March 25, 2003

Mr. J. A. Scalice
Chief Nuclear Officer
   and Executive Vice President
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, Tennessee 37402-2801

SUBJECT: SAFETY EVALUATION OF TOPICAL REPORT NO. 24370-TR–C-002, “RIGGING AND HEAVY LOAD HANDLING” (TAC NO. MB5370)

Dear Mr. Scalice:

On April 15, 2002, the Tennessee Valley Authority (TVA, the licensee) submitted Topical Report (TR) No. 24370-TR–C-002, “Rigging and Heavy Load Handling” to the U. S. Nuclear Regulatory Commission (NRC) staff, as supplemented by letters dated January 15, February 4, and February 19, 2003.

The enclosed NRC safety evaluation (SE) contains the NRC staff’s review. The NRC staff’s acceptance of this topical applies only to technical issues addressed in the TR. A license amendment that would allow the use of this TR by TVA at the Sequoyah Nuclear Plant Unit 2 was submitted in a letter dated July 10, 2002, as revised in a letter dated November 15, 2002, and is under NRC staff review. If the proposed amendment is accepted by the NRC staff, a separate safety evaluation will be issued to the licensee.

In accordance with the guidance provided on the NRC web site, we request that TVA publish an accepted version of this TR within three months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed SE between the title page and the abstract. It must be well indexed such that information is readily located. Also, it must contain in appendices historical review information, such as questions and accepted responses, and original report pages that were replaced. The accepted version shall include an "-A" (designated accepted) following the report identification symbol.

If the NRC's criteria or regulations change so that the conclusions in this letter are invalidated, thus making the TR unacceptable, TVA will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the TR without revision of the respective documentation.

If you have any questions concerning this matter, please contact me at (301) 415-2734.

Sincerely,

/RA/

Michael L. Marshall, Project Manager, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-327

Enclosure: Safety Evaluation

cc w/encl: See next page

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SEQUOYAH NUCLEAR PLANT

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR SAFETY EVALUATION OF TOPICAL REPORT NO. 24370-TR–C-002,

"RIGGING AND HEAVY LOAD HANDLING"

TENNESSEE VALLEY AUTHORITY

SEQUOYAH NUCLEAR PLANT, UNIT 1

DOCKET NO. 50-327

1.0 INTRODUCTION

In a letter dated April 15, 2002, as supplemented by letters dated January 15, February 4, and February 19, 2003. Tennessee Valley Authority's (TVA, the licensee) Sequoyah Nuclear Plant (SQN) submitted a topical report (TR) which provides details and evaluation of heavy load lifts over plant systems, structures, and components (SSCs), during the spring 2003 refueling outage. These heavy load lifts are associated with the Unit 1 steam generator replacement (SGR) project. TVA has identified that several of the heavy load lifts would be over various parts of SSCs, including the essential raw cooling water (ERCW) system. ERCW provides cooling water to various SSCs, including the emergency diesel generators (EDGs). The existing SQN Updated Final Safety Analysis Report (UFSAR) does not include an evaluation of the consequences of a load drop onto significant SSCs. Therefore, SQN developed and submitted TR 24370-TR-C-002, "Rigging and Heavy Load Handling," to address (1) safe load paths and procedures, (2) crane design, maintenance, and inspection, (3) load drops and consequences, and (4) compensatory measures necessary to provide reasonable assurance that heavy loads are handled safely. Specific compensatory measures were developed to provide reasonable assurance of the safe shutdown (SSD) of Unit 2 following a postulated accidental load drop that damages the ERCW.

The SQN Plant units are pressurized water reactors (Westinghouse Ice Condenser design) that operate with an ERCW system that supplies cooling water to both units. Water is supplied to the auxiliary building station from the ERCW pumping station through four independent sectionalized supply headers designated as 1A, 2A, 1B, and 2B. Four pumps are assigned to train A, and four to train B. The two headers associated with the same train (i.e., 1A/2A or 1B/2B) may be cross-tied to provide greater flexibility. The headers are equipped with isolation valves, such that a rupture in any header can be isolated and would not jeopardize the safety functions of the other headers.

During the Unit 1, Cycle 12 refueling and SGR outage, a nonsingle failure proof commercial crane (i.e., outside lift system) would be used to lift the original steam generators (OSGs) and replacement SGs (RSGs) through the top of the containment and concrete shield building. In

Enclosure

its evaluation of the handling of these heavy loads with the outside lift system (OLS), the licensee determined in the unlikely event that a heavy load was dropped, this accident could potentially damage both trains of ERCW in Unit 1, and affect certain safety-related systems of Unit 2 while it continues to operate during the Unit 1 SGR project.

2.0 REGULATORY EVALUATION

In U. S. Nuclear Regulatory Commission (NRC) Bulletin (NRCB) 96-02, "Movement of Heavy Loads over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment," dated April 1996, the NRC requested licensees planning to perform activities involving the handling of heavy loads over spent fuel, fuel in the reactor core, or safety-related equipment (e.g., ERCW), while the reactor was at power and that involve a potential load drop accident that has not been previously evaluated in the UFSAR, to submit a license amendment request to afford the NRC staff time to perform an appropriate review.

NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," dated July 1980, provides regulatory guidelines in two phases (Phase I and II) for licensees to assure safe handling of heavy loads in areas where a load drop could impact on stored spent fuel, fuel in the reactor core, or equipment that may be required to achieve SSD or permit continued decay heat removal. The Phase I guidelines address measures for reducing the likelihood of dropping heavy loads and provide criteria for establishing safe load paths, procedures for load handling operations, training of crane operators, design, testing, inspection, and maintenance of cranes and lifting devices, and analyses of the impact of heavy load drops. Phase II guidelines address alternatives for mitigating the consequences of heavy load drops, including using either (1) a single-failure-proof crane for increased handling system reliability, or (2) electrical interlocks and mechanical stops for restricting crane travel, or (3) load drops and consequence analyses for assessing the impact of dropped loads on plant safety and operations. NUREG-0612, Appendix C provides alternative means of upgrading the reliability of a crane to satisfy the guidelines in NUREG-0554, "Single Failure Proof Cranes for Nuclear Power Plants."

The basis for the guidelines in NUREG-0612 was to minimize the occurrence of the principal causes of load handling accidents and to provide an adequate level of defense-in-depth for handling heavy loads near spent fuel and SSD systems. Defense-in-depth was generally defined as a set of successive measures that reduce the probability of accidents and/or consequences of such accidents. In the area of control of heavy loads, the emphasis was on measures that prevent load drops or other load handling accidents. These measures include (1) use of rigorous crane design standards with substantial safety margins; (2) implementation of prudent maintenance, testing, and inspection guidance; (3) selection and use of appropriate lifting devices; and (4) establishment of crane operator training programs and heavy load handling procedures.

The licensee must show, and the NRC staff must find acceptable, that for postulated accident conditions the plant continues to meet dose limit guidelines given in Title 10 to the *Code of Federal Regulations* (10 CFR) Part 100 and 10 CFR Part 50, Appendix A, General Design Criteria (GDC)-19, Control Room. For assessing offsite dose consequences, the drop of an OSG was considered to most closely resemble rupture of a tank containing radioactive material. Additional guidance on assessing the consequences of a waste gas tank rupture may be found in Branch Technical Position (BTP) ETSB 11-5, "Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure" (July 1981), which establishes an offsite whole body dose limit of 0.5 rem. This dose limit was consistent with the guidelines that existed at the time of the

BTP issuance in 10 CFR Part 20 for a unique unplanned release, and was substantially below the 10 CFR Part 100 guideline value. Part 20 of 10 CFR has been revised since that time.

