January 15, 2003

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	

SEQUOYAH NUCLEAR PLANT (SQN) - STEAM GENERATOR REPLACEMENT PROJECT - TOPICAL REPORT NO. 24370-TR-C-002, "RIGGING AND HEAVY LOAD HANDLING TOPICAL REPORT," RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

Reference:

1. NRC letter to TVA dated December 19, 2002, "Sequoyah Nuclear Plant Unit 1 - Steam Generator Compartment Roof Modification Topical Report (TAC NO. MB5387)"

2. NRC letter to TVA dated December 4, 2002, "Sequoyah Nuclear Plant, Units 1 and 2 - Request for Additional Information Concerning Unit 1 Steam Generator Replacement Topical Reports and Associated Technical Specification Amendment (TAC NOS. MB5370, MB5371, MB5387)"

The purpose of this submittal is to provide additional information in response to the staff's reference 2 letter. Based on discussion with the staff during a meeting between TVA, Bechtel, and NRC on October 24, 2002, TVA understands that the additional information will allow the staff to complete their review of the subject topical report. The approval of the topical report supports SQN's Unit 1 steam generator replacement outage that is scheduled to begin in March 2003.

Due to circumstances beyond TVA's control, the crane that was originally scheduled to be utilized for SQN's Unit 1 steam generator replacement project will not be available. Consequently, TVA will be utilizing a second crane whose design specifications are similar to the original crane and provide equivalent or greater safety margins. The information described by this submittal contains information associated with the original crane. TVA will provide updated information regarding the second crane.

Enclosure 1 provides additional information that supports the latest revision (i.e., Revision 3) of Topical Report No. 24370-TR-C-002. Enclosure 2 provides a copy of Revision 3 to the topical report.

In the reference 1 letter, NRC staff issued a letter of denial for Topical Report 24370-TR-C-003, "Steam Generator Compartment Roof Modification." A public meeting was held on December 23, 2002 to discuss the technical reasons for the denial of the topical report. Based on discussion from the public meeting, TVA plans to address the technical issues and provide a redesign of the splice plate for the compartment roof modification. At this time TVA finds this course of action precludes the need for responding to the questions contained in reference 1 regarding Topical Report No. 24370-TR-003.

This letter is being sent in accordance with NRC Regulatory Issue Summary 2001-05. The revised commitments are contained in enclosure 2, Appendix A of the topical report.

If you have any questions about this change, please telephone me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

Sincerely,

Original signed by

Pedro Salas
Licensing and Industry Affairs Manager

I declare under penalty of perjury that the foregoing is true and correct. Executed on this *15* day of *January* , *2003* .

Enclosures
cc (Enclosures):
Mr. Raj K. Anand, Senior Project Manager
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ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 1
DOCKET NO. 327

ADDITIONAL INFORMATION FOR TOPICAL REPORT NO. 24370-TR-C-002, "RIGGING AND HEAVY LOAD HANDLING"

Note: TVA is providing a revision format to show changes to the NRC RAI questions and TVA responses from the October 24, 2002 meeting between TVA, NRC, and Bechtel. Because changes to Attachment 1 were extensive, revision format was not used. Accordingly, Attachment 1 should be reviewed in its entirety.

NRC Question No. 8

8. Section 7.1 of the topical report discusses the dose consequences of dropping an original steam generator (OSG) outside the containment. For staff to complete review of your dose consequences analysis, additional information is needed on the referenced calculation (Reference 23 of the topical). Provide the assumptions, inputs and methodologies used to determine the dose consequences of dropping the OSG. This should include the source term (isotopes and activities), control room ventilation system operation assumptions and the atmospheric dispersion factors (X/Qs) used in the dose calculation. Additionally, if the X/Qs are newly calculated and have not been reviewed by the staff, provide the inputs (including meteorological data), assumptions (including the location of the drop) and methodologies used to calculate the X/Q values.

TVA Response

SUMMARY OF DOSE CALCULATION

The purpose of the old steam generator (OSG) drop dose analysis was to determine the doses at the exclusion area boundary (EAB), the low population zone (LPZ), and the control room (CR) due to the failure of an OSG during the steam generator replacement (SGR) effort. The scenario postulated to cause the failure was a drop of an OSG from the outside lift system (OLS) crane or from the transporter at the worst location along the haul route between the containment and the OSG Storage Facility (OSGSF). The dose analysis was performed using the following inputs, assumptions, and methodology.

INPUT

1. Based on 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, the dose rate at a radial distance of 10 feet from the outside surface of the shell in the vicinity of the tube region (at elevation 723 ft) is 85 mR/hr.

   (Note: Surveys taken during the November 2001 outage show the maximum dose rate at 3 ft from steam generator (SG) No. 3 is 85 mR/hr at El. 722 ft with the primary side full and the secondary side drained. Thus, the dose rate used in this analysis of 85 mR/hr at 10 ft under the same fill conditions is conservative.)

2. Isotopic surveys for a number of components in the reactor coolant cleanup and radwaste systems during full power operation were performed. Chemical and Volume Control System (CVCS) resin and drain tank residue represent the worst case distributions since they have the highest fractions of Co-60, the most dominant contributor to organ and whole body doses. The CVCS distribution was selected as bounding because it has higher amounts of Cs-134 and Cs-137 than the drain tank residue; these isotopes are also important dose contributors. Since the isotopic surveys were taken while the plant was at power and the SG external dose rate survey was only a few days after shutdown, the two surveys are well matched in time and thus no adjustment was necessary.

3. Dimensions of the tubes within the OSGs and of the tube region of the OSG were as reported in Updated Final Safety Analysis Report (UFSAR) Table 5.5.2-1.

4. The maximum accident atmospheric dispersion factors (X/Qs) are as follows:

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	CR	1.59E-3	UFSAR, Table 15.5.3-6
Haul Route or OSGSF	EAB	2.71E-3	See X/Q Calc Summary Below
Haul Route or OSGSF	LPZ	4.51E-5	See X/Q Calc Summary Below

5. The maximum breathing rate of persons offsite and in the control room is 3.47E-4 m^3/sec [Regulatory Guide 1.4, Sheet 2]. This rate was conservatively assumed for the duration of the accident.

6. Doses are calculated using the inhalation, air submersion, and ground deposition dose conversion factors (DCFs) in Federal Guidance Reports 11 and 12 [Ref. EPA-520/1-88-020 and EPA-402-R-93-081].

7. Based on experimental data and NRC recommendation, the structural shielding factor used was 0.75 for submersion and 0.33 for ground deposition [Ref. NUREG/CR-5164, Sheet 18; NUREG/CR-4551, Volume 2, Part 7 Sheet 3-28]. These factors account for the shielding provided by buildings and other structures during normal activities.

8. Based on experimental data for various aerosol compositions and sizes and various deposition surfaces, the mean ground deposition velocity used was 0.3 cm/sec [NUREG/CR-4551, Volume 2, Part 7, Sheet 2-21].

