Mr. David A. Lochbaum
80 Tuttle Road
Watchung, New Jersey 07060

October 12, 1995
50-445/446

Mr. Donald C. Prevatte
7924 Woodsbluff Run
Fogelsville, Pennsylvania 18051

SUBJECT: SPENT FUEL POOL COOLING GENERIC REVIEW

Gentlemen:

By letter dated October 24, 1994, I forwarded to you a copy of the staff's "Task Action Plan for Spent Fuel Storage Pool Safety." Item 5 of the action plan prescribed a series of spent fuel pool storage safety assessments at selected nuclear power plants. In a letter dated May 17, 1995, I forwarded copies of assessment reports for the first two planned assessments. The staff has completed assessment reports for two additional sites, Commanche Peak and R.E. Ginna. Based on your expressed interest in the task action plan, I am forwarding the reports to you. The staff does not plan to perform any additional assessment visits and is proceeding with consolidation of the findings from the four assessments completed to date.

As I noted in my May 17, 1995 letter, the staff has not yet made a final determination regarding potential generic action and nothing in the individual assessment reports should be construed as such.

If you have any additional comments or questions, please do not hesitate to call me at (301)-415-1428.

Sincerely,
/S/
Joseph W. Shea, Project Manager
Project Directorate I-2
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Enclosures: 1. Assessment Report- Commanche Peak
2. Assessment Report- Ginna

cc w/enclosures:
Mr. Paul M. Blanch
135 Hyde Road
West Hartford, Connecticut 06117

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

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COMANCHE PEAK SPENT FUEL POOL STORAGE ASSESSMENT
APRIL 24-28, 1995

Introduction

The NRR staff conducted the third safety assessment of wet storage of spent fuel in pools at the Comanche Peak Steam Electric Station (CPSES) from April 24 to April 28, 1995. The assessment team focused on postulated loss of spent fuel pool cooling and loss of spent fuel coolant inventory events, but the overall assessment scope encompassed a broad range of spent fuel issues.

System Description

The common fuel building served both units at CPSES and housed the two spent fuel pools, the common spent fuel transfer canal and cask handling area, and the systems associated with the spent fuel pools. The fuel building was situated between the two reactor containment buildings and adjacent to the common auxiliary building.

The spent fuel pool cooling and cleanup system (SFPCCS) was designed as a common system supporting both spent fuel pools at CPSES. The SFPCCS consisted of two cooling loops, two purification loops, and one surface skimmer loop. Although each cooling loop was designed to be aligned to both spent fuel pools, the licensee identified that simultaneous cooling of both pools with a single cooling loop was not practicable without modifications to the SFPCCS because differences in piping flow resistance between pools could induce a diversion of coolant from one pool to the other until flow resistance was balanced at some different level. At the time of the assessment, the licensee had installed storage racks in the unit 1 spent fuel pool only, and the licensee placed irradiated fuel discharges from both units in that pool. Each cooling loop included one SFPCCS pump, one SFPCCS heat exchanger, and associated piping, instrumentation, and controls. Each purification loop was designed to filter and demineralize a portion of the flow through each cooling loop. The surface skimmer loop was designed to filter water drawn directly from the surface of the two spent fuel pools.

The spent fuel pool cooling water was cooled by the component cooling water (CCW) system flow that passed through the SFPCCS heat exchangers. The CCW system for each unit was comprised of two redundant safeguards loops and a non-safeguards loop. Each unit's CCW system non-safeguards loop was normally aligned to supply CCW system flow to one SFPCCS heat exchanger, but the CCW system was designed with the capability to manually cross-connect the system such that the non-safeguards loop for one unit supplies both SFPCCS heat exchangers. Flow from the CCW system of one unit to the associated CCW system non-safeguards loop was designed to be automatically terminated by redundant, motor-operated valves upon initiation of containment spray and phase B containment isolation for that unit.

The CCW system was configured to reject heat to the service water (SW) system. A separate SW train served each of the four CCW heat exchangers for the two units. The seismic Category I safe shutdown impoundment (SSI) formed the ultimate heat sink for the CPSES SW system.

The design capacity of each SFPCCS heat exchanger was 13.6 million BTU/hr at a spent fuel pool temperature of 120° F and a CCW supply temperature of 105° F. The team determined that the SFPCCS would have a greater heat removal capacity at a higher spent fuel pool temperature or at a lower CCW supply temperature.

In conjunction with an amendment request for a spent fuel storage capacity increase, the licensee developed revised spent fuel inventory design conditions and peak spent fuel pool temperature limits. The licensee defined the following design conditions and the associated assumptions for ultimate heat sink conditions:

> Maximum Design Condition - The decay heat from a full core off-load 7 days after shutdown for one unit, the opposite unit's refueling discharge 52 days after shutdown of that unit, and the discharged fuel assemblies from a maximum number of previous refuelings at 18 month intervals while maintaining at least 193 vacant storage spaces. The specified SSI temperature was 94° F, which the licensee considered representative of the maximum SSI temperature with one unit operating at full power and one unit shutdown during normal refueling periods from September to May.
>
> Maximum Summer Design Condition - The decay heat from discharged fuel assemblies for two consecutive 45 day refueling outages on alternate units at the end of the second outage period and the discharged fuel assemblies from a maximum number of previous refuelings at 18 month intervals while maintaining at least 193 vacant storage spaces. The specified SSI temperature was 102° F, which the licensee considered representative of the maximum SSI temperature with two units operating at full power.
>
> Abnormal Maximum Design Condition - The decay heat from discharged fuel assemblies for two consecutive 45 day refueling outages on alternate units 150 hours after the end of the second outage period, an emergency full core off-load 150 hours after shutdown from the unit completing the earlier refueling outage, and the discharged fuel assemblies from a maximum number of previous refuelings at 18 month intervals. The specified SSI temperature was 102° F, which is consistent with the maximum summer design condition.

For the maximum design condition and the maximum summer design condition, the licensee selected spent fuel pool bulk temperature limits of 150° F with both SFPCCS cooling loops in operation and 200° F with a single cooling loop in operation. For the abnormal maximum design condition, the licensee selected a spent fuel pool temperature limit of 212° F with both cooling loops in operation. For all design conditions, the licensee proposed a design limit of 140° F for the temperature of the fuel pool water at the outlet of the heat exchanger.

The licensee evaluated the decay heat rate for each design condition for the configuration of spent fuel storage racks that were installed at the time of the assessment visit, which provided 556 storage locations in the unit 1 spent fuel pool. The estimated decay heat rates were 39.8 million BTU/hr, 12.7 million BTU/hr, and 48 million BTU/hr for the maximum normal, maximum summer, and maximum abnormal design conditions, respectively. Assuming both spent fuel pools were filled with high-density storage racks, the storage capacity would increase to 3386 assemblies and the decay heat rate would increase to 55.7 million BTU/hr for the maximum normal design condition.

For comparison purposes, the assessment team estimated the heat removal capacity of one SFPCCS cooling loop based on safety analysis report information. For the maximum normal design condition, the team estimated the heat removal capacity of each loop to be 43 million BTU/hr at a pool temperature of 150° F and 68 million BTU/hr in single loop operation limited by heat exchanger outlet temperature. For the maximum summer and abnormal maximum design conditions, the team estimated the heat removal capacity of each loop to be 37 million BTU/hr at a pool temperature of 150° F, and 56 million BTU/hr limited by heat exchanger outlet temperature. These values indicate that the heat exchanger capacity was adequate to satisfy the temperature limits for all three revised design conditions. However, the licensee identified that design modifications were necessary for a single cooling loop to simultaneously cool both spent fuel pools without causing a level transient and this capability would be necessary to satisfy the system design basis once spent fuel storage in the unit 2 spent fuel pool begins.

The primary source of makeup water to the spent fuel pool was the demineralized and reactor makeup water system. The demineralized and reactor makeup water system consisted of a demineralized water subsystem, a seismic Category I reactor makeup water storage tank (RMWST) for each unit, reactor makeup water pumps for each unit, and associated piping and valves. The demineralized water subsystem provided the normal source of makeup water to the spent fuel pool. The RMWSTs provided the essential source of makeup water to the spent fuel pools. The spent fuel pool makeup water flow-path from each RMWST passed through the respective unit's reactor makeup water pumps to the suction header of the respective SFPCCS cooling loop. Fire hose stations in the fuel building provided an alternate source of makeup water for the spent fuel pools.

The team found that the SFPCCS and the relevant portions of its essential support systems (i.e., the CCW system, the SW system, and the demineralized and makeup water system) were designed and constructed to seismic Category I criteria. Structures housing these systems, which were constructed to seismic Category I criteria, provided protection from natural phenomena for the SFPCCS and its essential support systems. Additionally, the SFPCCS, the CCW system, the SW system, and the demineralized and reactor makeup water system were powered from essential electrical buses that were designed to receive power from on-site power sources.