3.0 TECHNICAL EVALUATION

Safety-related SSCs such as the (1) Unit 1 ERCW supply piping and Train A discharge piping, (2) Unit 2 ERCW supply piping, and (3) ERCW ductbanks could potentially be damaged during postulated heavy load drops during the Unit 1 SGR outage. The bounding heavy load operation during the outage is the 16-hour period when the SGs are lifted. Damage from an SG load drop onto the ERCW could result in a loss of safety function for Unit 2. Also, the following SSCs could be indirectly affected by a postulated heavy load drop:

- EDGs,
- Train A auxiliary air compressor,
- Main control room chillers,
- Electrical board room chillers,
- Component cooling system pump space coolers,
- Train A 6.9 kilovolt (kV) shutdown board room chiller, and
- Cooling to auxiliary building gas treatment system.

Therefore, dropping an OSG/RSG onto the Unit 1 ERCW could damage the supply piping to both ERCW trains and the Train A discharge piping. As a result, the plant would no longer meet the single-failure criteria of 10 CFR Part 50, Appendix A. As part of its TR, the licensee developed specific compensatory measures to deal with an OSG/RSG load drop.

The NRC staff reviewed the licensee submittal for acceptability of selected safe load paths, crane design and selection, postulated heavy load drop analyses, load handling procedures, regulatory commitments, compensatory measures, and dose consequences from a postulated SG drop.

3.1 Heavy Loads and Rigging

The TVA heavy load control measures for the SQN are presented in TR 24370-TR-C-002, "Rigging and Heavy Load Handling," as supplemented by letters dated January 15, 2003, and February 4, 2003, provide the technical justification for handling heavy loads over safety-related SSCs. The review of the proposed operation during the Unit 1, Cycle 12, refueling and SGR outage focuses on the procedures for controlling heavy loads, compensatory measures, crane design, and similar operating experience for commercial cranes lifting similar loads. The following evaluation was based on the material presented in the TR, supplementary information, discussions with TVA, and responses to requests for additional information.

The licensee evaluated the proposed handling of the Unit 1 SGs with respect to the applicable guidelines in NUREG-0612 as discussed below.

3.1.1 Safe Load Path

Primary reliance for safe load handling during the proposed replacement of the SQN Unit 1 SGs was placed on the rigging/OLS, mobile Manitowoc cranes for assembly/disassembly of the OLS, and the transporter used to handle and control the SGs to and from the SG storage facility. The SGs are considered critical loads in accordance with NUREG-0612 and

NUREG-0554, since they would be carried over the Unit 1 shield building and over safety-related SSCs that support both SQN Unit 1 (defueled) and SQN Unit 2 (operating at full power). The licensee provided information regarding the safe load path for the (1) OLS (i.e., Mammoet PTC Heavy Lift Crane), (2) Manitowoc mobile (lattice boom and truck) cranes used for assembly disassembly of the OLS, and (3) the transporter used to haul the OSGs and RSGs to and from their storage locations. According to the licensee, movement of an OSG along the load path (from the time the lifted load clears the shield building dome to the transporter), where potential interaction with the safety-related SSCs could occur, would take approximately 2 hours. The same 2-hour time frame was anticipated for the lift and transfer of an RSG once upended from the transporter to the containment dome opening. The resulting total time to move the OSGs and RSGs between the transporter and the containment dome opening was approximately 16 hours. The 16-hour time estimate represents the total time when the SGs would be in a position to drop and potentially damage safety-related SSCs within the designated safe load path.

Assembly and disassembly of the OLS would be conducted utilizing mobile cranes. The safe load path for the mobile cranes during assembly/disassembly was around the OLS boom. To ensure adequate protection of SSCs along the designated safe load path, the licensee indicated that the following operating restrictions for the mobile cranes would be imposed:

- Load handling with the mobile cranes was limited to an approved area around the OLS boom location [and was identified on site drawings].

- The load imposed on the ground by the crane was limited to the calculated allowable ground bearing pressure of 4 [kips per square foot (ft)].

  Timber mats would be placed [as indicated on site drawings] over safety-related utilities (ERCW pipes).

- Loads traveling over safety-related [SSCs] shall be carried as low to grade as possible. Loads up to 50 thousand pounds may be lifted up to 20-ft above safety-related SSCs as long as the safety-related SSCs are protected with [one-ft] of timber mat. Handling of loads in excess of 50 [thousand pounds] over safety-related SSCs requires engineering evaluation and approval prior to commencement of the lift.

The operating restriction requiring engineering evaluation for heavy loads carried in excess of 50 thousand pounds is consistent with the guidelines of NUREG-0612, Appendix A, “Analyses of Postulated Load Drops.”

A transporter will haul the RSG/OSG approximately 2,180 ft between the lay-down area and the storage location. Also, the transporter will operate at a speed less than 5 miles per hour (mph) while hauling an OSG/RSG between these two locations. The licensee provided supplemental information stating that the haul route would be load tested using a weight equal to or greater than that of a loaded transporter to identify “soft spots.” Consequently, the licensee has committed to load testing the entire haul route prior to SG transport to ensure the stability of the haul route. Therefore, the NRC staff finds the load testing and any necessary repairs made from the identification of soft spots acceptable to ensure the stability of the haul route.

The NRC staff concludes that the designated safe load paths have been identified in a manner consistent with the guidelines in NUREG-0612, and therefore, are acceptable. Additionally, the designated safe load paths, to the extent practical, avoid potential interactions between the SGs and safety-related SSCs.

3.1.2 Transfer/Hoisting System

NUREG-0612 Phase I guidelines address measures for reducing the likelihood of dropping heavy loads and, in part, provide criteria for the design, inspection, maintenance, and testing of cranes and lifting devices in Section 5.1.1(4), "Special Lifting Devices," 5.1.1(5), "Lifting Devices that are not specially designed," and 5.1.1(7), "Crane Design." Section 5.1.1(7) states that the crane should be designed to meet the applicable criteria and guidelines of Chapter 2-1 of the American National Standards Institute (ANSI) B30.2-1976, "Overhead and Gantry Cranes" and of the Crane Manufacturers Association of America (CMAA)-70, "Specifications for Electric Overhead Traveling Cranes." This section also states that alternatives to the above specifications/criteria may be accepted as long as the intent of the specification was satisfied. The cranes proposed for the SGR outage are mobile type cranes.

3.1.2.1 Outside Lift System

Rigging and lifting of the OSGs and RSGs would be performed by the OLS, in part, by following the load handling procedures which are discussed in more detail in Section 3.1.4 of this safety evaluation (SE). The OLS would arrive at the Sequoyah site in standard containers. These containers will then be moved to the OLS assembly/disassembly area on tractor trailers, where assembly/disassembly would be conducted in accordance with the manufacturer's instructions. The licensee stated that they plan to assemble/disassemble the OLS while SQN Units 1 and 2 were in any mode or defueled condition.

The OLS was a commercially designed crane that has a maximum load capacity of 1763.2 tons, however this capacity would vary with crane configuration and lift radius. The licensee's TR for the SQN SGR stated that the rated load for the proposed crane configuration ranges from 440.8 tons to 517.9 tons, depending on the lift radius. The licensee stated that the OLS would be supported on top of an 8-ft wide, 78.5-ft outer diameter concrete ring foundation with a 4-ft thick integral concrete cap supported by 80 piles driven to bedrock. The crane base would be supported on 24 independent jacks, which are seated on top of the pile cap.