ASSUMPTIONS

1. It was assumed that 90 percent of the total SG isotopic inventory was in the tube region and that this activity corresponds to the dose rates measured in the vicinity of the tube region. Of the 3 regions of the generator (steam dome, tube region, channel head), it was assumed that most of the activity was in the tube region because the channel head is much smaller than the tube region and the steam dome, by design, is expected to have negligible levels of activity. The isotopic inventory inside the tube region was calculated based on this dose rate and the known isotopic distribution and physical dimensions.

The inventory for the entire SG was then estimated by dividing the tube region activity by 90 percent.

2. It was assumed that 10 percent of the SG activity was released due to the impact of the drop and that 1% of this release amount was in the form of particulates small enough to become airborne. Hence, the fraction of the total SG activity that gets released to the environment is 0.001. The use of the 0.1 percent of the isotopes for dose assessments has been used historically on other (SGRs). The early SGRs were not performed under the requirements of 10 CFR 50.59. Instead, a repair report was prepared and submitted to the NRC for review and concurrence. As part of their review, the NRC performed confirmatory analyses that used this percentage of isotopes being released. Recent SGRs performed under 10 CFR 50.59 have continued to use this isotopic release percentage.

3. All activity releases were assumed to occur within the first 2 hours of the accident. This is conservative as it minimizes the dispersion of activity released to the environment, thereby maximizing the doses.

4. The inhalation dose to the control room operator was calculated using the atmospheric dispersion factor for the control room, but without taking credit for the control room structure.

5. LPZ doses due to ground deposition are conservatively calculated assuming no evacuation or remediation during the 30-day exposure period.

6. The control room is closer to the containment than to any point on the haul route. It was therefore assumed that the control room dose from a SG rupture at the containment bounds the dose from a rupture at any point along the haul route or at the OSGSF.

METHODOLOGY

The dose analysis was performed using the following steps.

1. Using the worst case measured isotopic distribution [Table 1] for the activity inside the SG, a characteristic energy spectrum was calculated in the units of MeV/sec by energy group.

2. The energy spectrum [Step 1] was used in a point-kernel computer program to calculate a dose rate 10 ft from the outside of the SG.

   As the dose measurement was taken with the primary side of the generators filled with water and the secondary side drained, the internal medium of the tube region was modeled as a homogenized mixture of steel and water. The homogeneous density of the tube region was calculated by dividing the total mass of the steel and water by the volume of the region.

3. By ratioing the calculated dose rate [Step 2] to the measured dose rate 10 ft from the outside of the SG, a source adjustment factor was determined. Dividing this ratio by 90% [Assumption 1] yielded an adjustment factor of 9.0. The assumed initial isotopic inventory [Input 2] was multiplied by 9.0 to obtain the estimated total activity inside the generator.

4. The isotopic distribution [Step 1] was multiplied by the source adjustment factor [Step 3] to obtain the isotopic activities inside the SG corresponding to the measured dose rate of 85 mR/hr at 10 ft from the outside of the SG.

5. It was assumed that a certain fraction [Assumption 2] of the isotopic activity in the SG [Step 4] is released to the environment as a result of the rupture. For a given isotope and organ, the inhalation, submersion, and deposition doses were calculated based on the guidance in NUREG/CR-5164. Doses were calculated for the containment to EAB pathway. The doses for the other pathways were obtained by applying X/Q ratios to the total EAB doses. The doses from all isotopes and pathways were summed to arrive at the total dose.

The total activity in the SG was calculated to be 777 Ci, with approximately 8 percent being from Fe-55, 6 percent from Co-58, 18 percent from Co-60, 38 percent from Ni-63, 12 percent from Cs-134, and 15 percent from Cs-137. The rupture of each SG was postulated to release 0.777 Ci to the atmosphere.

Table 1 - Isotopic Survey Data from CVCS Resin Tank

Isotope	ÌCi/g	Isotope	ìCi/g	Isotope	ìCi/g	Isotope	ìCi/g
H-3	3.99E-03	Ni-59	2.79E-01	Sn-113	2.90E-02	Pu-239	2.30E-04
C-14	6.72E-01	Ni-63	3.26E+01	Sb-125	4.94E-01	Pu-240	2.30E-04
Mn-54	1.11E+00	Zn-65	3.65E-02	I-129	5.60E-05	Pu-241	3.13E-02
Fe-55	6.71E+00	Sr-89	7.49E-03	Cs-134	1.01E+01	Am-241	1.00E-04
Co-57	1.94E-01	Sr-90	1.07E-01	Cs-137	1.30E+01	Cm-242	2.59E-04
Co-58	4.98E+00	Tc-99	1.08E-04	Ce-144	1.25E-02	Cm-243	2.66E-04
Co-60	1.59E+01	Ag-110m	7.87E-02	Pu-238	6.51E-04	Cm-244	2.66E-04
						TOTAL	8.63E+01

Table 2 - Summary of Doses from OSG Rupture

Event	Release Point	Dose Point	Dose (Rem)			
			Whole Body	Lung	Bone	Skin
Drop from Crane	Containment	EAB	2.94E-02	1.28E-01	9.55E-02	1.83E-04
		LPZ	4.63E-03	1.62E-02	1.27E-02	1.30E-03
		CR	3.76E-02	1.31E-01	1.03E-01	1.06E-02
Drop During Transport	Haul Route	EAB	4.86E-02	2.11E-01	1.58E-01	3.02E-04
		LPZ	1.07E-03	3.73E-03	2.93E-03	3.00E-04
		CR	3.76E-02	1.31E-01	1.03E-01	1.06E-02

SUMMARY OF X/Q CALCULATION

The calculation performed to estimate worst-case atmospheric dispersion factors (X/Qs) at the EAB and at the LPZ for a hypothetical steam generator drop accident occurring at any point along the steam generator haul route [Figure 1] during the SGR is summarized below.

INPUT

1. The representative meteorological data used were as reported in UFSAR Section 2.3 and Tables 2.3.2-23 through 29, “Joint Percentage Frequencies of Wind Speed by Wind Direction” for the 10-meter level (1/1/72-12/31/75).

2. Distance/location information for the EAB and LPZ were as reported in UFSAR Table 2.3.4-1 and Section 2.3.4.2,

respectively. Centered on the Unit 1 containment vent, a radius of 4828m was used for the outer boundary of the LPZ.

3. The containment building cross-sectional area (1800 m^2) used in estimating the atmospheric dispersion factors were as reported in UFSAR Section 2.3.5.2.

4. A haul route drawing [Figure 1] shows the locations of the steam generator haul route and the old steam generator storage facility (OSGSF).

5. The elevation at the top of the containment building is 856.04 ft with a grade elevation of 705 ft. Therefore, the physical height above ground level of the containment building is 151 ft (46 m).

ASSUMPTIONS

1. It was assumed that a postulated steam generator drop could occur at any point along the identified haul route from the Unit 1 containment to the OSGSF.

2. To account for the reduction in vertical cross-sectional area due to the sloping roof of the containment building, the top of the containment was assumed to be about 45 m for modeling purposes.

METHODOLOGY

1. The primary methodology used was based on information contained in the following guidance documents:

   a. NRC Regulatory Guide 1.145 - “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants,” Rev. 1.

   b. NUREG/CR-2858, “PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations.”