The team noted that instrumentation of the spent fuel pool and associated systems was extensive at the common local spent fuel pool panel, but limited in the control room. Each unit's control room panels had a single annunciator dedicated to the spent fuel pool and the SFPCCS, which was designed to alarm when the local alarm horn relay actuated and clear when the local alarm was acknowledged on the common spent fuel pool panel located in the fuel building. Local alarms on the common spent fuel pool panel included SFPCCS cooling water pump trip, skimmer pump trip, low SFPCCS cooling water pump discharge pressure, low SFPCCS cooling water flow, spent fuel pool high or low level, spent fuel pool high temperature, and filter and demineralizer high differential pressure. Local indications at the common spent fuel pool panel included pump status, SFPCCS cooling water flow rate, spent fuel pool temperature, and SFPCCS cooling loop activity. Control room computer displays were capable of monitoring SFPCCS pump breaker status, spent fuel pool temperature, and SFPCCS cooling water activity. The team determined that the above alarms and instrumentation were not designed to retain their functional capability following postulated design basis events.

The SFPCCS cooling water pumps and the associated controls were designed as Class 1E devices. The SFPCCS cooling water pumps had an over-current trip, and these pumps were designed to be shed from the Class 1E buses by initiation of the bus under-voltage or safety injection load sequencers. After a short duration operator lockout during load sequencer operation, the SFPCCS cooling water pumps were capable of being manually loaded onto the Class 1E buses. In addition to the local SFPCCS cooling water pump control switches located on the common spent fuel pool panel, each SFPCCS cooling water pump was provided with a redundant control switch located on the respective Class 1E motor control center in the common auxiliary building. The redundant control switches bypassed the local control switches and allowed operation of the SFPCCS cooling water pumps following events that damaged the common spent fuel pool panel. Although the licensee had not evaluated shielding adequacy for restoration of the SFPCCS cooling water pumps in the postulated post-accident environment, the licensee had evaluated shielding adequacy and operator dose for fuel pool make-up at 17 hours post-accident. Based on the low calculated operator dose, the proximity of the make-up station to the SFPCCS operating panel, and the absence of significant contained sources in the fuel building, the team concluded that the calculated operator dose for post-accident access to the SFPCCS operating panel for restoration of the cooling water pumps would satisfy the appropriate acceptance criterion.

The two SFPCCS cooling water pumps were located in separate pump rooms with the associated SFPCCS heat exchanger. Emergency fan coil units in each of these rooms were designed to maintain ambient room temperature below the maximum temperature allowed by the equipment design. The emergency fan coil units were supplied from the safety-related chilled water system and were designed to operate following a loss of off-site power.

The ventilation exhaust from the fuel building was routed through the primary plant ventilation system, which was designed to maintain a slight negative pressure with respect to the outside environment in connected structures, including the fuel building, following design basis accidents. The fuel building ventilation system was designed to develop airflow from areas of lower potential radioactivity to areas of higher potential radioactivity. The exhaust from the fuel building passed through mist eliminators and exhaust fans, which were not required to maintain a negative fuel building pressure, before entering the primary plant exhaust plenum. The fuel building exhaust mixed with exhaust from the auxiliary and safeguards buildings in the plenum before being exhausted through one of twelve primary plant exhaust filter trains or one of four engineered safety features filter trains.

The two spent fuel pools at CPSES were constructed from reinforced concrete as an integral part of the seismic Category I fuel building structure. The pools were located adjacent to their respective containment building with the new fuel storage area and the cask pit located between the pools. A transfer canal connected the spent fuel pools with the single cask pit and the two fuel transfer tubes. The transfer tubes permitted underwater fuel assembly transfer to and from the refueling cavities inside the containment buildings. The refueling cavity was provided with a permanent refueling seal around the reactor vessel. The pools, the transfer canal, and the cask pit were lined with welded stainless steel plates. Channels embedded in the concrete below the liner plates in the fuel building collected leakage, which drained through flow indicators that provided a liner leak detection capability.

Hinged gates with redundant, inflatable seals were installed to separate the spent fuel pools from the transfer canal, and lift gates with inflatable seals were available to separate the cask pit from the transfer canal and divide the transfer canal into three segments. The inflatable seals were designed as passive devices, and the licensee maintained one seal isolated to prevent a loss of pressure in the air system from affecting seal performance. The transfer tubes were fitted with gate valves on the fuel building side and a blank flange on the containment side for isolation purposes. Each reactor cavity was equipped with a removable gate capable of dividing the reactor cavity into two sections.

In addition to the capability to partition the fuel handling and storage areas with gates, CPSES was designed with features to prevent inadvertent drainage of the spent fuel pool coolant inventory. The spent fuel pools were designed with no penetrations or drains capable of draining the coolant level sufficiently to expose the stored fuel. The bottom of the hinged gate opening was about 23 feet below the normal water level, but still 2 feet above the top of the stored fuel. The suction strainers for the SFPCCS cooling water loops were located about 4 feet below the normal water level, and the cooling loop return spargers were located about 6 feet above the top of the stored fuel. To prevent development of a siphon path, the cooling loop return piping was provided with a drilled siphon-break about 1 foot below the normal water level.

Heavy Load Handling Program

The team concluded that the licensee had an acceptable heavy load handling program to ensure SFP safety at CPSES. The main hook of the fuel building crane was precluded from travelling over any part of the spent fuel pools or the SFPCCS cooling water pump rooms by the location of the crane rails. The team noted that critical piping runs for fuel pool cooling and makeup capability were separated from heavy load handling operations by the fuel building operating floor, and the FSAR stated that the concrete floors of the fuel building can withstand a fully-loaded cask drop. Additionally, the main hoist of the seismic Category I fuel building crane was constructed with single-failure-proof design features that substantially reduce the risk of a load drop event by providing redundant hoisting and braking systems. Based on this information, the team concluded that the risk of a heavy load drop affecting spent fuel pool cooling or coolant inventory control was low.

SFP Training Programs

Texas Utilities Electric Company (TU) provided training and qualification programs for engineers, licensed operators, and auxiliary operators on the design and operation of the spent fuel pool, its cooling systems, and associated fuel handling activities. The training program included classroom instruction, on-the-job training, written examinations, and performance-based qualifications. In addition to training operators on a variety of normal and abnormal procedures, the course material included industry events related to the spent fuel pool, such as spent fuel pool overflow events, uncontrolled leakage events, radiation overexposure related to the spent fuel pool, inadvertent drain-down of the spent fuel pool, and loss of spent fuel pool cooling events. The team found the program to be thorough and well documented.

Quality Assurance

The team reviewed documentation to determine the effectiveness of the licensee's quality assurance program, including self-assessment, problem identification, and corrective action measures. The documents reviewed by the team focussed on the spent fuel pool and associated support systems. The team reviewed a Problem Identification Report (PIR), self-assessment reports, field notes, and Licensee Event Reports.

The PIR provided the analysis and corrective actions performed by the licensee to address an event where the transfer gate seal for the spent fuel pool failed. The extensive actions detailed in the PIR, including installation of a bottled nitrogen backup supply and training operators on its use, were well documented and implemented in a timely manner.

The self-assessments and field notes (observations on field activities) included observations and recommendations by QA inspectors that were reviewed and evaluated by the cognizant field supervisor.

The team found the practices to be adequate and the implementation of corrective measures timely. Thus, the licensee's program contributed positively to the safe operation of the plant's spent fuel storage facility.

Maintenance and Surveillance

To assess the licensee's maintenance and surveillance practices, the team focused on the following areas: blackness testing of solid neutron absorbers, spent fuel pool cooling and cleanup system surveillance, water chemistry monitoring, pool leakage monitoring activities, and drainage and siphon protection features.

The team found that the licensee used physical separation of the spent fuel assemblies created by the storage rack design to maintain the fuel array subcritical. Therefore, the licensee did not perform blackness testing.

The team reviewed the schedule of surveillance for the spent fuel pool cooling and cleanup system. The team noted no significant backlog of SFP related maintenance or surveillance items. The team reviewed the availability of the components in the system and found that, since 1993, both trains of the system have been rendered inoperable for maintenance only one time. During that repair, the licensee took compensatory measures to ensure cooling would be available when needed. Specifically, before beginning the maintenance, the licensee measured the actual SFP heat-up rate by securing all cooling and trending the rise in pool temperature over an 8 hour period to verify that the rate of pool temperature increase was sufficiently low without cooling to allow a conservatively large maintenance period without exceeding temperature limits. Due the low unavailability of the spent fuel pool cooling system for maintenance and surveillance, the team determined that these activities do not contribute to the overall risk of a sustained loss of cooling event.