Since the OLS is a mobile type crane, certain criteria specified in NUREG-0612 may not be applicable to the design, load handling, testing, inspection, operator training, and maintenance of the OLS. Consequently, the licensee, in the TR, identified ANSI B30.5-1968, "Crawler, Locomotive, and Truck Cranes," as an alternative to the maintenance, testing, inspection, and operator training criteria identified within the guidelines of NUREG-0612. Because the guidance in ANSI B30.5-1968 meets the intent of NUREG-0612, the NRC staff found this to be an acceptable alternative to the ANSI B30.2-1976 requirements identified in NUREG-0612.

The TR stated that lifting devices and lifting devices that were not specially designed, do meet the requirements of the American Society of Mechanical Engineers (ASME), Nuclear Quality Assurance (NQA)-1-1997, Subpart 2.15, "Quality Assurance Requirements for Hoisting, Rigging, and Transporting of Items for Nuclear Power Plants." The licensee provided information concerning the OLS safety devices and the alternative design criteria which the OLS satisfies. The licensee indicated that the OLS design included the following safety features:

- Anti two-block switch which prevents raising the lifting block into the boom tip.

- Boom back stop switch which prevents the boom from being boomed back too far.

- Jib preventer switch which keeps the jib from being boomed up too far.

- Minimum and maximum radius switches that would be set during erection based on the load path for loads to be moved.

- Load cells to indicate the lifted load and the load cells would be tested after erection of the OLS during a system load test.

- Safe load indicator (SLI) system which was tied into the load cell and the min/max radius switches and the SLI would not allow the OLS radius to extend beyond the crane chart capacity for the lifted load.

Also, the licensee indicated that the OLS originally scheduled for operations during the outage would not be available and that a second crane with similar design specifications with similar or greater safety margins would be utilized. Subsequently, the licensee provided the NRC staff with a comparative analysis of the OLS and the replacement Platform Ring Heavy Duty (PRHD) crane (i.e., alternate OLS). The replacement OLS was designed and manufactured by the same company. The licensee stated that the OLSs (proposed and replacement) design satisfies the criteria of ASME NQA-1-1997, Subpart 2.15 (or ANSI/ASME N45.2.15, “Hoisting, Rigging, and Transporting of Items for Nuclear Power Plants”). The NRC staff found that the proposed and replacement OLS safety devices and alternative criteria in ANSI B30.5-1968 and ASME NQA-1-1997, Subpart 2.15, satisfies the intent of NUREG-0612 as an alternative and is, therefore, acceptable.

The OLS was not designed to withstand the external events addressed by 10 CFR Part 50, Appendix A, GDC 2, that are part of the SQN design and licensing basis. Since the OLS was not necessarily required to meet the design and licensing basis for external events at SQN, the NRC staff reviewed the robustness of the OLS design and its ability to withstand a design basis event such as an SSD earthquake during heavy load handling operations. A seismic analysis was performed for the OLS by the licensee. The seismic evaluation of the OLS was based on dynamic model analysis using response spectra method with a GT-STRUDL 3-D lumped mass finite element model. The model also included the soil-structure interaction effects at the OLS ring foundation. In addition, the horizontal spectra corresponding to the plant’s safe shutdown earthquake (SSE) design basis spectra, input at the ground surface, were incorporated into the seismic analysis of the OLS. The magnitude of the vertical spectrum was two-thirds of the magnitude of the horizontal spectrum. The NRC staff found the licensee’s input spectra and their location proper and the overall approach to the seismic analysis of the OLS acceptable, as it was consistent with the UFSAR. The NRC staff also found the use of GT-STRUDL computer program for the OLS analysis acceptable because the program was in the public domain and capable of performing such an analysis.

The licensee analyzed three critical crane configurations based upon lift radius and load which envelop all possible crane configurations allowed by the min/max radius switches. The min/max radius was set to the specified load path prior to load handling operations. Each of the critical crane configurations was analyzed with and without the lift load. The critical crane configurations are as follows: (1) a lift radius equal to 23.2 meters (m) and a lifted load that includes the maximum weight of a SG; (2) a lift radius equal to 55 m and a lifted load of the maximum weight of an SG; and (3) a lift radius equal to 83.5 m with a lifted load of 250 tons. The seismic analysis of the three critical crane configurations included a load combination of the dead weight (D), lifted load (L), and SSE as an input to the analysis. The analysis results are indicated as follows:

- Maximum axial stress in the chord of the superstructure lattice frame mast components was 54.4 kips per square inch (ksi) against the yield strength of 101.4 ksi.
- Maximum axial stress in the diagonal bracing of the superstructure lattice frame mast components was 26.6 ksi against the yield strength of 66.6 ksi.
- Maximum combined axial and bending stress in a base component, such as longitudinal beams, was 79.1 ksi against the yield strength of 101.4 ksi, and
- Maximum bearing stress in a connection was 78.1 ksi against the yield strength of 101.4 ksi.

The licensee performed an OLS stability check for overturning and sliding. The overturning moment (Mo) was the maximum base moment reaction obtained from the analysis for the D+L+SSE load combinations. In the response the licensee stated that overturning can occur about the edge of the jack cylinders located at a radius of 11.75 m from the center of the crane. In addition, the resistance moment (Mr) was computed as the minimum vertical reaction obtained at the crane base for the D+L+SSE load combination times the radius. The results of this analysis, which include the three critical locations, were completed assuming no load or load on the OLS considering the 1300 ton counterweight system, are listed below:

- Configuration I - No Load: Mo = 126,180 kip-foot (k-ft) Mr = 142,586 k-ft
- Configuration II - No Load: Mo = 92,273 Mr = 143,820 k-ft, and With Load: Mo = 105,391 k-ft Mr = 170,046 k-ft
- Configuration III - With Load: Mo = 138,840 k-ft Mr = 160,952 k-ft

For the condition of crane sliding, the computed sliding forces are 1,483 kips for configuration I with no lift load, 1,395 kips with no lift load and 1,371 kips with lift load for Configuration II, and 1,408 kips with no lift load for Configuration III while the computed sliding resistance forces are 2,306 kips for Configuration I with no lift load, 2,326 kips with no lift load and 2,750 kips with lift load for configuration II, and 2,332 kips with no lift load for configuration III. The licensee concluded that the OLS was strong and stable and would not result in any seismic II/I issues because its structural members/connections would not yield, and the crane would not overturn or slide during an SSE. The NRC staff agrees with the licensee’s conclusions and approach to the OLS stress and stability analysis as the strength, stability, and sliding analysis performed demonstrate that the OLSs structural integrity would be maintained under the load combinations, which are consistent with the UFSAR.

The NRC staff finds that the licensee has used an acceptable approach to perform the seismic analysis for the OLS, to input seismic motions to the OLS mathematical model, and to select critical OLS configurations to complete the stress and stability analysis. The analysis results demonstrate that the stresses in the structural members/connections of the OLS are less than the yield stress of the materials, the resistance moments are always greater than the overturning moments, and the sliding resistance forces are always greater than the sliding forces under the condition of D+L+SSE loading combinations for all OLS load handling configurations. The NRC staff found that the amplified ground motion and response spectrum applied to the OLS in the seismic analysis was consistent with the UFSAR and was acceptable. The NRC staff agrees with the licensee's conclusion that the OLS was strong and stable and would not result in any seismic II/I issues for the SQN Unit 1 SGR. Therefore, the NRC staff finds that the OLS design meets the intent of 10 CFR Part 50, Appendix A, GDC 2, and satisfies the guidelines of NUREG-0612 for handling the proposed heavy loads.