2. Since for a nonbuoyant ground-level release, ground-level pollutant concentrations decrease with increasing downwind distance, the shortest distance from the haul route to the EAB and LPZ for points corresponding to the 16 wind direction sectors was determined. Based on guidance provided in Section 1.2 of Regulatory Guide 1.145, the assumed release points for each of the 16 directions were determined from Figure 1 as the minimum distance between

any point on the haul route and the EAB for each direction. The shortest distances between each direction-specific release point on the haul route and the EAB are presented in Table 1. The LPZ is the area within a 4828 m (15840 ft) radius measured from the Unit 1 shield building vent. The shortest distance from the haul route to the LPZ was found to be 4196 meters measured from the OSGSF (located near the north end of the haul road) in the north direction. Since shorter distances are generally associated with less dispersion, this minimum distance was conservatively used in all directions to calculate the X/Q values at the LPZ (see Table 1).

3. UFSAR Section 2.3.2.4 indicates that terrain variations in the site region are minimal. Therefore, site-specific terrain adjustment factors (TAFs) were not used in the model.

4. The PAVAN model was configured to calculate X/Q values assuming both wake-credit allowed and wake-credit not allowed. The closest EAB is located 666 feet (203 m) from the haul road in the N and NNW directions [Table 1]. The containment buildings are 151 feet (46 m) above grade. The maximum wake-influence distance between a wake-producing structure and a release point was assumed to be 10 “building heights” downwind of the structure. This distance was based on guidance contained in Regulatory Guide 1.23, Proposed Rev. 1, for the siting of meteorological instruments away from wake-producing objects/structures. The shortest distances from the haul road to the EAB are less than 10 building heights away in the NW, NNW, N, NNE, NE, and ENE directions. Receptors at these sectors are therefore located within the building wake influence zone induced by the containment building. Thus, the PAVAN “wake-credit allowed” scenario results were used for the X/Q analysis at these sectors. However, the entire LPZ, which at its shortest distance from the haul route is 13765 feet (4196 m), is located beyond this wake influence zone. Thus, the PAVAN “wake-credit not allowed” scenario results were used for the X/Q analysis at the LPZ.

5. As described in Section 1.4 of Regulatory Guide 1.145, the 0-2 hour and annual average 5% site limit X/Q values were used to determine the X/Q values for the intermediate time periods by the logarithmic interpolation approach described in the PAVAN computer code.

6. Based on Regulatory Guide 1.145, the 0.5% sector X/Q or the 5% overall site X/Q, whichever was higher, was selected. Summarized below (Table 2) are the maximum X/Q values for the EAB and LPZ.

Table 1

Shortest Distances from the Haul Route to the EAB and LPZ

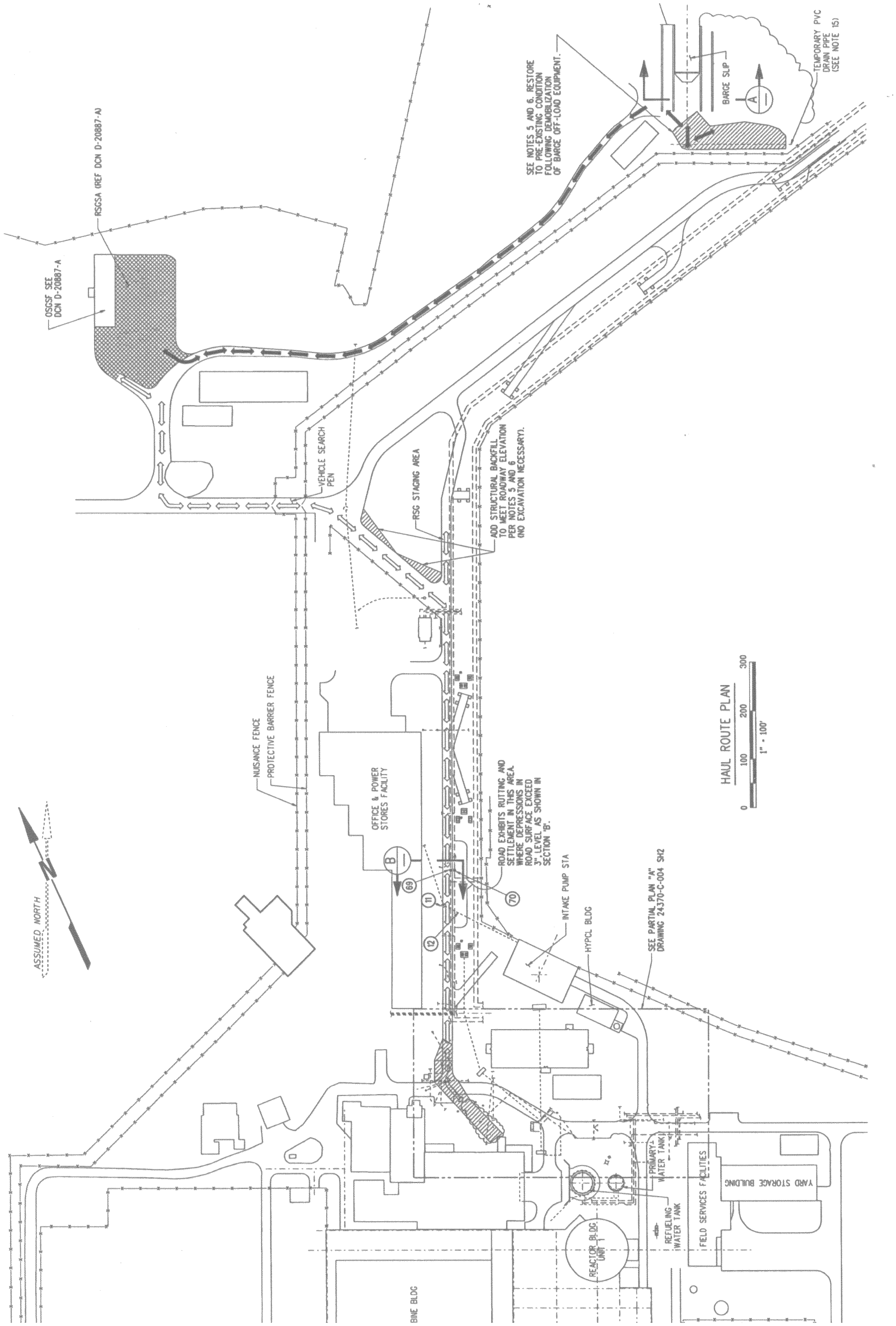
Sector	**Distance from Unit 1 Shield Bldg Vent to EAB**		**Shortest Distance from Haul Road to EAB**		**Shortest Distance from Haul Road to LPZ**	
	feet	**m**	**feet**	**m**	**feet**	**m**
N	3100	945	666	203.0	13765	4195.6
NNE	2402	732	800	243.8	13765	4195.6
NE	2300	701	1200	365.8	13765	4195.6
ENE	1824	556	1450	442.0	13765	4195.6
E	1850	564	1760	536.4	13765	4195.6
ESE	2001	610	1900	579.1	13765	4195.6
SE	2100	640	2065	629.4	13765	4195.6
SSE	2300	701	2167	660.5	13765	4195.6
S	2851	869	2500	762.0	13765	4195.6
SSW	3225	983	2967	904.3	13765	4195.6
SW	4199	1280	3556	1083.9	13765	4195.6
WSW	2999	914	2560	780.3	13765	4195.6
W	2201	671	1940	591.3	13765	4195.6
WNW	2149	655	1690	515.1	13765	4195.6
NW	2175	663	1045	318.5	13765	4195.6
NNW	2402	732	666	203.0	13765	4195.6