Water chemistry monitoring practices were also reviewed during the assessment. The licensee maintains at least 2400 ppm boron in the spent fuel pool under all operating conditions. The licensee drew SFP water samples every week during refueling and analyzed those samples for pH, specific conductivity, boron concentration, chloride ion concentration, fluoride ion concentration, magnesium, calcium, gamma activity, and tritium activity. Maintaining spent fuel pool chemistry reduces the likelihood that corrosion or inadequate cleanup could contribute to an increased level of radioactivity in the spent fuel pool coolant.

Administrative Controls and Common Practices

The licensee for CPSES controlled activities related to the spent fuel pool with a combination of procedures, good practices, and engineering evaluations. The assessment team reviewed aspects of these controls considered to affect risk. The NRC staff has concluded that operating practices can significantly impact spent fuel storage risks during refueling outage periods when equipment may be out of service and the decay heat rate may be large.

The team noted that the licensee conducted refueling operations in accordance with procedure RFO-102, "Refueling Operation," which was part of the CPSES Station Refueling Manual. The licensee designed this procedure to provide overall instructions for refueling either unit in a safe and controlled manner. The procedure specified the necessary status or availability of certain design features, systems, and components through prerequisites, precautions, limitations, and procedural steps. The assessment team noted that this procedure included the following directions:

1. Verify that the SFPCCS is in operation with the capacity to remove the residual heat generated by fuel assemblies that will be placed in the SFP.

2. Verify that the fuel building ventilation system is in operation.

3. Verify that the SFPs are initially isolated with the swing gates closed and sealed.

4. Verify that the refueling cavity drain valves are closed with blind flanges installed.

5. Note that significant level differences can occur between the refueling cavity and the SFPs as a result of differences between containment and fuel building internal pressures.

6. When the fuel transfer tube gate valve is open with the refueling cavity and transfer canal drained, designate a person to monitor installed gate seals for leakage from the flooded pools.

7. Maintain Technical Specification (TS) limits with respect to water level where irradiated fuel is located during fuel movement or storage of fuel outside the reactor vessel.

8. Maintain TS limits with respect to availability of power sources and energized electrical buses.

9. Verify that the reactor has been subcritical for greater than 100 hours prior to beginning movement of irradiated fuel within the reactor vessel

10. Ensure that boron concentration is adequate to satisfy Technical Specification (TS) limits in fuel pool and adjoining areas.

The staff did not identify any administrative controls relating to the availability of spent fuel pool make-up capability or the degree of redundancy for the spent fuel pool cooling function. The reactor make-up water system is the seismic Category I source of make-up water to the spent fuel pool, and the FSAR states that at least one reactor water makeup pump per unit operates constantly. However, the assessment team determined that procedure RFO-102 did not specify availability of spent fuel pool make-up capability during refueling outage periods. Similarly, the team determined that administrative controls did not specify availability of a back-up spent fuel pool cooling loop or system during refueling outage periods when fuel pool boiling could develop within several hours following a loss of the cooling function.

The licensee stated that, although temporary modifications were sometimes used to allow pumps to be run from the available train of power, both loops of spent fuel pool cooling have been available during refueling outage periods and that all past refueling outage periods have involved a full-core off-load. Based on these practices, the team concluded that the licensee recognizes the transfer of risk from the reactor refueling cavity to the fuel pool during full-core off-load periods despite the absence of administrative controls on cooling system redundancy and makeup capability.

The assessment team examined limits on spent fuel pool fuel assembly inventory, coolant level, and coolant temperature. Spent fuel assemblies from both units at CPSES were stored in the unit 1 spent fuel pool in low density racks with a capacity for storage of 556 fuel assemblies. The unit 2 spent fuel pool had no installed racks at the time of the assessment visit, but the licensee had submitted a license amendment request to authorize installation of high density racks in the unit 2 pool with a capacity for 735 fuel assemblies in a 2 out of 4 storage pattern without the use of a solid neutron absorber. The licensee stated that spent fuel pool level was maintained between the low and high level alarms, with setpoint elevations of 858 feet and 859 feet, respectively. The assessment team identified an administrative spent fuel pool temperature limit of 140° F and a spent fuel pool high temperature alarm setpoint of 150° F.

Emergency and Off-Normal Procedures

The team reviewed procedures that operators may refer to during recovery from loss of spent fuel pool cooling or loss of spent fuel pool coolant inventory events. The team noted that the licensee had developed alarm response procedures to address alarming annunciators for the SFPCCS and associated systems. The licensee reserved abnormal condition procedures for more complex recovery actions.

The team found that the alarm response procedures provided adequate direction to correct the direct cause of the alarm. The alarm response procedure for the common control room annunciator for spent fuel pool trouble (ALM-0062A, Rev. 4) directed that an operator be dispatched to the local spent fuel pool panel to determine and correct the cause of the alarm. The licensee also had developed an alarm response procedure for the local spent fuel pool panel (ALM-0701, Rev. 3), which provided certain immediate actions for each annunciator on the panel and referenced the abnormal procedure for spent fuel pool or refueling cavity malfunction (ABN-909, Rev. 2) when a loss of spent fuel pool cooling or a loss of coolant inventory was indicated. The team concluded that the alarm response procedures were complete and well written.

The abnormal procedure for spent fuel pool or refueling cavity malfunction was divided into two principle sections: spent fuel pool or refueling cavity leakage and loss of spent fuel pool cooling. The format of the abnormal procedures at CPSES was similar to that of Westinghouse Emergency Operating Procedures (EOPs). Each principle section of the abnormal procedure for spent fuel pool or refueling cavity malfunction included specific measures to address abnormal radiation levels that may result from a loss of spent fuel pool coolant inventory or a loss of spent fuel pool cooling. The spent fuel pool or refueling cavity leakage section directed the addition of make-up water to recover or maintain level and checks of potential leak paths. The loss of spent fuel pool cooling section directed checks of spent fuel pool level, SFPCCS pump status, and CCW flow to the SFPCCS heat exchanger. The loss of spent fuel pool cooling section also referred to appropriate procedures to correct identified problems and directed the operator to contact support personnel for assistance in restoring spent fuel pool cooling. If efforts to recover spent fuel pool cooling are unsuccessful as indicated by spent fuel temperature above 140° F or increasing, the procedure directed the operators to locally close the fuel building doors and maintain a negative pressure in the fuel building by operation of the primary plant ventilation system.

Because the SFPCCS cooling water pumps were designed to be shed from the Class 1E buses by initiation of the bus under-voltage or safety injection load sequencers, the team examined procedures expected to be entered by operators during events involving these load sequencers. The team found that the EOPs referenced abnormal procedures that provided specific direction to restore

SFPCCS cooling water flow following these events. Direction for restoration of CCW flow to the non-safeguards loops was also provided.

In addition to a detailed review of the procedures, the team observed simulated operator performance of the spent fuel pool make-up water addition procedure and the alarm response procedure for high spent fuel pool temperature with subsequent entry into the abnormal procedure for spent fuel pool or refueling cavity malfunction. Based on the procedure review and the observed performance, the team concluded that the procedures were complete and well integrated.

Radiological Controls

The assessment team examined design features and administrative controls that the potential radiation exposure of personnel during recovery from anticipated operational occurrences. The principle event considered was the unplanned loss of water from a spent fuel pool resulting in the loss of water shielding of non-fuel radioactive materials stored in the pool at elevations above the spent fuel racks and degradation of spent fuel shielding. Such an event could result in high radiation levels limiting access to the operating floor of the fuel building.

The team found that potential problems with respect to the storage of radioactive materials above the fuel racks were not significant at CPSES. The team noted that the licensee was not storing any radioactive materials above the fuel racks. The licensee had developed a procedure governing the storage of non-fuel materials in the spent fuel pool. The procedure required specific approval of such storage prior to the placement of any radioactive materials in the fuel pool for storage. The assessment team also noted that, with the exception of repositioning refueling gates, adding make-up water using local firehouse stations, and directly observing pool level, likely recovery actions for a loss of spent fuel pool coolant inventory can be performed from areas shielded from the stored irradiated fuel by concrete structures.

Reactivity Control

The team noted that solid neutron absorbers were not used for reactivity control at the time of the team's visit nor was their use planned for the planned storage capacity increase. Instead, the licensee intended to use restrictions on assembly position and fuel assembly burnup to satisfy NRC staff reactivity criteria.

Vulnerability to Sustained Loss of Spent Fuel Pool Cooling

Based on the risk assessment performed to evaluate the frequency of spent fuel pool boiling events at Susquehanna Steam Electric Station, the NRC staff determined that the probability of a spent fuel pool boiling event is related to the reliability of spent fuel pool cooling system components, the redundancy and diversity of the spent fuel pool cooling systems, and the time available to recover from a loss of cooling prior to the onset of spent fuel pool boiling. The reliability of spent fuel pool cooling system components becomes most important when multiple components are necessary to satisfy functional requirements, such as periods of high heat load or high heat sink temperature where multiple heat exchangers and pumps may be necessary to prevent boiling. The redundancy and diversity of systems becomes important to avoid a loss of spent fuel pool cooling initiated by a single component failure or common failure modes. Finally, the time available for recovery determines the number of potential methods of recovery.