3.1.2.2 Comparative Analysis of Replacement OLS

In the January 15, 2003, letter, the licensee indicated that the OLS originally scheduled for operations during the outage would not be available, and that a second crane with similar design specifications with similar or greater safety margins would be utilized. The licensee, in a letter dated February 4, 2003, provided the NRC staff with its comparative analysis concerning the replacement OLS. The licensee stated that the stiffness properties of the major structural components (main mast, jib, back mast, stay beams, longitudinal beams, etc.) are generally equivalent or better for the [replacement OLS]. The licensee indicated that the similarity in dynamic response for the SSE had been demonstrated via calculation 24370-C-026, Revision 1. In addition, the licensee stated that considering the large geometry and mass of the crane system, any differences were not sensitive enough to cause any significant change in the structural/dynamic response characteristics of the replacement OLS versus the originally proposed OLS.

The NRC staff, in its review of the matrix for the proposed and replacement OLS noted the following differences:

Description	PTC Crane (proposed)	PRHD Crane (replacement)	Comments
Mast Head Capacity	1600 tonnes (metric)	2000 tonnes (metric)	PRHD has better mast head capacity
Outrigger plates (Request for Additional Information (RAI) 14, topical report Section 5.1)	21.5 m diameter ringer base mounted on 24 jacks, self leveling	21.5 m diameter ringer base mounted on 48 jacks, self leveling	Increased number of jacks/out-rigger plates enables better load distribution and minimizes foundation bearing pressures
Main chords or main mast, jib, back mast and stay beams	StE 690 (Fy=101.4 ksi)	StE 690 (Fy=101.4 ksi)	Material of all structural components was the same.
Bracings of main mast, jib, back mast and stay beams	StE 460 (Fy=66.6 ksi)	StE 460 (Fy=66.6 ksi)	
Base Components: Longitudinal beams, cross beam, winch beams, ballast trays, base ringer	StE 690 (Fy=101.4 ksi)	StE 690 (Fy=101.4 ksi)	

Description	PTC Crane (proposed)	PRHD Crane (replacement)	Comments
Vertical height of crane center of gravity	13.94 m	11.14 m	The cg of the PRHD crane was lower by 9 ft. This was favorable for stability (overturning) of the crane under seismic loads.
Minimum tipping factor of safety (FOS) associated with the safe working load specified in the crane rated load capacity charts (includes effect of permissible operating wind speed) RAI 14, 35	1.25	1.3	PRHD has a better FOS against tipping
Rated load capacity for the range of heavy lifts for the SQN SGR Project as stated in topical section 5.1	440.8 tons to 517.9 tons	465.2 tons to 554.6 tons	PRHD has a higher rated load capacity that the PTC for the range of SGR lifts

Also, the licensee evaluated the replacement OLS by modifying the GT-STRUDL model to incorporate the changes in the replacement OLS geometry, mass and stiffness from that of the proposed OLS and ran the response spectrum analysis for the new configuration for stability. The difference in overturning and resistance moments between the two OLSs was of the order of 5 percent, which was insignificant according to the licensee. The FOS against overturning improved for the replacement OLS. The difference in sliding and resistance forces between the two OLSs was of the order of 5 percent, which again the licensee stated was insignificant.

The staff reviewed the results of the comparative analysis and found that the replacement OLS stress and stability analysis compared favorably to the proposed OLS. The analysis results demonstrated that the stresses in the structural members/connections of the replacement OLS were less than the yield stress of the materials, the resistance moments are always greater than the overturning moments, and the sliding resistance forces were always greater than the sliding forces under the condition of D+L+SSE loading combinations for the critical replacement OLS load handling configurations. The NRC staff agrees with the licensee's conclusion that the replacement OLS was strong and stable. Consequently, the NRC staff finds that handling of heavy loads utilizing the replacement OLS acceptable. The NRC staff finds that the OLS design meets the intent of 10 CFR Part 50, Appendix A, GDC 2 and satisfies the guidelines of NUREG-0612 for handling the proposed heavy loads.

3.1.2.3 Mobile Cranes for Assembly/Disassembly of the OLS

Mobile cranes would be used to assemble and disassemble the OLS. The licensee, in its TR, stated that the mobile cranes used to erect and disassemble the OLS were commercially designed, ruggedly constructed, cranes with a main boom that is stabilized using a counterweight system. Further, the licensee indicated that the mobile cranes satisfy the ANSI B30.5-1968 requirements.

NUREG-0612 allows alternatives to the ANSI B30.2-1976 and CMAA-70 criteria as long as the alternative criteria satisfy the intent of the NUREG-0612. The proposed alternative, ANSI B30.5-1968, specifies criteria for the construction (which include stability, load rating capacity, and hoist mechanism), inspection, test, maintenance, and operation of the mobile cranes. ANSI B30.5-1968 is consistent with the Phase I guidelines of NUREG-0612. Therefore, the NRC staff finds that the proposed alternative criteria in ANSI B30.5-1968 is acceptable for the mobile cranes during the assembly and disassembly of the OLS.

The mobile cranes are not designed to withstand the external events addressed by 10 CFR Part 50, Appendix A, GDC 2 that are part of the SQN design and licensing basis. Since the mobile cranes are not necessarily required to meet the design and licensing basis for external events at SQN, the NRC staff reviewed the stability of the mobile cranes and the protection of safety-related SSCs, in the vicinity of the OLS assembly/disassembly area, in the unlikely event of an SSE.

The licensee indicated that specific measures would be taken and regulatory commitments would be implemented to ensure the protection of any SSCs that may be affected if a mobile crane were to drop its load during a seismic or any other event during the SGR project. Further, the licensee revised the TR to state that mobile crane usage beyond 60-ft from the OLS boom location may only be allowed if engineering evaluation shows no adverse impact to nearby safety-related SSCs. The NRC staff found the licensee's approach to conducting an engineering evaluation prior to using the mobile cranes outside the specified load path to be acceptable. Completing an engineering evaluation on loads to be carried outside the load path that may potentially affect safety-related SSCs is consistent with NUREG-0612.

3.1.3 Analysis/Consequences of Drop Accidents

The licensee stated that the SSCs in the vicinity of where the OLS would be erected and disassembled are the ERCW system piping, refueling water storage tank, and fire protection piping. Further, the licensee stated that to ensure adequate protection of those SSCs within the assembly/disassembly area certain restrictions would be placed on mobile crane operations. For example, timber mats would be placed over safety related utilities, loads traveling over safety-related SSCs would be carried as low to grade as possible, and loads up to 50,000 pounds may be lifted up to 20-ft above safety-related SSCs as long as those SSCs are protected with one ft of timber mat.

3.1.3.1 Impact of Load Drop Accidents during OLS Assembly/Disassembly

The mobile cranes are not designed to withstand the external events addressed by 10 CFR Part 50, Appendix A, GDC 2 that are part of the SQN design and licensing basis. However, if an external event were to occur during assembly/disassembly of the OLS, the mobile cranes could potentially drop their lifted load and damage certain SSCs. The NRC staff questioned what SSCs could be affected during OLS assembly/disassembly and what processes or procedures would be used to ensure that mobile crane operations were conducted in a safe manner.

With respect to the fire protection piping, the NRC staff was concerned if the fire protection piping was damaged, could the system still perform its intended function in accordance with the UFSAR. The licensee indicated that the underground fire protection piping in the yard area was evaluated for the surcharge (bearing pressure) loads created by the mobile cranes. The results of the licensee's evaluation determined that the surcharge loads from the cranes did not adversely affect the piping. Further, the fire protection system design criteria provide sectionalizing valves to isolate system faults. Consequently, a fault in the system piping resulting from a load drop was no different from a fault created by other means. Albeit, the fire protection system design criteria only allow one section of the auxiliary building fire protection system ring header to be out of service in order to perform its intended safety function. Since this piping segment was in the yard, there was no impact on operation of the high pressure fire protection system from isolating a fault that occurs in the system from a postulated heavy load drop during OLS assembly/disassembly. Therefore, the NRC staff found that the restrictions on mobile crane operation, the engineering evaluation for loads over those analyzed within the mobile crane load path, and the protective measures used during the erection and disassembly was acceptable, because they satisfy the guidelines of NUREG-0612.