Table 2

EAB and LPZ X/Q Values

Time Period	**Exclusion Area Boundary**		**Low Population Zone**	
	Sector / Distance (m)	**Max. X/Q Value (sec/m^3)**	**Sector / Distance (m)**	**Max. X/Q Value (sec/m^3)**
0 to 2 Hours	N / 203 m	2.71E-03	N/A	N/A
0 to 8 Hours	N / 203 m	1.84E-03	SSW / 4196 m	4.51E-05
8 to 24 Hours	N / 203 m	1.52E-03	SSW / 4196 m	3.39E-05
1 to 4 Days	N / 203 m	1.00E-03	SSW / 4196 m	1.82E-05
4 to 30 Days	N / 203 m	5.50E-04	SSW / 4196 m	7.42E-06

Figure 1 – Steam Generator Haul Route



NRC Question No. 9

9. Describe the attributes of the heavy lift plan for the various loads to be lifted. Specifically identify who is responsible for the development and approval of the lift plan. Are persons responsible for the plan development registered professional engineers having specialized knowledge of critical lift operations? Demonstrate that the plan, in part, is based upon the following: (1) the rated capacity and operational limitations specified by the crane's load chart; (2) measured, as opposed to calculated, weights for the materials to be hoisted; (3) thorough studies of wind speed and its effect on crane and hoisted load; and (4) consideration of the effects of ground conditions and all dynamic forces on the crane's stability.

TVA Response

The heavy lift plan is detailed in engineering packages, which define the requirements for the safe rigging of the heavy loads associated with the SGR project. These engineering packages were developed by registered professional engineers having special knowledge of critical lift operations with many years of experience performing this type of work. The engineering packages associated with the rigging plan include the following details:

- Calculations to determine the critical aspects (e.g., lifted weight, center of gravity, size, etc.) of items to be rigged
- Qualification of rigging components
- Qualification of rigging equipment
- Comparison of lifted load with crane capacity
- Allowable load paths and allowable locations of cranes with respect to the load paths
- Crane foundation design and construction details
- Relocation details for underground utilities in the OLS foundation area
- Qualification and design of SG rigging attachment points
- Load test requirements
- Evaluation of safety-related buried commodities in the vicinity of heavy lift load path for a postulated load drop from the OLS
- Evaluation of the OLS for seismic and wind/tornado loads
- Evaluation of the response from a postulated drop onto the shield building
- Load path restrictions (path, height)

- Operating weather restrictions (detailed in the response to Question 15) and associated work instructions
- Protection details for safety-related SSCs if a load drop occurs
- Contingency measures for the realignment of plant systems if a load drop occurs

The list of components provided in the response to Question 32 indicates which component weights were measured and which weights were calculated.

Incorporated into these engineered products are the load limitations derived from the crane manufacturer's load charts. For lifting of the SGs, calculated weights will be confirmed by load cell measurements upon initial lift operations. The potential for winds to influence the safety of the lift operations will be controlled administratively using the monitoring described in the response to Question 10. As noted above, cranes performing heavy lift operations will be limited to locations where ground conditions have been examined and evaluated; more specifically, the OLS will be supported on an engineered pile foundation. A discussion of how the evaluation of the OLS for ground conditions and dynamic forces conforms to the design criteria and bases in the UFSAR is provided in the response to Question 34.

A specific work plan and inspection record (WPIR) is written for each work activity associated with the above rigging plan that invokes the necessary requirements dictated by the engineering packages. These WPIRs are prepared by construction personnel who plan the overall SGR construction/ maintenance program. Each WPIR is reviewed by design engineering personnel to confirm that the planned activities are within the limits established by the engineering evaluations and analyses.

NRC Question No. 10

10. Will cranes (outside lift system (OLS) and mobile cranes used to erect the OLS) and work areas be equipped with strategically located instruments to monitor wind velocity (speed and direction) at or near the elevation of hoisted loads? If not, provide a justification for not making the necessary provisions to measure wind velocity. If monitoring will be done, describe how and provide the basis for the monitoring scheme chosen.

TVA Response

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 anemometers are verified to be operational prior to the boom/back stay being erected.

The mobile cranes are generally not equipped with wind speed monitoring capabilities. To assure that any restrictions on the wind speeds are implemented, the mobile cranes will rely on the site wind speed readings that are recorded at the site meteorological tower. In general, the mobile cranes have restrictions on their operational wind speed, as well as other operational limitations. To assure that the crane manufacturer's operational limitations are followed, there are job specific construction procedures in place for the work associated with assembly/disassembly of the OLS. These controls regulate the construction activities. In addition, there is a work plan and inspection record (WPIR) specifically written for each work activity that invokes the requirements dictated by engineering, including wind speed limitations on crane operation. Meteorological forecasts will also be used to monitor wind speeds.

NRC Question No. 11

11. What actions will be taken to ensure the crane is equipped with correctly calibrated instruments to accurately monitor all parameters affecting safe crane operation?

TVA Response

The instrumentation on the OLS (PTC crane) was last calibrated in September 2002. Instrument calibration is normally performed once a year, or as required by clients. Calibration of the OLS load cell instrumentation will be performed as required in ASME NQA-1 Subpart 2.15. As indicated in the response to Question 12.(1), the OLS will be load tested prior to use. Since this load test will be performed with a test load of known weight, it will confirm the calibration of the OLS load cells. Additionally, the OLS boom radius indication readouts will be verified during the load test, which will also verify the incline meter readings. The safe load indicator, which stops crane operation unless the operation improves the safety margin, will also be tested during the load test.

After erection of the boom/jib and during the functional test and load test, the anti-two block switches, airplane warning lights, and boom stops will be checked.

NRC Question No. 12 (Item a)

12. Section 5.1 of the topical report states that the rated load for the proposed crane configuration for the SQN SG replacement ranges from 440.8 tons (400 metric tons) to 517.9 tons (470 metric tons), depending on the lift radius. The OLS does not completely conform to the requirements of ANSI B30.5, "Crawler, Locomotive, and Truck Cranes," and the load test requirements of B30.5 in Section 5-2.2.2 do not subject the OLS to complete functional testing with and without the load following erection. Provide a response to the following:

(a) Will a load test of the OLS at 110-percent of the largest postulated load to be carried by the OLS be performed? What is that load and how is it determined? Will full-performance tests with 100-percent of the largest postulated lifted load for all speeds and motions for which the system is designed be performed?