The assessment team examined the design of the SFPCCS and its essential support systems. The team found that the reliability of spent fuel pool cooling system components at CPSES was very high based on the quality of the SFPCCS, which was demonstrated by the standards employed in the design and construction of the systems. Redundancy was provided by a combination of the following factors:

1. Redundant SFPCCS cooling loops were capable of independently removing the maximum normal design condition heat load from the spent fuel pools without violating design temperature limits.

2. Redundant unit non-safeguard loops of CCW were capable of removing the design decay heat rate from either SFPCCS heat exchanger.

3. Redundant, independent CCW loops, which were cooled by redundant, independent service water loops, were capable of supplying cooling water flow to each non-safeguard loop of CCW.

4. Normal off-site power and redundant on-site power supplies were capable of powering the SFPCCS cooling water pumps and the associated CCW and service water pumps.

Although individual components shared similar designs and, in that sense, were not diverse, the team concluded that the redundant nature of the design, the diverse sources of electrical power, and the quality standards employed in the design of the SFPCCS helped to ensure a high degree of reliability.

The time available to the onset of boiling was important for the Susquehanna evaluation in assessing the capability to initiate recovery action prior to developing adverse environmental conditions. The team determined that the time to the onset of boiling conditions in a spent fuel pool housing a recent full-core off-load and the preceding refueling outage discharge from the opposite unit at CPSES may be as short as 5 hours based on an initial spent fuel pool temperature of 150° F. However, the team noted that the licensee had determined that the SFPCCS cooling loops would have adequate net positive suction head to restore cooling following the onset of boiling, the licensee had developed procedures to isolate and ventilate the fuel building in the event of a sustained loss of spent fuel pool cooling, and the fuel building did not house equipment necessary for safe shutdown of the reactor or accident mitigation.

Based on the above considerations, the staff concluded that the probability of spent fuel pool boiling at CPSES was low and, should spent fuel pool boiling develop, the probability of adverse environmental conditions caused by boiling degrading essential systems for safe shutdown and accident mitigation is also small. The construction of the fuel building as a separate structure from the reactor buildings and the auxiliary building contributed significantly to this conclusion. The team noted that a loss of off-site power, which was the most significant contributor to near boiling frequency at Susquehanna, would be less significant at CPSES due to the design capability of on-site power sources to support the SFPCCS.

Vulnerability to Spent Fuel Pool Draining or Siphoning

Piping within a SFP may fail in a manner that creates a path to drain or siphon water out of the SFP to an extent the shielding and/or cooling are lost. Of particular concern are lines which extend or originate below the top of the stored fuel assemblies. Draining can be precluded by having all penetrations above an elevation which provides adequate shielding and cooling. If lines extend to lower pool elevations, siphon protection can be provided by siphon breaks or check valves.

The assessment team found that few paths for significant drainage of the pool were present. At CPSES, only the SFPCCS lines extended into the spent fuel pool. The suction flow to each cooling loop of the SFPCCS was drawn through separate suction screens located 4 feet below the normal SFP level at opposite ends of each pool, and the suction piping travelled horizontally from the suction screen through the spent fuel pool wall. The SFPCCS return lines ended in headers located about 6 feet above the spent fuel storage racks, but the return line was fitted with an anti-siphon hole located about 1 foot below the normal spent fuel pool level. The team concluded that the risk of siphoning or draining the SFP from piping systems connected to the SFP was minimal.

Potential alternate leakage or drain paths from the SFP would be a puncture of the liner (i.e., by a dropped object as in the Hatch event) or failure of the SFP gates/gate seals. Flow rate through a hole in the liner would be limited to seepage through the concrete and flow through the small diameter liner drain system. Combined flow would be limited to less than 100 gpm. A variety of operator actions were available (e.g., isolating the liner drain path, adding water from the demineralized water supply, and using fire protection water) to mitigate this type of event. The team concluded that the frequency of a liner leakage event was moderate, but that potential operator corrective actions resulted in a low overall risk.

The swing gate that connected the spent fuel pool to the transfer canal was provided with two pneumatic seals. One pneumatic seal was normally pressurized and isolated, and the other seal was aligned to the service air system with backup compressed air bottles available. The team noted that this configuration minimized the potential for a coincident failure of both seals.

Failure of the swing gate (or common mode failure of both seals on that gate) would create a drain path from the spent fuel pool to the transfer canal, but the transfer canal volume was small relative to the spent fuel pool volume such that only a small level loss would occur in the spent fuel pool with the transfer tube isolated and the transfer canal drains isolated. The spent fuel pool low level alarm was designed to alarm in the event of a gate failure, and operator action could terminate drainage through the transfer tube or drain lines by closing the respective isolation valve. Without any action, the fuel would remain covered because the bottom of the swing gate opening was above the top of the stored fuel.

For each of the preceding leakage scenarios, the team estimated that coolant inventory loss would be small. The team concluded that these events were unlikely to result in a rapid loss of coolant inventory. Therefore, the ability of the plant staff to implement corrective actions results in a low probability of a significant loss of spent fuel pool coolant inventory.

Conclusions

The assessment team concluded that the potential for a sustained loss of spent fuel pool cooling or a significant loss of spent fuel pool coolant inventory was remote at CPSES based on certain design features and operational procedures. Specific features that contribute to the remote potential of a loss of spent fuel pool cooling or coolant inventory include: (1) the quality, redundancy, and flexibility of the SFPCCS, (2) the well-integrated procedures addressing loss of spent fuel pool cooling or loss of spent fuel coolant inventory events, (3) the multiple, reliable sources of make-up water, and (4) the design features limiting the potential for a loss of spent fuel pool coolant. Additionally, the assessment team noted that, if spent fuel pool boiling conditions developed, the licensee had developed procedures to isolate and ventilate the fuel building. However, the staff identified potential improvements in administrative controls for availability of spent fuel pool cooling and make-up systems during refueling that may further reduce risk.

COMANCHE PEAK SPENT FUEL POOL ASSESSMENT

Entrance Meeting - April 25, 1995

TU Electric

J. Muffett, Station Eng. Manager
F. Madden, Eng. Overview Manager
R. Calder, Eng. Analysis Manager
T. Hope, Reg. Compliance Manager
M. Bozeman, Chemistry Manager
C. Corbin, Licensing
J. Blaikie, Radiation Protection
W. Moore, Training
G. Ruszala, Chemistry
G. Krishnan, Project Engineer
D. Bersi, Design Engineer - Mech.
C. Feist, Design Engineer - Mech.
D. Basinger, Operations Support
D. Fuller, System Engineer

NRC

A. Gody, Sr. Resident Inspector
S. Jones, NRR
C. Gratton, NRR

Exit Meeting - April 28, 1995

TU Electric

C. Terry, Group VP
W. Guldemoni, System Eng. Manager
T. Hope, Reg. Compliance Manager
C. Corbin, Licensing
J. Blaikie, Radiation Protection
D. Bersi, Design Engineer - Mech.
C. Feist, Design Engineer - Mech.
J. Barker, Design Engineer - Mech.
D. Basinger, Operations Support
D. Fuller, System Engineer
D. Woodlan, Licensing
N. Terrel, Reactor Engineering
C. Cote, Reactor Engineering
R. Carver, NOD
J. Ayres, NOD

NRC

A. Gody, Sr. Resident Inspector
S. Jones, NRR
C. Gratton, NRR

GINNA SPENT FUEL POOL STORAGE ASSESSMENT
JUNE 19-23, 1995

Introduction

The NRR staff conducted the fourth and final planned safety assessment of wet storage of spent fuel in pools at the R. E. Ginna Nuclear Power Plant (Ginna) from June 19 to June 23, 1995. The assessment team focused on postulated loss of spent fuel pool cooling and loss of spent fuel coolant inventory events, but the overall assessment scope encompassed a broad range of spent fuel issues.

System Description

In addition to reactor auxiliary systems, the auxiliary building at Ginna housed the spent fuel pool, the spent fuel transfer canal, and the systems associated with the spent fuel pool. The auxiliary building was situated on the south side of the reactor containment building and adjacent to the intermediate building.

