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September 28, 1995

MEMORANDUM TO: Gary M. Holahan, Director
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

FROM: Conrad E. McCracken, Chief
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Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

SUBJECT: SPENT FUEL POOL STORAGE ASSESSMENT FINDINGS AT GINNA

As part of our generic spent fuel pool action plan, we have completed on-site visits to four sites to gather information on spent fuel storage design features and practices for use in a qualitative assessment of spent fuel storage safety. The attached report provides assessment findings for the final planned on-site assessment conducted at Ginna from June 19-23, 1995.

The team concluded that the risks of either a sustained loss of spent fuel pool cooling event or a significant loss of spent fuel coolant inventory event were low. However, we identified potential improvements in administrative controls for availability of spent fuel pool make-up systems during refueling, analysis of spent fuel pool decay heat rate, and implementation of in-vessel decay time restrictions that would decrease the probability of inadequate forced cooling of the spent fuel pool during refueling. We also noted potential improvements in emergency response procedures for recovery from loss of spent fuel pool cooling or coolant inventory that may further reduce risk. Specific findings and recommendations are identified in the respective report areas.

In response to concerns regarding spent fuel pool design bases at Milltone, Unit 1, the team examined the basis for spent fuel pool cooling system heat exchanger capacity. We found that the safety analysis report design basis description did not adequately present the NRC staff's reliance on appropriate in-vessel decay prior to transfer of fuel to ensure the decay heat rate was within the capacity of spent fuel pool cooling system heat exchanger. This information was contained in licensing basis documents. We believe the licensee's next safety analysis update should include this information to clarify the design basis.

The team presented the basis for on-site assessment risk at an entrance meeting and the significant findings at an exit meeting at the plant site. We will transmit this report to Projects by memo for forwarding to the licensee.

Attachment: As stated

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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. Although 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

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.

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.

<u>Vulnerability to Spent Fuel Pool Draining or Siphoning</u>

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

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