3.1.3.2 Analysis/Consequences of OLS Test Load Drop

ANSI B30.5-1968, Section 5-2.2.2, "Rated Load Test," requires the OLS to be load tested at 110 percent of the rated load at any selected radius. The OLSs maximum rated load capacity was approximately 1763.2 tons (1600 metric tons). Following assembly of the OLS, the OLS would be tested to 110 percent by lifting a 275-ton test load assembly with the OLS boomed out to a radius where the test load represents 110 percent of the OLS chart capacity at that radius. The completion of the OLS load test requires the 275-ton test load to travel over safety-related SSCs (i.e., ERCW). The ERCW is common to both units and provides cooling water to other safety-related plant equipment. NUREG-0612 states that licensees should address the potential for dropping heavy loads and damaging equipment in redundant or dual SSD paths, and that licensees should demonstrate that these postulated drops would not result in loss of required SSD functions. This was also the subject of NRCB 96-02 for plants carrying heavy loads that could potentially result in a loss of SSD function during operations.

The NRC staff questioned whether a postulated load drop during the OLS testing would result in a loss of ERCW safety function for any operating unit. The licensee indicated that the test load would be limited to 2-ft above grade so that underground utilities, such as the ERCW, would not be detrimentally affected if a drop occurs. In addition, the licensee provided supplemental and clarifying information regarding its analysis/measures that support its 2-ft lift restriction on the test load. The licensee stated that the ERCW pipes in the area of concern have an 18-inch thick concrete slab for missile protection near grade level. Additionally, the missile protection has been qualified for several missiles and impact velocities in accordance with the UFSAR. As a result, the energy impact from a 2-ft test load drop was approximately equal to the maximum energy for which the missile protection slab was tested and found adequate. Further, a soil pressure of approximately 3.5 kips per square foot (or 25 pounds per square inch) on the pipe would result in a hoop stress in the pipe of 1.5 ksi against a yield strength of 32 ksi. Consequently, the structural integrity of the ERCW pipe would be maintained following a postulated drop of the OLS test load.

The licensee's load handling procedures which include (1) a test load height restriction of 2-ft over the ERCW piping, (2) engineered barrier (missile protection) over the ERCW piping, and (3) its calculation of the resulting stresses, which are less than the yield stress of the ERCW piping, provide a reasonable assurance that test loads traveling over the ERCW in accordance with the load handling procedures should not result in a loss of ERCW safety function if the load were to drop. Therefore, the NRC staff finds that the licensee's load drop and consequence analysis for the OLS test load satisfies the guidelines of NUREG-0612.

3.1.3.3 Analysis/Consequences of SG Drop in Vicinity of the Unit 2 ERCW Piping

The postulated heavy load drop involved dropping the SG while traversing the load path segment above the dome at or near the parapet along the peripheral circumference resulting in a first impact near the dome periphery or parapet and then falling over to the ground. Although, the drop distance, including the flop-over fall of an OSG/RSG, would be approximately 63-ft away, the energy impact and the subsequent surface/subsurface vibrations could potentially affect the Unit 2 ERCW. The evaluation methodology used by the licensee included:

- Determining the peak particle velocity of the soil at the location of the pipe,
- Determining the free field soil pressure at the pipe-soil interface, and
- Evaluation of the buried pipe based upon the free field soil pressure on the pipe.

The licensee's evaluation of the pipe stresses resulting from the impact and resultant soil vibrations included the following conservatisms:

- The internal pressure of water in the ERCW pipe (design pressure was 160 pounds per square inch gauge), which counteracts the effects of shock wave loading, was neglected.
- Although the design thickness of the pipe wall was 0.375 inches ("), the pipe wall thickness was taken as 0.3125" in the calculation.
- The load path for the SGs when they are near the periphery of the dome was in a northerly direction. Due to slope of the dome, the direction of the swing, and configuration of the channel end nozzles, the direction of fall was likely to be in a northerly direction in which case the distance of the impact location from the ERCW pipes would be well over 100-ft. However, it was postulated that the fall takes place in an easterly direction, thereby reducing the distance of impact location to the Unit 2 ERCW pipes to 63-ft. The distance used in the computations was 60-ft. Hence, the distance of the computations was quite conservative.
- The scaled energy equation as applied to the response of high energy impact was conservative.
- The time taken for the SG to traverse the load path above the dome near its periphery would be small (approximately 5 minutes for each lift). Therefore, the time duration during which the postulated drop was plausible was very small.

In the evaluation, the licensee assumed a maximum deflection of 10-percent under the resulting shock wave (vibration) loading which allows a reasonable margin of safety against failure/collapse of the pipe. The licensee stated that this criterion was conservative given that the internal pressure of the pipe (which would counteract the wave loading) was neglected. The circumferential stress in the pipe was estimated to be 22.75 ksi against the ERCW pipe minimum yield strength of 32 ksi.

The staff finds that the licensee's evaluation methodology is adequate approach to (1) perform the impact analysis for the OSG/RSG drop in the vicinity of the Unit 2 ERCW piping; and (2) to conservatively select the inputs to resolve the peak particle velocity into a resultant stress at the pipe from the shock waves resulting from the impact on flop-over fall. The analysis results demonstrate that the structural integrity of the Unit 2 ERCW piping would be maintained even if the OSG/RSG were to fall as postulated in the analysis.

3.1.3.4 Analysis/Consequences of SG Drop Over Containment

The potential exists for the licensee to drop an OSG/RSG onto the Shield Building dome. The licensee's TR stated that SGs would be hoisted up to 20-ft above the dome during the SGR refuel outage. Prior to moving heavy loads, Unit 1 would be defueled and the spent fuel pool (SFP) pit would be isolated from containment. According to the licensee, once these activities are completed a load drop from the OLS inside or above containment would not result in (1) release of radioactive material due to damage to spent fuel, (2) damage to fuel or fuel storage racks, or (3) damage to the reactor vessel or SFP that causes a loss of water and subsequent uncovery of the fuel.

The licensee indicated that the common systems that could be affected from an SG drop in containment were the ERCW system, component cooling water (CCW) system, and the control air system. As part of its load handling procedures and compensatory measures the licensee indicated that the isolation valves outside containment for the CCW and ERCW would be closed prior to lifting heavy loads. Closure of these valves ensures that the ability to safely shut down Unit 2 would not be affected.

Further, the licensee indicated that, if an SG were to roll off of the dome, it could potentially hit the Auxiliary Buildings and impact the SFP and/or equipment required to safely shutdown Unit 2. Moreover, the consequences of an SG drop onto the Auxiliary or Control Buildings requires that the handling of the SGs be done in a manner that if a drop occurs it penetrates the dome rather than rolls off of it. The NRC staff agrees with the licensee's rationale, as it aims to protect safety-related SSCs required to support safe operations of Unit 2 and it avoids, to the extent practical, the impacting of the fuel stored in the SFP. The NRC staff finds the minimum hoisting limit of 20-ft above the dome and isolation of shared SSD equipment between Unit 1 and Unit 2 satisfies the guidelines and evaluation criteria of NUREG-0612.