The spent fuel pool cooling system (SFPCS) was designed to remove the decay heat from stored irradiated fuel assemblies. In 1980, the SFPCS at Ginna consisted of a permanently installed cooling loop (loop 1), a skid-mounted cooling loop (loop 3), a purification loop, and a surface skimmer loop. At that time, Rochester Gas and Electric Corporation (RG&E or the licensee) proposed a modification to the SFPCS that would add a large capacity, permanently installed cooling loop (loop 2). The purpose of the modification was to accommodate future spent fuel storage capacity increases and address NRC staff concerns regarding Systematic Evaluation Program (SEP) Topic IX-1, "Fuel Storage," at Ginna. The licensee completed the modification and revised the Ginna Updated Final Safety Analysis Report (UFSAR) to reflect the installation of loop 2 of the SFPCS in 1988. The UFSAR designated loop 2 as the primary cooling loop.

Each permanently installed cooling loop included one SFPCS pump, one SFPCS heat exchanger, and associated piping, instrumentation, and controls. Loop 2 included spent fuel pool pump B and spent fuel pool heat exchanger B, and loop 1 included spent fuel pool pump A and spent fuel pool heat exchanger A. Loop 3 consisted of a skid-mounted pump, a skid-mounted heat exchanger, and hoses. The purification loop was designed to filter and demineralize a small portion (5 to 10 percent) of the flow through either permanently installed cooling loop using the heat exchanger differential pressure as the driving head, which results in the purification flow being uncooled. The surface skimmer loop was designed to filter water drawn directly from the surface of the spent fuel pool and return it to the pool.

The SFPCS heat exchangers were cooled by the plant service water system (SWS). The SWS supplied cooling water via a 20-inch loop supply header that was split into two semi-independent headers by two normally closed manually operated cross-tie valves. The licensee designated the two headers A and B. Each header was supplied by two service water pumps that drew water from Lake Ontario at the screen house. The licensee operated the SWS headers with an open 4-inch cross-tie in the supply lines to the two emergency diesel generators and an open 14-inch cross-tie in the supply lines to the containment fan coolers to balance flow to these components. Minor supply lines to the reactor compartment coolers and pump area coolers were also cross-tied. Two pairs of motor-operated valves were designed to isolate the service water supply to the two component cooling water heat exchangers and the SFPCS heat exchangers.

The licensee had established a safety basis heat load of 16 million BTU/hr and a normal basis heat load of 7.6 million BTU/hr for the spent fuel pool. The UFSAR stated that the safety basis heat load was based on the projected spent fuel assembly inventory from normal refueling operations through 1998 combined with a full core discharge at the end of 1999, and the normal basis heat load was based on the projected spent fuel assembly inventory from normal refueling operations through 1998 combined with a one-third core discharge at the end of 1999. However, the team did not identify documents that detailed the methodology used to calculate these design heat loads from the described bases.

In a letter dated June 9, 1981, which responded to an NRC staff request for information regarding modification of the SFPCS, RG&E projected heat loads for future full-core discharges. These projections indicated that the safety basis heat load limit would be satisfied by progressively extending the irradiated fuel decay time in the reactor vessel prior to initiation of fuel movement from 8 days in the year 1981 to 14 days in the year 2010. The progressively increasing decay time reduces the decay heat from the full-core discharge to accommodate the increasing decay heat load from previous yearly refueling discharges. The team reviewed a cycle-specific spent fuel pool decay heat analysis, which the licensee prepared for the spring 1994 refueling outage, that demonstrated that the decay heat load would be below the safety basis value of 16 million BTU/hr after a 10 day in-vessel decay. The team did not identify any administrative controls that prescribed performance of this design analysis or that implemented operational restrictions based on the results of the analysis.

The licensee determined that the heat removal capacity of the original loop 1 SFPCS heat exchanger was 9.3 million BTU/hr at a spent fuel pool temperature of 150° F and a SWS supply temperature of 80° F. With the service water temperature increase through the heat exchanger limited to 20° F at the same inlet conditions, the loop 1 heat transfer was reduced to 7.9 million BTU/hr. The standby, skid-mounted loop 3 SFPCS was designed to achieve identical heat removal capability. The UFSAR stated that loop 1 and loop 3 operated in parallel are capable of removing the safety basis heat load of 16 million BTU/hr with the spent fuel pool at 150° F and the SWS supply temperature at 80° F and no SWS discharge temperature limit. The limit on SWS temperature increase was based on an environmental guideline rather than a physical design limit or a safety limit.

The design criterion used in the selection of the loop 2 SFPCS heat exchanger was to maintain spent fuel pool temperature below 150° F at the safety basis heat load of 16 million BTU/hr with a SWS supply temperature of 80° F and with a SWS temperature increase through the heat exchanger limited to 20° F. The team did not locate the information necessary to determine the absolute physical capability of the loop 2 SFPCS heat exchanger, but the team concluded that the loop 2 SFPCS heat exchanger would have a greater heat removal capacity than the safety basis heat load at spent fuel pool temperatures above 150° F or at SWS supply temperatures below 80° F.

The primary source of makeup water to the spent fuel pool was the refueling water storage tank (RWST), which was capable of providing borated spent fuel pool make-up water at a rate of 60 gpm using the refueling water purification pump. The Ginna technical specifications imposed limits on RWST minimum water volume and boron concentration. Alternate sources of make-up water included the primary water treatment plant, the reactor makeup water tank, chemical and volume control system hold-up tanks, monitor tanks, and the plant fire hose stations. Many of the alternate make-up water sources required temporary hose connections to add water to the spent fuel pool.

The SFPCS and its supporting systems at Ginna were not designed to uniform quality standards. The team found that loop 2 of the SFPCS and the portions of the SW system essential for spent fuel pool cooling were designed and constructed to seismic Category I and safety class 3 criteria. The licensee included loops 1 and 3 of the SFPCS and the make-up water flow-path from the RWST in the quality assurance program, but these portions of the SFPCS were controlled to the less stringent "safety significant" or "Q" criteria. The make-up water supplies and loops 1 and 3 of the SFPCS were not constructed to Seismic Category I criteria.

The team noted that local instrumentation of the SFPCS was relatively complete, but the control room instrumentation was limited to two annunciators and radiation monitors. The control room spent fuel pool annunciator was designed to alarm on high pool temperature or high or low pool water level. A separate control room annunciator was designed to alarm on SFPCS loop 2 low flow. High radiation levels measured in the spent fuel pool general area or in the service water outlet from the SFPCS heat exchangers also generated control room alarms. Local indications included pressure, flow, and temperature at selected points in the SFPCS and SWS piping. Local indication of spent fuel pool temperature was also available. The B SFPCS pump in loop 2 was designed to trip at a spent fuel pool level about 1 foot below normal. The team determined that the above alarms and instrumentation were not designed to retain their functional capability following postulated design basis events.

The SFPCS pump B motor, control circuits, and power supply circuits were designed to Class 1E criteria. The permanently installed SFPCS pumps and the SWS pumps were powered from essential electrical buses that were designed to receive power from on-site power sources. The permanently installed SFPCS pump motors were designed to be shed from their respective safety buses on bus under-voltage coincident with a safety injection signal. After operators reset appropriate initiation signals, the SFPCS cooling water pumps were capable of being manually loaded onto the Class 1E buses. In addition to the local SFPCS pump control switches located in the vicinity of the pumps, the licensee stated that the permanently installed SFPCS cooling water pumps were capable of being started by manual operation of the respective breaker on the associated motor control center in the auxiliary building.

The redundant motor-operated valves in the SWS supply lines to the SFPCS heat exchangers and component cooling water (CCW) heat exchangers were powered from independent safety buses. Each valve was designed to close following a safety injection signal coincident with an under-voltage condition on the respective safety bus when power is restored to the bus by its emergency diesel generator. The valves were installed with a provision for remote manual operation from the control room to restore SWS flow to the CCW heat exchangers and the SFPCS heat exchangers.

The two permanently installed SFPCS cooling water pumps were located in a common area within the auxiliary building. The SFPCS heat exchangers were located in widely separated areas of the auxiliary building. The skid-mounted SFPCS pump and heat exchanger were designed to be installed in designated locations within the auxiliary building, and the skid-mounted SFPCS pump received a temporary power feed from a non-safety bus.

The spent fuel pool area ventilation was provided by the auxiliary building ventilation system. The system was designed to duct a portion of the auxiliary building supply air flow to the south side of the spent fuel pool. The exhaust from the spent fuel pool area was drawn through ducts on the north side of the spent fuel pool and routed through a filter assembly consisting of roughing filters, activated charcoal beds, and high efficiency particulate filters. From the filter assembly, air from the spent fuel pool area was exhausted through the auxiliary building exhaust fans. The non-engineered safety feature charcoal filters were required to be operable when irradiated fuel that has decayed for less than 60 days is handled in the spent fuel pool area. The auxiliary building ventilation system was designed to develop airflow from areas of lower potential radioactivity to areas of higher potential radioactivity, but the team concluded that the ventilation system would not limit the propagation of adverse environmental conditions if the spent fuel pool were to reach bulk boiling conditions.