TVA Response

The OLS has been tested by the manufacturer to 125% of rated capacity. After erection on site a functional test of the OLS will be performed over the area of motion required for the lifts to be conducted during the steam generator replacement outage. After the functional test is performed a load test will be conducted using a 550 kip test load (Note: this load is less than the largest load lifted by the OLS during the SGR). This load will be lifted and then the boom extended so that the crane is at 110 percent of rated capacity (ASME B30.5 5-2.2.2(a)(1)). This 550 kip test load will be limited to 2 feet above grade so that any underground safety-related SSCs will not be detrimentally affected if a load drop occurs. This 550 kips test load is the minimum load that is required to anchor the OLS during inclement weather. The only safety-related SSC that the test load will travel over is the ERCW piping. However, since the lift height will be restricted to 2 ft or less, the impact energy from a drop of the test load will be small enough that it will not detrimentally affect the ERCW piping as substantiated below.

During the load test the 550 kip load will travel over an area where ERCW piping is buried. The ERCW pipes in this area have an 18” thick concrete slab for missile protection near the grade level. The missile protection has been tested and shown to be adequate for several missiles and impact velocities (UFSAR page 3.5-23). The impact energy resulting from 2 ft drop of the test load is approximately equal to the maximum energy for which the tornado missile protection slab was tested and found adequate. Further, the test load will be mounted on a steel frame approximately 50 ft x 9 ft in plan. Thus the impact energy will in fact be delivered over a large area resulting in a soil pressure of approximately 3.5 ksf or 25 psi on the pipe. This will result in a hoop stress of approximately 1.5 ksi in the pipe against the yield strength of 32 ksi. Therefore, a 2 ft drop of the test load will not have any detrimental effect on the ERCW pipe.

NRC Question No. 12 (Item b)

(b) How will verification be performed during and following erection of the OLS of the proper assembly of electrical and structural components?

TVA Response

The OLS will be assembled by the manufacturer in accordance with the erection manual. The crane will be assembled and configured per instructions and drawings detailed in Section 4 of the OLS Users Manual by operators provided by the owner/designer who are well trained with full knowledge and understanding of the crane/manual and experienced in assembling and operating the PTC Crane. During assembly the OLS structure (e.g., bearings, gearboxes, bolts, shafts, wires, structural members, welds, etc.) will be inspected for wear and damage in accordance with the criteria set forth in Section 7 of the user manual. If any wear or damage is found, the appropriate corrective action will be taken. Following the erection of the OLS, functional tests will be performed that will verify proper assembly of the electrical and mechanical components. Once functional tests are complete and acceptable, the OLS will undergo load testing as described in the response to Question 12.(1).

NRC Question No. 12 (Item c)

(c) Describe how TVA will verify the integrity of all control, operating, and safety systems of the OLS following erection.

TVA Response

OLS monitoring instrumentation has been calibrated by Lloyds Register Rotterdam, The Netherlands, certificate NR 9855917, dated 01-03-1999 when the OLS was manufactured. Functional tests over the intended range of use and a load test will be performed on the OLS after it is erected to assure that the control, operating, and safety systems of the OLS are functioning properly. The load measuring devices on the OLS will be verified during the 110% load test that is performed after the OLS is erected on site.

NRC Question No. 12 (Item d)

(d) How will TVA demonstrate the ability of the OLS to protect against an overload situation to include the ability of the OLS to withstand a load hang-up?

TVA Response

The load measuring devices on the OLS will provide load indication to the OLS operator. A redundant load moment safety system progressively warns and then disables crane operations. Once a system is disabled (i.e., will not allow additional load to be taken or the lift radius to be increased), only OLS operations that will improve safety margins (i.e., reducing the lift radius or reducing the height of load being lifted) will be allowed by the system.

NRC Question No. 13

13. Will lifting devices that are not specially designed meet the guidelines of NUREG-0612, Section 5.1.1(5), as set forth in ANSI B30.9, "Safety Standard for Cranes, Derricks, Hoists, Hooks, Jacks, and Slings?" In addition, do the interfacing lift points on the old/new SGs, such as the lifting lugs meet the guidelines of NUREG-0612, Section 5.1.6(3)(a) or (b)? What criteria are the interfacing lift point (i.e., the SG trunnions) designed to meet?

TVA Response

The lifting devices that are not specially designed (i.e., commercially available rigging components such as wire rope slings and shackles) will ~~are required by the specification to which the rigging is designed and furnished to~~ comply with ASME~~ANSI~~ B30.9, “Slings.”~~.~~ Below-the-hook lifting devices that complement the slings will comply with ASME B30.20, “Below-the-hook Lifting Devices.” For the Sequoyah SG lifts, the lifting devices that are not specifically designed are the slings and shackles. The “below-the-hook” rigging devices consist of components such as spreaders, equalizers, links and pins.

~~The lifting trunnions have been designed per the requirements of ASME NQA-1, Subpart 2.15 and AISC Steel Construction Manual.~~

~~The design load by which the sling is selected includes the static load plus all dynamic loads (e.g., impact and wind), and these loads are documented in calculations prepared by the rigging contractor and reviewed by Bechtel. The guidance of Section 5.1.6 of NUREG-0612, which addresses Single-Failure-Proof Handling Systems, has not been applied to the interfacing lift points (e.g., trunnions) for loads handled by the OLS. While the OLS incorporates many redundant and safety-enhancement features, it is not considered a single-failure-proof lifting system. Consequently, the other heavy load handling and plant safety provisions, including compensatory measures, have been made a part of the load handling plan.~~

The below the hook devices have been designed for the loads that includes a dynamic load factor per the requirements of ASME NQA-1, Subpart 2.15 and meet the requirements of ASME B30.20 where the minimum factor of safety (FOS) to yield stress is $\geq$ 3.0.

The slings and shackles have been designed per the requirements of ASME B30.9 where the minimum FOS against ultimate capacity is required to be greater than or equal to 5. The minimum FOS for the SG lifts at Sequoyah is 5.3 for the slings and 7.1 for shackles, and is based on the maximum static and dynamic impact loads. These lifting devices, therefore, meet the guidelines provided by ASME B30.9 and Section 5.1.1(5) of NUREG-0612. The minimum FOS against ultimate capacity, based on the inclusion of seismic loads is 6.23 for shackles and 4.65 for the slings.

The design load by which the sling is selected includes the static load plus all dynamic loads (e.g., impact and wind), and these loads are documented in calculations prepared by the rigging contractor and reviewed by Bechtel. The guidance of Section 5.1.6 of NUREG-0612, which addresses single-failure-proof handling systems, has not been applied to the interfacing lift points (e.g., trunnions, lugs) for loads handled by the OLS, since a single-failure-proof lifting arrangement is not being provided. While the OLS incorporates many redundant and safety-enhancement features, it is not considered a single-failure-proof lifting system. Consequently, effects of postulated non-mechanistic load drops from the OLS have been evaluated and heavy load handling and plant safety provisions, including compensatory measures, have been made a part of the load handling plan to satisfy the evaluation criteria of Section 5.1 of NUREG-0612.

The discussion below provides the design criteria used for the design of interface lifting points and a measure of "robustness" of the interfacing lift point with the calculated FOS. The design load considered for the design of interface lifting points includes maximum static and dynamic loads.