3.1.3.5 Analysis/Consequences of SG Drop Over ERCW Ductbanks

The NRC staff evaluated ERCW equipment that could potentially be affected by an SG drop onto the ductbanks in the load path prior to placement on the SG transporter. The ductbanks of concern were (1) the ductbank between manhole MH12 and handhole HH3 (called ductbank DB1) and (2) the ductbank between manhole MH12 and handhole HH29 (called DB2). The NRC staff questioned the licensee's rationale for the load traveling height, as well as requested the licensee to describe how its evaluation of the potential consequences of an SG drop onto the referenced ductbanks satisfy the guidelines of NUREG-0612.

The licensee stated that a flop-over fall after a postulated SG drop from a height of 3-ft above grade, was the load drop that causes the most severe impact to the ERCW duckbanks. The licensee evaluated the worse-case locations along the SG load path for impacting the ductbanks. The critical response parameter for failure of the ductbanks was determined to be the bending moment. The maximum bending for DB1 was determined to be 535 kip-ft against its ultimate capacity of 608 kip-ft. The maximum bending moment under impact for DB2 was determined to be 368 kip-ft against its ultimate capacity of 597 kip-ft. However, using a minimum grade above DB1 of 704.5 ft indicated that the bending moment exceeded the ultimate capacity slightly. Therefore, it was chosen to raise the grade level above both ductbanks to 707 ft in the fall zone of a SG. The licensee also stated that timber mats could be used as an alternative to fill. Therefore, the ductbanks should be provided with protection in the form of earth fill or timber mats within the fall zone prior to OSG/RSG load handling to avoid potentially unacceptable consequences from an OSG/RSG drop onto the ductbanks (particularly DB1).

The staff agrees with the licensee's analysis, and finds its compensatory measures of adding earth fill (or the placement of timber mats) would ensure that the structural integrity of the ductbanks was maintained in the event of an OSG/RSG drop.

3.1.3.6 Impact of SG Drop Accident along the Haul Route

The NRC staff, in its review of the TR, was concerned about the stability of the OSG/RSG haul route used by the transporter and the potential of a dropped SG to interact and damage safety-related equipment along the route. A review of the haul route identified SSCs such as the ERCW ductbanks and 36-inch diameter ERCW piping in the vicinity of the route.

Although the SG transporter was not specifically designed to withstand external events addressed by 10 CFR Part 50, Appendix A, GDC 2, which are part of the facilities' design basis, the likelihood of an event occurring when the transporter was near safety related SSCs was extremely low. To ensure the stability of the haul route and provide an additional margin of protection for identified SSCs along the route the licensee stated that it would (1) load test the entire haul route prior to the SG transport, (2) place 2.5 ft of sand fill (or equivalent) along the ERCW pumping station access road, and (3) place 2.5 ft of wood cribbing along the perimeter to protect various manhole/handhole groups. The NRC staff reviewed the licensee's compensatory measures to protect various safety-related equipment along the haul route and its haul route stability test measures and found them acceptable. The NRC staff found them acceptable because the stability test and compensatory measures provide an increase margin of protection to an already unlikely load drop event that would have a negligible effect on the SSD capability of Unit 2.

3.2 Compensatory Measures to Support/Recover Unit 2 ERCW

The licensee included several regulatory commitments and compensatory measures in their submittal. These regulatory commitments and compensatory measures described a number of prerequisite actions to heavy load movement, active monitoring during heavy load movement, and protective actions in the unlikely event of a heavy load drop. Most of the regulatory commitments and compensatory measures are intended to avoid or minimize unacceptable consequences (e.g., damage to ERCW ductbanks) from a postulated SG drop or restore the operation of safety-related SSCs in the unlikely event of a SG drop.

Having reviewed the licensee's regulatory commitments and compensatory measures to ensure continued safe operations and the capability to safely shutdown Unit 2, the NRC staff finds that in the event of an SG drop, the proposed regulatory commitments and compensatory measures provide reasonable assurance that: (1) the Unit 2 ERCW system would continue to receive its design flow rates, (2) indirect SSD equipment between Unit 1 and Unit 2 can and would be restored within 18 hours, and (3) the EDGs functional status should not be adversely affected.

3.3 Load Handling Procedures

NUREG-0612 recommends that licensees provide an adequate defense-in-depth approach to maintaining safety during the handling of heavy loads near spent fuel or over safety-related equipment and cited four major causes of accidents: operator errors, rigging failures, lack of adequate inspection, and inadequate procedures. With respect to the Unit 1, Cycle 12 refuel and SGR outage, special precautions are required to handle the removal and replacement of the SGs.

3.3.1 Assembly/Disassembly of the OLS

The licensee stated that the OLS would be assembled/disassembled in accordance with the users manual by operators provided by the owner/designer who are well trained with full knowledge of the operating manual and experience with assembly/disassembly of the OLS. Further, following erection, the licensee stated that it would perform functional tests of the OLS over the intended range of use and a load test would be performed after it was erected to assure that the control, operating, and safety systems of the OLS are functioning properly. With respect to the mobile cranes the licensee stated that it would perform tests on the mobile cranes in accordance with ANSI B30.5-1968, and prior to each shift a 20-point checklist of the crane would be conducted by the shift operators. Based on the review of information submitted by the licensee, the NRC staff finds that the licensee's procedures for the assembly and disassembly of the OLS and use of the mobile cranes satisfy the intent of NUREG-0612.

3.3.2 Lifting Devices

NUREG-0612 provide guidelines for the design and use of lifting devices. The licensee stated that (1) slings would meet the guidelines of NUREG-0612 and alternatively below the hook devices would meet the requirements of ANSI B30.2-1976. Further, the design of lifting trunnions would be qualified to meet the requirements of ASME NQA-1-1997, Subpart 2.15. The NRC staff found the alternative criteria proposed for the lifting trunnions acceptable, as the alternative criteria satisfy the guidelines of NUREG-0612. In addition, for lifting devices other than the trunnions, the licensee would employ the use of devices that meet the guidelines of Phase I of NUREG-0612 and are, therefore, acceptable.

3.3.3 Crane Operator Qualifications

NUREG-0612 states that crane operators should be trained, qualified and conduct themselves in accordance with Chapter 2-3 of ANSI B30.2-1976, "Overhead and Gantry Cranes." Since the OLS and mobile cranes do not satisfy the criteria of ANSI B30.2-1976 the licensee needed to provide the NRC staff with alternate requirements that meet the guidelines of NUREG-0612. The TR indicated that operators would be qualified to meet the requirements of ANSI B30.5-1968. The NRC staff evaluated the qualification requirements in ANSI B30.5-1968 and found that the criteria within the standard satisfied the intent of Phase I of NUREG-0612 as an alternative and is, therefore, acceptable.

3.3.4 Design and Operating Wind Conditions

NUREG-0612 specifies that licensees should take special precautions as necessary in handling heavy loads in the vicinity of SSD equipment. OSG and RSG would be handled by the OLS for a period of approximately 16 hours. During this time, SGs traveling over the specified load path could be subject to high winds that can potentially cause a load drop. The design basis wind speed for the SQN was 95 mph and wind speeds exceeding 103 mph can be expected only during a tornado. The OLS has two anemometers for measuring wind speed, one in the boom tip and a duplicate at the top of the back stay. The NRC staff, as part of its operating experience review, found that cranes carrying similar loads in winds between 19 and 26 mph could potentially result in crane failure and loss of load. The licensee stated that the OLS manufacturer qualified the crane for wind speeds up to 103 mph, with the lower block secured to a 550 kip load and pretensioned to 440 kips. The licensee stated that the maximum allowable wind speed during operation of the OLS when the load was more than 3-ft off the ground and outside the containment would be 10m/second (22 mph). The maximum allowable wind speed would be 15m/second (33 mph) when the OLSs load is less than or equal to 3-ft off the ground.