The spent fuel pool at Ginna was constructed from reinforced concrete as a seismic Category I structure. The pool was located at the west end of the auxiliary building adjacent to the containment building. The structural integrity of the spent fuel pool had been analyzed at an assumed bulk temperature of 180° F, and the analysis confirmed acceptable integrity at that temperature. A transfer canal connected the spent fuel pool with the fuel transfer tube. The transfer tube permitted underwater fuel assembly transfer to and from the refueling cavity inside the containment building. The refueling cavity was provided with a removable, inflatable refueling seal around the reactor vessel. The spent fuel pool and the transfer canal were lined with welded stainless steel plates. Channels embedded in the concrete below the liner plates collected leakage, which drained through a collection tank that provided a liner leak detection capability.

A gate with an inflatable seal was installed to separate the spent fuel pool from the transfer canal. The inflatable seal was designed to be pressurized from the plant's instrument air system, and the licensee stated that installation of a back-up pressurization supply was planned. The transfer tubes were fitted with gate valves on the fuel transfer canal side and a blank flange on the containment side for isolation purposes.

The Ginna spent fuel pool was designed with features to prevent inadvertent drainage of the spent fuel pool coolant inventory. The spent fuel pools were designed with no penetrations or drains capable of draining the coolant level sufficiently to expose the stored fuel. The bottom of the transfer canal gate opening was about 23 feet below the normal water level, but above the top of the stored fuel. The lower of two suction lines for the SFPCS cooling loops was located more than 5 feet above the top of the stored fuel. To prevent development of a siphon path, the cooling loop return piping.was provided with a drilled siphon-break about 1 foot below the normal water level.

Heavy Load Handling Program

The team concluded that the licensee had an acceptable heavy load handling program to ensure SFP safety at Ginna. The auxiliary building crane, which was used to move new fuel assemblies into and out of their storage area and to move the spent fuel shipping cask, was electrically interlocked to prevent crane movement over spent fuel storage racks. The design of these interlocks allowed them to be defeated with keys, and flashing lights indicated the defeated status of the interlocks to the crane operator. The main and auxiliary hoists of the seismic Category I auxiliary building crane were constructed to meet the single-failure-proof design criteria of NUREG-0554, which substantially reduced the risk of a load drop event by providing redundant hoisting and braking systems. The licensee stated that spent fuel shipping cask transfer operations had been performed to transfer spent fuel to the West Valley Demonstration Project and return the fuel to the spent fuel pool without incident. Based on this information, the team concluded that the risk of a heavy load drop affecting spent fuel pool cooling or coolant inventory control was low.

Operator Training Regarding the Spent Fuel Pool

Ginna provides training and qualification programs for engineers, licensed operators and auxiliary operators on the design and operation of the spent fuel pool, its cooling systems, fuel handling activities, and operations. The training program included classroom instruction, on-the-job training, and examinations.

The staff reviewed two lessons plans during the audit: (1) the Spent Fuel Pool Storage and Cooling System (SFPSCS) lesson plan, and (2) the Loss of Spent Fuel Pit Cooling (ER-SFP.1) licensed operator training on emergency operating procedures. The course material, in general, was comprehensive and emphasized the design features and operating characteristics of the spent fuel storage and cooling system. The material included descriptions of the systems that provide makeup to the spent fuel pool and discussed the SFPSCS response to a variety of malfunctions, including failure of a spent fuel pool pump, failure of a spent fuel pool heat exchanger, and a system loss of cooling.

However, the staff noted that the lesson plan for ER-SFP.1 did not address a loss of pool cooling caused by a loss of pool inventory, even though the entry conditions for the emergency response procedure suggest a loss of pool level may be occurring (one entry condition stated Hi-Lo Level 20", 12" Alarm Lit). The lesson plan covers the restoration of cooling by lining up one of the redundant heat exchangers, but never verifies whether a loss of inventory has occurred. The team checked the underlying procedure (ER-SFP.1) and found that it does not address or reference the appropriate procedure for a loss of inventory.

The team did not consider the training program to be a negative contributor to the plant's overall risk.

Maintenance and Surveillance

The team reviewed the licensee's maintenance practices regarding the spent fuel pool pit cooling system. The licensee provided the repetitive task preventative maintenance program listing report and a listing of the work orders associated with the spent fuel pool cooling system for the team's review. The team noted no significant backlog of spent fuel pool related maintenance or surveillance items. The team also reviewed the availability of the system to provide cooling to the spent fuel pool during normal operation, maintenance, and surveillance activities. Althougn portions of the system were disabled for maintenance on a regular schedule, the team found that the system continually provided adequate cooling capability due to its inherent redundancy.

The team also reviewed the licensee's practices for maintaining the spent fuel pool water chemistry. The licensee typically samples the spent fuel pool weekly for pH, boron concentration, activity, chlorides, and fluorides, and samples boron daily during refueling activities. Maintaining spent fuel pool chemistry reduces the likelihood that corrosion or inadequate cleanup could contribute to an increased level of radioactivity in the spent fuel pool coolant. Spent fuel pool boron levels are maintained between 2000-2900, and are sampled more frequently (daily) during refueling outages and fuel movement activities.

The team concluded that maintenance and surveillance activities did not contribute negatively to risk.

Quality Assurance (QA)

The team sampled QA documentation to determine the effectiveness of the licensee's quality assurance program, including problem identification reports, and corrective action plans. The review focussed on three deficiency reports affecting the spent fuel pool and associated cooling systems, and an overall outage safety assessment checklist. No self-assessment reports or audits on spent fuel activities were available for this review. The three deficiency reports reviewed by the team detailed instances of non-conformance found by the licensee's staff. The corrective actions performed by the licensee to correct the deficient conditions were comprehensive and completed in a timely manner. The Outage Safety Assessment Checklist reviews the status of safety systems available to the plant during an outage. A quantitative risk measure is assigned to the plant each day during the outage based on the available safety systems. Included in the assessment is the spent fuel pool cooling and cleanup system. The risk rating that results from completing the checklist is designed to alert management and operations staff to a degraded safety situations that may result from the maintenance of safety systems.

The team found the practices to be adequate and the implementation of corrective measures timely, and thus the licensee's program did not negatively impact the plant's overall risk.

Administrative Controls and Common Practices

The licensee for Ginna controlled activities related to the spent fuel pool with a combination of procedures, good practices, and engineering evaluations. The assessment team reviewed aspects of these controls considered to affect risk. The NRC staff has concluded that operating practices can significantly impact spent fuel storage risks during refueling outage periods when equipment may be out of service and the decay heat rate may be large.

The team noted that the licensee controlled the availability of the SFPCS and spent fuel pool make-up capability through outage management guidance and individual operating procedures. Outage management guideline OMG-9.1, Revision 4, specified minimum equipment availability and provided direction to perform a semi-quantitative assessment of safety during shutdown periods. The individual operating procedures reviewed by the team specified the necessary status or availability of certain design features, systems, and components through initial conditions, precautions, and procedural steps.

With respect to systems related to the spent fuel pool, OMG-9.1 specified the availability the following: (1) a primary and a back-up SFPCS capable of maintaining the spent fuel pool temperature below 180° F, (2) independent active support components (e.g., redundant service water pumps) for the two SFPCS loops, and (3) at least three sources of power, one of which will be an emergency diesel generator aligned with an available reactor vessel or spent fuel pool decay heat removal path. The availability of primary and back-up spent fuel pool cooling loops capable of maintaining the spent fuel pool temperature below 180° F that was specified in OMG-9.1 satisfied a UFSAR commitment regarding cooling capability and indirectly placed restrictions on outage operations associated with the spent fuel pool. The team noted that the licensee had calculated the necessary in-vessel decay time to satisfy this commitment for past refueling outage periods. The licensee stated that in-vessel decay time restrictions were not procedurally directed. The licensee provided information indicating that the last five refueling outages involved full-core off-loads with a mean in vessel decay of 9 days prior to off-load at the end of 12 month operating cycles.

The semi-quantitative outage safety assessment directed by OMG-9.1 applied to spent fuel pool cooling capability only when all fuel was transferred to the spent fuel pool from the reactor vessel. The licensee's assessment of spent fuel pool cooling capability was based on the availability of each of the two permanently installed SFPCS loops, the availability within two hours of the skid-mounted SFPCS loop, and the existence of a spent fuel pool level above the low level alarm setpoint. For identified conditions where a reduced level of equipment redundancy exists, OMG-9.1 directed formulation of a contingency plan to address the increased level of risk.

