD/MTU
(2) higher density racking
  GI-82: independent boxes around each assembly with space between boxes
  Now: shared boron walls to form boxes around assemblies

Changes in information since GI-82 resolved:
(1) uncertainty on release fractions, particularly ruthenium
  GI-82: reactor fractions
  TWG: sensitivity studies on Ruthenium, fewer on Cesium, Iodine, Tellurium, Lanthanum, Strontium, and Barium

(2) potential for uncoolable geometry from large seismic event
  GI-82: analysis used intact SF rack geometry
  TWG: could not assume any geometry due to BDB seismic event

(3) greater probability of partial draindown
  GI-82: considered a transition phase to complete draindown
  TWG: seismic expert concluded that an earthquake could break the pool wall but stopped several feet above the floor causing a partial draindown

GI-82 information from NUREG-1353, "Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design basis Accidents in Spent Fuel Pools", April 1989

Seismic Hazard Issues:

Seismic Hazard Curve Outlier - HB Robinson Plant:

- Highest eastern and central US seismic hazard using LLNL; not highest using EPRI methodology

- Likely influenced by Charleston Earthquake

- Additional report (who - report #? - check with Goutam Bagchi) independently estimated that Robinson had high seismic hazard

- NUREG/CR-5176 found Robinson SFP capable of handing a 0.65 pga (peak ground acceleration) earthquake
    - TWG study assumed at earthquakes at 0.5 pga would damage pool
    - therefore, Robinson could have site-specific justification for seismic events

IPEEE: DID NOT EVALUATE SPENT FUEL POOL

NUREG/CR-5176, "Seismic Failure and Cask Drop Analysis of the Spent Fuel Pools at Two Representative Nuclear Power Plants," January 1989, performed in support of GI-82

G:\Decom.grp\Commission 2 2001 bkgrd info.wpd