The interfacing lift points for the Sequoyah Unit 1 steam generator lifts are as follows:

(a) For RSGs: Lifting trunnions that attach to the secondary manways

The lifting trunnions have been qualified per the requirements of ASME NQA-1, Subpart 2.15 and the allowable stress design of AISC Manual of Steel Construction – ASD, 8th Edition for the design load that includes a dynamic impact load. The stress interaction ratios for the trunnion base metal (ASTM SA 516 Gr 70) are 0.122, 0.275, and 0.03, for shear, bearing and bending stresses, respectively. The stress interaction ratios for the trunnion bolts (1.25”-8UN, ASTM A193 B7) are 0.565 and 0.586, for shear and tension stresses, respectively. The allowable stresses in the AISC-ASD design philosophy for bolts has a minimum factor of safety against yield strength of 2.55 for shear and tension. Based on the interaction ratios above, the trunnion design has a minimum factor of safety of 2.55/0.586 = 4.35 against yield.

(b) For Old Steam Generators (OSGs): Lifting lug welded to the main steam nozzle

The lifting lugs ("plugs") have been qualified per the requirements of ASME NQA-1, Subpart 2.15 and the allowable stress design of AISC Manual of Steel Construction – ASD, 9th Edition for the design load that includes a dynamic impact load. The lifting plug is of ASME SA-508 Grade 1A forged carbon steel material welded to the main steam nozzle using a 1-3/8" partial penetration weld. The maximum stress interaction ratio for the plug design was 0.59. The allowable stresses in the AISC-ASD design philosophy has a minimum factor of safety against yield strength of 1.6. The interaction ratio of 0.59 corresponds to a minimum FOS against yield of 1.67/0.59 = 2.83. The maximum stress interaction for the weld is 0.5. The allowable stress in the weld has a factor of safety of 1/0.3 = 3.33 against ultimate strength. Therefore, the interaction ratio of 0.5 corresponds to a FOS against ultimate of 3.33/0.5 = 6.66. The stresses in the main steam nozzle were checked and the minimum factor of safety in the stress intensity in the main steam nozzle was 3.1.

Summary

Slings (ASME B30.9)

The table below summarizes the minimum factor of safety for slings and shackles that are covered by ASME B30.9. All items have a factor of safety to ultimate greater than 5 as required by ASME B30.9.

Replacement Steam Generators		
Item	Factor of Safety (FOS)	FOS with inclusion of seismic loads
Shackles	7.1	6.2
Slings	5.3	4.7[(1)]
Old Steam Generators		
No Shackles or Slings		

(1) Per NUREG-0612, 5.1.1 (5), “the loads imposed by the SSE need not be included in the dynamic loads imposed on the sling of lifting device” but are included in this column since the crane has been qualified for seismic II/I lifts.

Below-the-hook Lifting Devices (ASME B30.20)

The table below summarizes the minimum FOS for additional below-the-hook lift device components that are covered by ASME B30.20. All items have a FOS to yield greater than 3 as required by 20-1.2.2 of ASME B30.20.

Replacement Steam Generators		
Item	Factor of Safety (FOS)	FOS with inclusion of seismic loads
Link Pins	6.9	6.1
Links	3.8	3.3
Spreader Pin	4.2	3.7
Equalizer Pin	3.5	3.1
Equalizer	3.6	3.2
Spreader	2.2 (2)	1.9 (2)
Trunnion	6.7	5.3
Trunnion Bolts	4.4	3.8
Old Steam Generators		
Link Pins	15.2	13.3
Links	3.8	3.3
Lifting Plug Base Metal	2.8 (1)	2.5 (1)
Lifting Lug Weld	3.3	2.9
Generator Nozzle Metal	3.1	2.7

(1) This base metal bending check was performed using a simplified analysis and thus is very conservative; therefore, the actual safety factor is much higher.

(2) As noted above the below-the-hook items were designed per NQA-1, Subpart 2.15 and many of these items have historical data that shows satisfactory performance in handling loads greater than that expected at Sequoyah which is an acceptable qualification method per NQA-1, Section 5.3.1 (a). This spreader beam has successfully been used at OHI Units 1 and 2 (Japan), Farley Units 1 and 2 and Sharon Harris lifting 946, 836 and 847 kips, respectfully.

NRC Question No. 14

14. Provide a description of how the OLS is anchored to the platform and describe the critical locations in the load carrying parts of the OLS for the various boom configurations. During a design basis earthquake with or without the largest postulated lifted load to include pendulum and swinging loads, demonstrate that the OLS will remain anchored to the platform and that the platform and OLS will be prevented from overturning.

TVA Response

The OLS will be supported on top of an 8 ft wide, 78.5 ft diameter concrete ring foundation that is supported by approximately 80 piles to bedrock and has an integral concrete cap that is a minimum of 4 ft thick. The crane base is supported on 24 independent jack stands, which are resting on top of the pile cap. Each jack stand is approximately 5 ft x 7.5 ft. Lateral loads are resisted by friction between the stands and the concrete.

The OLS was evaluated and seismic II/I qualified in Reference 21 of Topical Report 24370-TR-C002 for stability and stress under the minimum design basis earthquake event for the proposed SGR lift configurations in both the loaded and not-loaded conditions. Due to the very low natural frequency of the pendulum (~0.1 hz) with a SG as the lifted load, the lateral displacement response of the SG center-of-gravity relative to the boom tip is less than 0.25 ft. The corresponding lateral load applied to the boom tip is approximately 2 kips, which is negligible for crane stability and stress calculations. Therefore, lateral loading of the boom tip due to “swinging” was neglected in the stability and stress calculations.

A seismic analysis has been performed for the OLS which demonstrates that the OLS is capable of sustaining SSE loads without failure of the OLS foundation, the crane structural components or the rigging devices. The seismic evaluation of the OLS was based on dynamic modal analysis by the response spectrum method using a GT-Strudl finite element model. The seismic response spectrum used in the analysis was derived as explained in the response to Question 34. Three critical OLS configurations (based on lift radius and load) that envelop all the configurations of the OLS Crane for the Sequoyah Unit 1 SGRP were analyzed separately. Each of these three configurations were analyzed both in the not-loaded and loaded conditions. Responses were obtained for dead + lifted loads (D+L) load combination and under D+L+E load combination, where E is the seismic load. Based on the force and displacement responses from the finite element analyses, the OLS was evaluated for strength (stress) and stability.

~~Calculations have determined that the minimum factor-of-safety against overturning during a seismic event is 1.13. The factor-of-safety against sliding during a seismic event is 1.55. The factor-of-safety against torsional sliding is 1.91.~~

For the stress analysis of critical crane components it was conservatively assumed that all the members and connections have an interaction of 1.0 for combined stresses at their maximum working allowable for dead + lifted loads (D+L). The interaction value of 1.0 under D+L load condition is a baseline number for quick evaluation under D+L+E load condition, where E is the seismic SSE load condition and acceptance was yield stress for seismic II/I qualification. The minimum factor of safety to yield strength available in the allowable stress design is 1.5. The ratio of the responses (D+L+E)/(D+E) was calculated and compared to 1.5. If the ratio was less than or equal to 1.5, the members were considered adequate without any further evaluation. If the ratio was greater than 1.5, a more detailed evaluation of stresses was performed to determine adequacy of the member. For some components like the base components, stresses were directly evaluated without using the ratioing approach. The stresses in all components that were evaluated further remained within AISC-ASD 9th Edition allowables. The maximum combined stress interaction ratio under the load combination including seismic load was 1.2 in comparison to the allowable of 1.5.