Individual operating procedures for each SFPCS loop contained precautions and initial conditions applicable to all operating conditions. Procedure S-9B, Revision 10, "Removing SFP Cooling System A Purification and/or Cooling from Service," and Procedure S-9Y, Revision 2, "Removing SFP Cooling System B Purification and/or Cooling from Service," contained an initial condition specifying demonstration of the operability of the standby SFPCS loop prior to making SFPCS loop 1 or B inoperable and a precaution limiting spent fuel pool temperature to 120° F or less while a SFPCS loop is out of service. Procedure S-9S, Revision 15, "Standby SFP Heat Exchanger Operation," contained a procedural note specifying completion of the standby SFP pump electrical service installation and placement of the heat exchanger in order to consider the standby SFPCS loop operable for a full core discharge. Precautions from Procedure S-9S included a maximum spent fuel pool temperature of 150° F and restrictions on the alignment of SFPCS suction valves for various operating configurations of the SFPCS. The team noted that these initial conditions and precautions were consistent with UFSAR commitments and analyses regarding spent fuel pool cooling.

The staff did not identify any administrative controls relating to the availability of spent fuel pool make-up capability, but several sources of makeup water were procedurally identified. The precautions contained in these procedures relevant to the spent fuel pool concerned maintenance of an acceptable boron concentration during refueling operations and limiting spent fuel pool level increase below the high level alarm.

The assessment team examined limits on spent fuel pool fuel assembly inventory, coolant level, and coolant temperature. Fuel assembly inventory in the spent fuel pool was limited by technical specification to 1016 fuel assemblies. The storage positions were divide into two regions: Region 1 consisted of three low-density, flux trap racks and region 2 consisted of six high-density, fixed neutron poison racks. The licensee maintained spent fuel pool level between the low and high level alarms, which had setpoints of 20 inches below the pool curb and 12 inches below the pool curb, respectively. The assessment team identified an administrative spent fuel pool temperature limit of 120° F. The licensee set the spent fuel pool high temperature alarm at 115° F, and operators routinely logged spent fuel pool temperature.

Emergency and Off-Normal Procedures

The team reviewed procedures that operators may refer to during recovery from loss of spent fuel pool cooling or loss of spent fuel pool coolant inventory events. The team noted that the licensee had developed alarm response procedures to address alarming control room annunciators. The alarm response procedures for annunciators associated with the SFPCS (i.e., AR-K-29, Spent Fuel Pool Level High or Low or Pool Temperature High, and AR-K-21, SFPCS Loop

In addition to a detailed review of the procedures, the team observed simulated operator performance of the spent fuel pool make-up water addition procedure from the RWST and discussed the operator alarm response for high spent fuel pool temperature. Based on the procedure review and the observed performance, the team concluded that operating procedures related to the spent fuel pool were reasonably complete, but emergency response procedures often relied on the operator for identification of the correct recovery actions with respect to loss of spent fuel pool cooling or loss of coolant inventory.

Radiological Controls

The assessment team examined design features and administrative controls that the potential radiation exposure of personnel during recovery from anticipated operational occurrences. The principle event considered was the unplanned loss of water from a spent fuel pool resulting in the loss of water shielding of non-fuel radioactive materials stored in the pool at elevations above the spent fuel racks and degradation of spent fuel shielding. Such an event could result in high radiation levels limiting access to the operating floor of the fuel building.

The team found that potential problems with respect to the storage of radioactive materials above the fuel racks were not significant at Ginna. The team noted that the licensee was not storing any radioactive materials above the fuel racks. The licensee had developed a procedure governing the storage of non-fuel materials in the spent fuel pool. The procedure required specific approval of such storage prior to the placement of any radioactive materials in the fuel pool for storage. The assessment team also noted that, with the exception of repositioning refueling gates, adding make-up water using local firehouse stations, and directly observing pool level, likely recovery actions for a loss of spent fuel pool coolant inventory can be performed from areas shielded from the stored irradiated fuel by concrete structures.

The team noted that alarm response procedures for high radiation levels on the operating floor of the auxiliary building or in the service water system discharge from the SFPCS heat exchangers referred to the site emergency planning procedures. The staff did not identify operating procedures to recover from or mitigate these events.

Reactivity Control

The team noted that solid neutron absorbers were used for reactivity control in the high-density region 2 fuel storage racks. These racks contained Boraflex panels in the side walls of storage cells. The licensee stated that degradation of the installed Boraflex panels was monitored by regular sampling of pool water for silica and monitoring of removable Boraflex coupons installed in the Point Beach spent fuel pool. The team concluded that the monitoring for Boraflex degradation may not provide results representative of actual conditions because of purification flow that removes silica from the pool water and the reliance on coupons located in a different environment.

Vulnerability to Sustained Loss of Spent Fuel Pool Cooling

Based on the risk assessment performed to evaluate the frequency of spent fuel pool boiling events at Susquehanna Steam Electric Station, the NRC staff determined that the probability of a spent fuel pool boiling event is related to the reliability of SFPCS components, the redundancy and diversity of the SFPCS, and the time available to recover from a loss of cooling prior to the onset of spent fuel pool boiling. The reliability of SFPCS components becomes most important when multiple components are necessary to satisfy functional requirements, such as periods of high heat load or high heat sink temperature where multiple heat exchangers and pumps may be necessary to prevent boiling. The redundancy and diversity of systems becomes important to avoid a loss of spent fuel pool cooling initiated by a single component failure or common failure modes. Finally, the time available for recovery determines the number of potential methods of recovery.

The assessment team examined the design of the SFPCS and its essential support systems. The team found that the reliability of SFPCS components at Ginna was high based on the quality and performance of the normally operating SFPCS loop 2. Redundancy was provided by back-up SFPCS loops, the availability of both on-site and off-site power sources to the primary SFPCS loop 2 and the back-up SFPCS loop 1, and redundant service water active components to support the SFPCS.

The time available to the onset of boiling was important for the Susquehanna evaluation in assessing the capability to initiate recovery action prior to developing adverse environmental conditions. The team determined that the time to the onset of boiling conditions in the Ginna spent fuel pool, assuming that the pool contained a recent full-core off-load and preceding refueling outage discharges from Ginna, may be as short as 8 hours based on an initial spent fuel pool temperature of 150° F. For smaller refueling discharges of approximately 40 assemblies, the team determined that the time to the onset of boiling conditions would exceed 24 hours at any credible time during a refueling outage. Operation cycles greater than 12 months in length, which the licensee was considering, would result in a larger number of fuel assemblies in each refueling discharge and a somewhat shorter time to the onset of boiling conditions in the spent fuel pool.

Based on the above considerations, the staff concluded that the probability of spent fuel pool boiling at Ginna was low. The construction of Ginna as a single unit site contributed to this conclusion by precluding the interaction of a spent fuel pool containing an entire core recently transferred from the reactor vessel with a reactor operating at power with significant decay heat removal requirements. The team noted that a loss of off-site power, which was the most significant contributor to near boiling frequency at Susquehanna, would be less significant at Ginna due to the availability of an on-site power source to support two of the SFPCS loops. Because manual operator actions in the reactor building were necessary to restore a method of spent fuel pool cooling, the team concluded that an improvement in abnormal operating procedures would enhance the ability to recover from a loss of spent fuel pool cooling event. Because the structural analysis of the spent fuel pool was performed at an assumed temperature of 180° F at Ginna, recovery of cooling before the pool temperature reaches 180° F would be necessary to satisfy the structure's design basis. The team concluded that short pool temperature transients above 180° F would be unlikely to cause serious structural damage to the reinforced concrete structure, but localized liner damage is credible.

If spent fuel pool cooling is not recovered before the onset of bulk boiling conditions in the spent fuel pool, the decay heat loads in the fuel pool and the reactor vessel would be important considerations. With the entire inventory of irradiated fuel assemblies transferred to the fuel pool from the reactor vessel, the decay heat load in the fuel pool would be at a maximum for the existing decay time, and reactor vessel decay heat removal systems would be unnecessary. The NRC staff has previously concluded that pool boiling adequately protects the spent fuel from damage caused by internal decay heat generation. Therefore, an adequate source of make-up to the spent fuel pool to keep the fuel covered with water is the only essential function when no irradiated fuel is in the reactor vessel.

The rate of water vapor evolution with the fuel pool boiling would be proportional to the decay heat load. Therefore, the environmental effects from pool boiling would be most severe with all irradiated fuel in the fuel pool. Because personnel access to auxiliary building areas that communicate with the area above the spent fuel pool was necessary to monitor fuel pool conditions following a loss of the SFPCS and provide make-up water from certain sources, pool boiling could interfere with the performance of these functions. However, the team concluded that innovative, unproceduralized methods could be implemented to perform these essential functions in the available time period. Consequently, the team found the risk from this scenario to be negligible at Ginna.