Mobile cranes for OLS assembly/disassembly would cease operations if wind speeds exceed 35 mph. This wind speed was based upon the crane manufacturer's operating manual. The wind speed for operations using the mobile cranes was not lowered as the load drop and consequence analysis showed that no unacceptable consequences would result from a dropped load with the safe load path, load handling restrictions, and compensatory measures in place, which were found acceptable by the NRC staff. In addition, to assure that any restrictions on the wind speeds are implemented, the mobile cranes would rely on the site wind speed readings that are recorded at the site meteorological tower. Consequently, during heavy lift operations with the OLS and mobile cranes the licensee would also use meteorological forecasts to ensure operations are not conducted during severe weather conditions.

3.3.4.1 Commercial Crane Operating Experience

Since the OLS was a commercial crane not specifically designed for use at a nuclear facility, the NRC staff conducted a review of commercial crane operating experience. In particular, the staff evaluated an event that occurred on July 14, 1999, during the Miller Park construction project in Wisconsin. The stadium construction project included a multipanel retractable roof supported by curved truss assemblies. The contractor constructed the truss assemblies supporting the retractable roof panels on the ground in approximately 200 to 450 ton sections and used a heavy lift (Lampson) crane to hoist the loads over the stadium structure, place them, and connect them in the proper place. This operation followed specific procedures for lifting each roof section that used the heavy lift crane and was coordinated by the lift supervisor, who was in radio contact with the crane crews and observers' stations at strategic locations around the job site. During a critical lift of one of the various truss assemblies, in winds measured up to 17 mph, with the Lampson crane lowering the load over its proper place, the crane failed, killing three workers on site. The NRC staff was concerned that the licensee's operations, lifting similar loads under similar conditions, could lead to a heavy load drop that may result in unacceptable consequences.

The licensee provided the NRC staff with a comparison of the proposed OLS for the SG replacement and the Lampson crane used during the Miller Park construction project. "The boom and jib of the Lampson crane are of single lattice frame construction. The crane is mounted at the base on crawlers with a relatively smaller footprint, which induces relatively higher ground pressures on the base or [soil] foundation. The Lampson crane used on the Miller Park project was seated on the ground, not on an engineered foundation. The ground on which it was seated was not a level surface and it is reported that at the time of failure there were apparent cracks in the ground on which the crane was seated."

"In comparison, the main mast (main boom) and back mast are of a significantly more robust A-Frame construction with the two legs of the A-Frame connected by a horizontal cross beam/frame. The two pivots at the base of the A-Frame masts are 33 ft apart laterally for both the main mast and the back mast. Further, the jib of the crane was a double frame construction with the two parallel frames connected by cross beams at three levels. The two jib pivots at the base of the double frame are 13 ft apart laterally. The OLS has a 70.5-ft diameter ringer base mounted on 24 jacks seated on top of an engineered foundation using outrigger plates. The OLS ringer design with 24 jacks enables good distribution of bearing pressure under the jack pads. The OLS would be seated on the reinforced concrete pile cap of an engineered pile foundation consisting of approximately 80 piles anchored into bedrock. The battered pile foundation was designed for lateral loads (seismic and wind) in addition to gravity loads of the crane and [lifted] load."

Having reviewed the commercial crane operating experience and the proposed OLS for the SG outage, the NRC staff found the OLS structurally superior to other commercially constructed cranes lifting similar loads. Therefore, the NRC staff found the proposed use of the OLS, considering the above discussion and other load handling procedures and precautions, acceptable as it satisfies the intent of NUREG-0612 and the UFSAR for various external events.

The NRC staff, having found the stress and stability of the OLS acceptable as well as accepting the load drop and consequence analysis for the mobile cranes, agrees with the licensee's analysis and procedural controls for handling heavy loads under the specified wind conditions.

3.3.5 Other Procedures

The licensee committed to developing procedures to delineate specific actions required in case of a load drop. The licensee stated that an abnormal operating procedure (AOP) would be developed. The AOP will contain specific guidance to address a total flow blockage due to ERCW pipe crimping, as well as a complete pipe rupture. The AOP would be entered and implemented prior to a heavy load lift occurring with the operating crew remaining in the AOP for the duration of the heavy lift. In addition, all operating crews would receive training on the AOP during the operator requalification training conducted prior to the outage. With respect to communications, personnel observing the load lift would be in direct communications with the main control room to relay status information of the lift to the operating crew. The NRC staff, having reviewed the NRC commitments/compensatory measures and the licensee's responses, find that the procedures satisfy the guidelines of NUREG-0612 for controlling heavy loads during the refuel and SGR outage.

3.4 Dose Consequences

The TR included the dose consequences of dropping an OSG outside containment. For this submittal, two cases were considered. In the first case, the crane fails, dropping the OSG back into the containment. In the second case, the OSG was dropped during handling and transport along the haul route from the containment to the OSG storage facility (OSGSF). It was significant to note that this OSG movement was a short-term one-time operation and would not represent a continuing hazard, after the transport was complete.

3.4.1 Dose Consequences Analysis Evaluation

The NRC staff reviewed the licensee's evaluation of the dose consequences of dropping an OSG, including release of radioactivity from the failed SG. The licensee conservatively assumed that 10-percent of the OSG activity was released due to the impact of the drop, and 1 percent of this release amount was in the form of particulates small enough to become airborne. The NRC staff finds these assumptions acceptable based on historical use by NRC staff in early SGRs. The licensee assumed that all activity release occurred in the first 2 hours of the accident. This was the same assumption acceptable to the NRC staff for the fuel handling accident release. Due to the similarity of the failure mode between the two accidents, the NRC staff finds the 2-hour release assumption acceptable for this drop of an OSG.

The licensee determined the expected radioactivity in the OSG based on an isotopic survey of the SQN Unit 1 Chemical and Volume Control System resin and drain tank residue, taken while the plant was at power. An adjustment to the source term was made based on dose rate surveys taken between February 25, 2000, and March 1, 2000 (3 to 10 days following shutdown), with the primary side of the OSGs full of water and the secondary side drained, at a radial distance of 10-ft from the outside surface of the SG shell in the vicinity of the tube region. The licensee assumed that 90 percent of the total OSG isotopic inventory was in the tube region and that this activity corresponds to the dose rates measured in the vicinity of the tube region. The NRC staff finds the methodology used by the licensee to determine the isotopic source term for the OSG drop was reasonable and finds the results acceptable for use in the OSG drop dose consequences analysis, because the methodology and analysis are similar to methods and analyses used in earlier SGR projects by other licensees.

The licensee calculated the dose to the whole body, skin, lungs, and bone from three pathways: (1) submersion in the radioactive cloud, (2) inhalation, and (3) dose from radioactive material deposited on the ground. Dose conversion factors (DCFs) from Federal Guidance Reports (FGR) 11 and 12 (EPA-520/1-88-020 and EPA-402-R-93-081, Environmental Protection Agency) were used to determine the doses. The NRC staff generically finds the use of the FGR-11 and FGR-12 DCFs to be acceptable (see Regulatory Issue Summary 2001-19). The doses from all isotopes and pathways were summed to arrive at the total dose to each organ. The licensee used structural shielding factors of 0.75 for submersion and 0.33 for ground deposition, and a mean ground deposition velocity of 0.3 centimeter per second, all taken from NUREG/CR-4551, Volume 2, Part 7, "Evaluation of Severe Accident Risks: Quantification of Major Input Parameters," which was a report on the MELCOR Accident Consequence Code System and provides recommended inputs for the severe accident analysis code. The NRC staff finds these shielding factors and ground deposition velocity to be acceptable for this one-time use in determining the dose consequences of an OSG drop.