Stability (overturning, sliding) of the crane was evaluated based on base reactions obtained from the analyses. The evaluation determined that the minimum factor-of-safety against overturning during a seismic event was 1.13 and the minimum FOS against sliding during a seismic event was 1.55. The results of the evaluation showed that the critical failure mode of the OLS crane in a seismic event was by overturning (tipping).

The maximum lifted load of the SGs during the SGRP is about 386 mt (metric tonnes). The maximum lift radius with the full SG load is 54.84 m. The rated chart capacity (including effect of allowable operating wind speed) of the OLS based on 55 m lift radius is 408 mt. The worse case lifted load is therefore 94.3 percent of chart capacity. It is noted that this 94.3% chart capacity happens only for one of the RSGs. For the other RSGs and the OSGs, the percentage of chart capacity at their maximum lift radii are around 91 percent or less. The rated chart capacities of the OLS have a factor of safety of at least 1.25. For the worst case lift of the SG corresponding to 94.3 percent chart capacity, the factor of safety against overturning is at least (1.25/0.943) = 1.33. As discussed in the previous paragraph, during a seismic event the minimum factor of safety against overturning for the OLS crane was 1.13. Further, the OLS is seated on a firm engineered pile foundation that is adequately designed for the design loads including seismic loads, ensuring that there will not be a collapse of the crane due to a foundation failure in a seismic event.

The evaluation thus demonstrated that the OLS will remain structurally adequate and stable and will not collapse or result in a drop of the load during a design basis SSE event for the lift configurations to be used for the Sequoyah Unit 1 SGRP. Therefore, use of the OLS for the Sequoyah Unit 1 SGRP will not result in any seismic II/I interaction issues on the Category 1 SSCs located in the vicinity of the OLS. ~~For the stress analysis of critical crane components, it was conservatively assumed that all the members and connections have an interaction of 1.0 for combined stresses at their maximum working allowable for dead + lifted loads (D+L). The interaction value of 1.0 under D+L load condition is a baseline number for quick evaluation under D+L+E load condition, where E is the seismic SSE load condition and acceptance was yield stress for seismic II/I qualification. The minimum factor of safety to yield strength available in the allowable stress design is 1.5. The ratio of the responses (D+L+E)/(D+E) was calculated and compared to 1.5. If the ratio was less than or equal to 1.5, the members were considered adequate without any further evaluation. If the ratio was greater than 1.5, a more detailed evaluation of stresses was performed to determine adequacy of the member. The stresses in all components that were evaluated further remained within AISC-ASD 9th Edition allowables.~~

NRC Question No. 15

15. What are the minimum wind conditions for operation of the OLS, how was the minimum wind condition determined, and what is its basis? If these conditions are encountered during heavy load lifts what actions will be taken to secure the load and place it in a safe condition? ~~How long will it take~~

~~considering side loads effects could cause the OLS to tip over?~~

TVA Response

The maximum wind speed allowed during operation of the OLS (PTC Crane) when the lifted load is more than 3 ft off the ground and outside the containment is 10 m/s (22 mph) in any direction measured at the boom tip. This operating wind speed is specified in the PTC Crane Manual and the load capacity charts. The wind load due to this maximum wind speed has been accounted for by the manufacturer in the crane structural and stability calculations based on which the safe working load specified in the load capacity table was arrived at with safety margins specified in the lifting codes. The maximum wind speed allowed during operation of the OLS when the lifted load is less than or equal to 3 ft off the ground or inside the containment is 15 m/s (33 mph) in any direction measured at the boom tip. The lifting capacity of the OLS was determined by the manufacturer in accordance with the following codes (lifting codes): DIN 15018 Parts 1 & 3, DIN 15019 Part 2, DIN 15020 Part 1 and DIN 1055 Part 4, ASME B30.5-1994, SAE J987, SAE J765 and CE. It is noted that the OLS comes instrumented with a wind speed anemometer mounted at the boom tip.

The rigging contractor’s calculation provides a comparison between the actual calculated wind force on the steam generator, using a wind speed of 50 mph, and the allowable lateral load on the steam generator, per the OLS manufacturers requirements. This comparison indicates that even with a wind speed of 50 mph the wind force on the steam generator will be approximately 55 percent of the allowable wind force. Keeping in mind that the allowable wind speed will be limited to 22 mph (10 m/s) in the high lift position (with the load outside containment) and 33 mph (15 m/s) in the lowered position (or with the load inside containment) one can see that sufficient margin remains to maintain the OLS in a safe condition.

In case the wind at the tip is expected to exceed the specified 10 (15*) m/s (22 (33*) mph), the crane will be secured in the configurations below as specified in the PTC Crane Manual and the rigging contractor’s calculation:

Wind Speed at Tip	Mainmast Angle	Jib Offset Angle	Slew Drive	Load
10 (15*)-22 m/s (22 (33*)-49 mph)	All angles allowed $0^o – 85^o$	Minimum 10^o	Braked	Lower Block (**) suspended
22-30 m/s (49-67 mph)	80^o	10^o	Braked	Lower Block (**) suspended
30-46 m/s (67-103 mph)	80^o	10^o	Braked + Park Brake	Lower Block (**) secured with 200 tonne (440 kip) pretension to 250 tonne (550 kip) ballast on the ground
>46 m/s (> 103 mph)	Boom lowered	Jib lowered	Free	Not applicable

(*)– Only when lifted load is carried not more than 3 ft above grade.
(**) Lower Block is the terminology used by the crane manufacturer for the main hook block or load block.

The above table shows that the load may remain suspended from the lower block (main hook block) for wind speeds up to 67 mph with the slew drive braked and the mainmast and jib offset angles configured as specified in the table. The maximum time required to bring the OLS from the operating configuration to the specified configuration is less than 15 minutes. For wind speeds anticipated in the 67-103 mph range, the OLS shall be configured with regard to mainmast and jib offset angles as specified in the above table and the following cases apply with regard to the load: (1) If the load on the hook is equal to or greater than 550 kips, the load will be partially lowered to the ground so as to maintain a pretension of 440 kips; (2) If the load on the hook is less than 550 kips or there is no load on the hook, the load will be lowered and removed from the hook and the lower block tied off to a 550 kip ballast on the ground with a 440 kip pretension. The maximum time required to bring the crane from the operating configuration to the specified configuration is less than 30 minutes.

When wind speeds could exceed 103 mph (this would be expected to occur only during tornadoes), the boom and the jib will be lowered. The time required to accomplish this is about 2 hours (if no load is on the hook). Should there be an unexpected detrimental change in weather while the OLS is loaded, the lift will be completed and the OLS will be placed in its optimum safe configuration or the load will be grounded and the crane will be placed in a safe configuration. The time to accomplish this will vary depending on the load being lifted and the stage of the lift.