When irradiated fuel is present in the reactor vessel, decay heat removal from the reactor vessel becomes an additional essential function. However, the presence of irradiated fuel in the reactor vessel reduces the inventory of recently irradiated fuel in the spent fuel pool and significantly reduces the decay heat load in the spent fuel pool. Consequently, the time available to recover fuel pool cooling before the onset of boiling increases. Because the rate of water vapor production during pool boiling is lower when the most recently irradiated fuel is in the reactor vessel, the time from the onset of boiling to the development of adverse environmental conditions would be longer and the peak auxiliary building temperature would be lower with the reactor in operation than when all irradiated fuel is stored in the fuel pool. The team found safety-related equipment vulnerable to high concentrations of water vapor in the auxiliary building near the spent fuel pool. Therefore, although protection of certain essential equipment within the auxiliary building from adverse environmental conditions becomes important with irradiated fuel in the reactor vessel, the extended time to recover from a loss of fuel pool cooling or to protect equipment from adverse environmental conditions reduces the risk to irradiated fuel in the reactor vessel from spent fuel pool boiling events at Ginna.

Based on the above considerations, the staff concluded that the probability of spent fuel pool boiling at Ginna was low, and the probability of adverse environmental conditions caused by boiling resulting in degradation of essential systems necessary for safe shutdown and accident mitigation was also small. The team noted that a loss of off-site power, which was the most significant contributor to near boiling frequency at Susquehanna, would be less significant at Ginna due to the design capability of on-site power sources to support two of the SFPCS loops.

Vulnerability to Spent Fuel Pool Draining or Siphoning

Piping within a SFP may fail in a manner that creates a path to drain or siphon water out of the SFP to an extent the shielding and/or cooling are lost. Of particular concern are lines which extend or originate below the top of the stored fuel assemblies. Draining can be precluded by having all penetrations above an elevation which provides adequate shielding and cooling. If lines extend to lower pool elevations, siphon protection can be provided by siphon breaks or check valves.

The assessment team found that few paths for significant drainage of the pool were present. At Ginna, only the SFPCS lines extended into the spent fuel pool. The suction flow to the SFPCS was drawn through two separate suction pipes located at least 5 feet 4 inches above the top of the stored, irradiated fuel, and the suction piping travelled horizontally from the suction through the spent fuel pool wall. The SFPCS return lines ended in headers located near the bottom of the pool, but the return line was fitted with an anti-siphon hole located about 1 foot below the normal spent fuel pool level. The team concluded that the risk of siphoning or draining the SFP from piping systems connected to the SFP was minimal.

Potential alternate leakage or drain paths from the SFP would be a puncture of the liner (i.e., by a dropped object as in the Hatch event) or failure of the spent fuel pool gate or gate seal. Flow rate through a hole in the liner would be limited to seepage through the concrete and flow through the small diameter liner drain system. Combined flow would be limited to a value within the capacity of available make-up water systems. A variety of operator actions were available (e.g., isolating the liner drain path, adding water from the demineralized water supply, and using fire protection water) to mitigate this type of event. The team concluded that the frequency of a liner leakage event was moderate, but that potential operator corrective actions resulted in a low overall risk.

The gate that connected the spent fuel pool to the transfer canal was provided with a single pneumatic seal. The pneumatic seal was normally aligned to the instrument air system, with backup pressurization supply from the nitrogen system in planning. Failure of the gate or seal would create a drain path from the spent fuel pool to the transfer canal, but the transfer canal volume was small relative to the spent fuel pool volume such that only a small level loss would occur in the spent fuel pool with the transfer tube isolated and the transfer canal drains isolated. The spent fuel pool low level alarm was designed to alarm in the event of a gate failure, and operator action could terminate drainage through the transfer tube or drain lines by closing the respective isolation valve. Without any action, the fuel would remain covered because the bottom of the gate opening was above the top of the stored fuel.

For each of the preceding leakage scenarios, the team estimated that coolant inventory loss would be small. The team concluded that these events were unlikely to result in a rapid loss of coolant inventory. Therefore, the ability of the plant staff to implement corrective actions results in a low probability of a significant loss of spent fuel pool coolant inventory.

Conclusions

The assessment team concluded that the potential for a sustained loss of spent fuel pool cooling or a significant loss of spent fuel pool coolant inventory was remote at Ginna based on certain design features and operational controls. Specific features that contribute to the remote potential of a loss of spent fuel pool cooling or coolant inventory include: (1) the availability of multiple loops for spent fuel pool cooling, (2) the extended period available to recover from a loss of pool cooling prior to the onset of bulk boiling conditions in the pool when the associated reactor is operating at power, (3) the special controls on spent fuel pool cooling and support system capability when the reactor vessel fuel is completely transferred to the spent fuel pool, and (4) the anti-siphon protection provided for flow-paths capable of draining spent fuel pool coolant level below the top of stored fuel. However, the assessment team noted that, if spent fuel pool boiling conditions developed, an adverse environment could rapidly develop throughout the auxiliary building due to an absence of internal partitions, and operators would have difficulty monitoring pool conditions due to the limited capability of installed instrumentation outside of the auxiliary building. Additionally, the assessment team found that administrative controls on spent fuel pool make-up capability were absent and administrative controls did not direct analyses to verify decay heat removal would be adequate for refueling. Also, emergency response procedures related to spent fuel pool operations were written in a manner that would not reliably direct operators to appropriate recovery actions based on observed plant conditions. Finally, the team found the link between the design safety basis spent fuel pool cooling system heat exchanger capacity and fuel assembly inventory to be unclear.

GINNA FUEL POOL ASSESSMENT

Entrance Meeting - June 20, 1995

Rochester Gas & Electric
J. Widay, Plant Manager
J. Wayland, Manager, System Eng.
G. Wrobel, Manager, Nuclear Safety
J. Hotchkiss, Manager, Mech. Maint.
R. Marchionda, Supt., Production
J. Zulawski, Component Eng.
R. Eliasz, Sr. Nuclear Eng.
G. Hermes, Sr. Licensing Eng.
D. Klemz, Station Eng.
P. Bamford, Reactor Eng.

NRC
T. Moslak, Sr. Resident Inspector
S. Jones, NRR
C. Gratton, NRR

Exit Meeting - June 23, 1995

Rochester Gas & Electric
J. Widay, Plant Manager
J. Wayland, Manager, System Eng.
J. Hotchkiss, Manager, Mech. Maint.
R. Marchionda, Supt., Production
G. Hermes, Sr. Licensing Eng.
J. Cook, Manager, Scheduling
P. Bamford, Reactor Eng.

NRC
P. Drysdale, Sr. Resident Inspector
S. Jones, NRR
C. Gratton, NRR

2 Low Flow) referred to the emergency procedure for loss of spent fuel pool cooling. ER-SFP.1, Revision 4, "Loss of Spent Fuel Pit Cooling."

The procedure for loss of spent fuel pool cooling listed annunciators AR-K-29 and AR-K-21, low SFPCS pump discharge pressure, and no running SFPCS pumps as potential entry conditions. The procedure steps were arranged into three principal sections, in preferential order, beginning with SFPCS loop 2, then SFPCS loop 1, and, finally, the standby SFPCS loop. Entry into each section was determined by the loop initially in service. The procedure was written assuming that loop 1 would be operating only if loop 2 was unavailable and the standby loop would be operating only if loops 1 and 2 were unavailable. Each section directed the operator to perform the following steps as necessary:

1. Check operation of the in-service pump;
2. If the in-service pump has failed, operate the next less capable loop (or restore loop 1 or B if the standby SFPCS pump failed);
3. Check spent fuel pool temperature trend;
4. If the temperature has increased, place the standby loop in service or restore loop 1 or loop 2;
5. Check valve alignment;
6. Check service water flow if spent fuel pool temperature has increased;
7. Notify supervision if temperature has continued to increase.

The team noted that entry into procedure ER-SFP.1 would be directed following a low spent fuel pool level alarm or a loss of cooling loop suction flow caused by a significant loss of spent fuel pool coolant inventory. Despite these potential entry conditions, procedure ER-SFP.1 did not include measures to restore spent fuel pool coolant inventory. Also. the team did not identify a procedure addressing reduced SWS cooling capability.

Because the SFPCS pump B was designed to be shed from the safety-related bus 16 by a safety injection signal alone, and because SFPCS pump A was designed to be shed from MCC C by a loss of off-site power signal coincident with a safety injection signal, the team examined procedures expected to be entered by operators during events involving these signals. The team found that the emergency operating procedures (EOPs) and referenced procedures did not provide specific direction to restore SFPCS cooling water flow following these events. However, EOP:AP-ELEC.1, Revision 11, "Loss of 12A and/or 12B Busses," did direct that operators verify that alarm status is valid for plant conditions during equipment restoration from a loss of off-site power. Based on these observations, the team concluded that spent fuel pool cooling recovery actions would most likely be initiated through an alarm response rather than a preemptory recovery from events likely to initiate a loss of spent fuel pool cooling.