The only calculation input values that differed between the two analyzed drop cases were the atmospheric dispersion factors (X/Qs) for the different drop locations. The staff's evaluation of the X/Q values used by the licensee in the calculation of the dose consequences is evaluated in Section 3.4.2.

The NRC staff performed independent dose calculations that confirmed the licensee's results. The licensee's calculated maximum doses in the control room from a postulated drop of an OSG at the containment (the bounding case) are 0.0376 rem whole body, 0.0106 rem skin, 0.131 rem lung, and 0.103 rem bone, which meet the GDC-19 dose criteria of 5 rem whole body or its equivalent to any part of the body. The licensee's calculated whole body doses for a drop of an OSG during transport at the limiting location along the haul route are 4.86E-02 rem at the exclusion area boundary (EAB) and 1.07E-03 rem at the boundary of the low population zone (LPZ). The whole body doses for a drop of an OSG from the crane into the containment are 2.94E-02 rem at the EAB and 4.63E-03 rem at the LPZ. These doses are substantially below the Part 100 whole body guideline value of 25 rem and are, therefore, acceptable. They are also far below the offsite whole body dose criterion of 0.5 rem given in BTP ETSB 11-5.

3.4.2 Atmospheric Dispersion Factors Evaluation

The licensee used the following X/Q values in the calculation of the dose consequences of dropping an OSG outside of containment:

Release Point	Dose Point	X/Q (sec/m^3)	Reference
Containment	EAB	1.64E-3	UFSAR Table 15A-2
Containment	LPZ	1.96E-4	UFSAR Table 15A-2
Containment	Control Room	1.59E-3	UFSAR Table 15.5.3-6
Haul Route or OSGSF	EAB	2.71E-3	New
Haul Route or OSGSF	LPZ	4.51E-5	New

The containment X/Q values were calculated for a release from the shield building vent. These were used for the crane failure case. The haul route/OSGSF drop X/Qs were calculated using the shortest distance from the haul route to the EAB in all compass sectors. Given the relatively long distance to the LPZ, the shortest distance of 4195 m was used as the distance in each sector. The PAVAN computer code was used to generate the X/Q values, assuming these distances, a ground level release, no terrain adjustment factors, and using the joint frequency distribution (JFD) data presented in UFSAR Tables 2.3.2-23 through 2.3.2-29.

The staff considered the application of the UFSAR X/Q values for the containment for the crane failure case and determined that the application was appropriate. The UFSAR values had previously been reviewed by the NRC staff and the application was limited to a one-time, short duration operation for which sufficient margin exists in the dose estimates. As such, the NRC staff finds no reason to challenge use of the current licensing basis values.

For the newly calculated X/Q values, the NRC staff performed a review and confirmatory calculations. TVA had previously (August 2002) submitted electronic files of hourly meteorological data in the ARCON96 format for the years 1989 through 1993. The NRC staff had previously considered the quality of these data in the review of the tritium production core amendment (MB2972/MB2973). The NRC staff processed the meteorological data through the METQA code suite, converting the format to the standard NRC format, then generated JFD from the data. PAVAN was then run using the JFD and other applicable inputs from the licensee's RAI response dated January 15, 2003. The staff's results indicated that the EAB X/Q was 5.01E-3 seconds per meter cubed (sec/m^3) for 0-2 hours, and that the LPZ X/Q was 8.67E-5 sec/m^3 for 0-8 hours. These values were nearly twice that obtained by the licensee. The NRC staff then ran a second case on PAVAN using the data from the Sequoyah UFSAR. This second run yielded 2.77E-3 sec/m^3 for the 0-2 hour EAB X/Q and 4.31E-5 sec/m^3 for the 0-8 hour LPZ X/Q. Both these values are acceptably close to the values generated by the licensee.

The wind speed used in the staff's JFD preparation was 0.27m per second (0.6 mph) -- the breakaway speed for the anemometer given in Chapter 2.3 of the UFSAR. The minimum wind speed (below which the wind was considered to be calm) in the licensee's ARCON96 run was 0.5m per second, the default value. The NRC staff did not request that TVA evaluate this concern and correct the submittal because (1) there was sufficient margin between the calculated doses and the regulatory acceptance criteria to conclude that doses would still be acceptable for a possible factor-of-2 error in the X/Q values, and (2) this particular assessment supports a one-time, short-term operation.

For the control room doses from the haul route case, the licensee conservatively used the UFSAR control room X/Q used for the crane failure case. The haul route was at a greater distance from the control room intakes than the containment. The wind directions at the SQN site are largely bimodal on an NNE to SSW axis. The haul route generally lies within the NNW to NE sectors, while the Unit 1 containment was within the ESE to SSE sectors and the Unit 2 containment was within the SSE to SW sectors. Based on engineering judgment, the licensee's conclusion that the containment X/Q can be used for the haul route control room dose calculations was likely conservative.

The staff finds that TVA's use of the SQN UFSAR X/Q values and the newly calculated values are acceptable in the context of the current amendment, due to the one-time (all OSGs), short-term nature of the planned movement of the OSGs for the SGR.

4.0 CONCLUSION

The design and construction of the OLS were capable of withstanding external events that satisfy the intent of the UFSAR and the guidelines of NUREG-0612. The licensee's use of the highly reliable OLS, coupled with the proposed inspection, testing, and maintenance of the system in accordance with the requirements of ANSI B30.5-1968 and ASME NQA-1-1997 Subpart 2.15 provides assurance of the systems reliability to safely handle the SGs. Therefore, lifting of the SGs using the OLS presents little to no risk of an accidental drop of the SGs. In addition, the licensee's commitment to continuously monitor inclement weather conditions coupled with its load handling procedures would enable the licensee to ensure that operations are suspended in a timely manner to avoid subjecting the OLS and the mobile cranes used for OLS assembly/disassembly to severe conditions that could help initiate a drop of the SG.

The proposed compensatory measures to mitigate the effects of a postulated SG drop onto the safety-related ERCW system and provide support for continued operation of Unit 2 and assurance of continued operation of indirect SSD equipment between Unit 1 and Unit 2 were adequate. These measures would be adequate to maintain operational safety at both units, and restore the functions of the indirect SSD equipment that may be impacted. The proposed compensatory measures are suitable for handling both nonseismic and seismic initiation of a drop of a SG. The proposed compensatory measures should enable the licensee to promptly restore the functional capability of the EDGs and maintain the ERCW function, should a load drop occur, with minimal risk to the safety of the plant.

Based on the preceding discussions, the NRC staff finds that the aforementioned considerations and transportation requirements for movement of the SGs (and other heavy loads) in the vicinity of safety-related SSCs during the SQN SGR outage as described in TR 24370-TR-C-002, "Rigging and Heavy Load Handling," acceptable. The movement of the OSGs/RSGs over safety-related SSCs creates a possibility for an accident of a different type than any previously evaluated in the UFSAR which the licensee has adequately analyzed and implemented compensatory measures to preclude and mitigate the potential hazards of a drop. Additionally, the NRC staff concludes that there is reasonable assurance that dose consequences of the postulated drop of an OSG during SGR meet the dose limits given in 10 CFR Part 100 and meet the requirements of 10 CFR Part 50, Appendix A, GDC-19 for control room habitability. Therefore, the heavy load handling methodology and compensatory measures described in TVA's TR 24370-TR-C-002, "Rigging and Heavy Load Handling," are acceptable for use at SQN Unit 2 during the spring 2003 refueling outage.

5.0 References

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