The OLS manufacturer has qualified the crane for wind effects, including side load effects, for wind speeds up to 103 mph, with the lower block secured to a 550 kip load and pretensioned to 440 kips. Thus, the OLS will not tip over from side load effects for wind speeds up to 103 mph. The design basis wind speed for Sequoyah Nuclear Plant is 95 mph (UFSAR Section 3.3.1.4). Wind speeds exceeding 103 mph can be expected only during a tornado. However, for the Sequoyah SGR Project, all heavy lift operations using the OLS will commence only after confirming, based on weather forecasts and reports, that no severe weather conditions are expected for the duration of the lift. In the event a tornado watch or warning is announced in accordance with Procedure AOP-N.02, crane operations shall cease and the boom and jib will be lowered and oriented in a N-E direction as indicated on Figure 5-2 of Topical Report 24370-TR-C-002.

Lateral Capability of the OLS Compared to a Lampson Crane

Lampson Transi-Lift Crane: 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 pressures on the base or 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.

OLS: 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 is 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 (average) 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 will be seated on the reinforced concrete pile cap of an engineered battered pile foundation consisting of approximately 80 piles anchored into bedrock. The battered pile foundation is designed for lateral loads (seismic and wind) in addition to gravity loads of the crane and load.

The above structural features and configuration of the OLS provides its with a significantly higher lateral load carrying capability in comparison to the Lampson crane.

Correlation of Operating Wind Speeds of OLS and Other Cranes

- The permissible operating wind speed (measured at the tip of the jib) specified for the OLS (Mammoet PTC Crane) for the Sequoyah SGR Project is 22 mph (for all wind directions) when the load is more than 3 ft off the ground and outside the containment and 33 mph (for all wind directions) when the load is 3 ft or less off the ground or inside containment. The maximum permissible wind load at the load is 0.75% of the safe working load (SWL) specified in the load capacity chart. For the worse case lift of the SG for the Sequoyah SGRP, this lateral wind force will occur on the load at a wind speed of 50 mph. The OLS has been load tested for side loads corresponding to 2% of SWL, which corresponds to a side load on a steam generator that is 2.9 times that from a 50 mph wind. This comparison indicates the substantial safety factor for wind load even at 50 mph for the use of the OLS for the Sequoyah SGR.

- For the Lampson Transi-lift crane used in the Miller Park Project, the specified operating wind speed was 20 mph. The wind anemometer was mounted on the boom at an elevation of ~175 ft from the ground, not at the jib tip. Based on reports of the accident, winds were gusting in the 28-30 mph range during the afternoon of the accident.

It is noted that in the cases of crane failures that have occurred at low wind speeds (e.g, the Lampson crane at Miller Park), the wind in and of itself, has not been the ultimate factor for failure, but a contributing factor among others, the combination of which resulted in the final collapse. Some of these factors are included in the discussion below.

- For the OLS, wind loads have been accounted for by the manufacturer both on the crane structure as well as the load in developing the rated load capacity tables. The maximum permissible lateral wind load at the load is 0.75% of the safe working load (SWL) specified in the load capacity chart. For the worse case lift of the steam generator for the Sequoyah SGRP, this lateral wind force will occur on the load at a wind speed of 50 mph. The OLS has been load tested for side loads corresponding to 2% of SWL, which corresponds to a side load on a steam generator that is 2.9 times that from a 50 mph wind. This comparison indicates the substantial safety factor for wind load even at 50 mph for the use of the OLS for the Sequoyah SGRP. The actual permissible operating wind speed at the tip of the jib specified for the crane for the Sequoyah steam generator replacement is 22 mph (for all wind directions) when the load is more than 3 ft off the ground and outside the containment and 33 mph (for all wind directions) when the load is 3 ft or less off the ground or inside containment. Thus, there is significant margin available with regard to wind load on the OLS.

For the Lampson crane at Miller Park that failed, the manufacturer's recommendation with regard to permissible wind speeds was 20 mph. Based on reports of the accident, winds were gusting in the 28-30 mph range during the afternoon of the accident. Also, the wind anemometers were placed at a lower elevation relative to the tip of the jib and therefore, were not measuring the wind speed at the jib tip. Wind loads were not accounted for on the 180 ft x 100 ft load. In addition, the actual lifted load was ~105% of that allowed by the Lampson crane's rated load capacity chart. Further, the rated loads for the Lampson crane were 85% of its tipping load in comparison to less than 80% for the OLS.

- All calculations/tests performed by crane manufacturers with regard to stability of crane under wind loads in developing their rated load capacity charts assume that the crane base is seated on a firm level surface and the foundation is capable of carrying the bearing pressures. The OLS crane to be used for the Sequoyah SGR Project 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 will be seated on the reinforced concrete pile cap of an engineered battered pile foundation consisting of approximately 80 piles anchored into bedrock. The battered pile foundation is designed for lateral loads (seismic and wind) in addition to gravity loads of the crane and load. Thus, the OLS will be seated on a firm level foundation designed to carry all the expected loads.

The Lampson crane at Miller Park was not seated on a firm level surface. There was no engineered foundation designed especially considering heavy loads of the order of 450 tons that were lifted. Also, the crane was mounted on crawlers with relatively smaller footprint in comparison to the ringer base. In addition, it is reported that at the time of failure there were apparent cracks in the ground on which the crane was seated.

- Due to the structural (A-Frame/double-frame construction and ringer base) configuration of the OLS discussed under the 'Lateral Capability Of The OLS Compared to a Lampson Crane' section above, the OLS has significantly higher lateral load carrying capability in comparison to other cranes available. In comparison, the Lampson crane mast components are of single lattice frame construction.

NRC Question No. 16

16. Section 5.2 of the submittal indicates that the mobile (lattice boom and/or truck) cranes used in the assembly/disassembly of the OLS will have a current certification and will be load tested during production. However, the licensee did not indicate if the mobile cranes will be "proof tested" to ensure proper operation. Demonstrate the operability of the mobile cranes prior to assembly of the OLS by testing in accordance with B30.5. Will a 110 percent static load test be completed and will full performance tests with 100 percent of the largest postulated lifted load for all speeds and motions for which the system is designed be conducted prior to heavy lift operations?

TVA Response

The term "proof tested" refers to the performance testing of the crane features. Section 5-2.2 of ASME B30.5 discusses operational tests and rated load tests for mobile cranes. Operational crane tests are performed at the time of production of the crane and the crane manufacturer maintains records of these tests. During the assembly/disassembly of the OLS and prior to each shift usage of the mobile cranes, a 20-point checklist of the crane features will be conducted by that shift operating team and signed off.

If a load sustaining part of a crane (other than the wire rope) is altered, replaced, or repaired, ANSI B30.5 requires that the crane be load tested using a maximum of 110% of the manufacturer's load rating. For wire rope replacement, a functional test is performed using normal operating loads. The mobile cranes used in the assembly/disassembly of the OLS will follow these ANSI requirements.

NRC Question No. 17 (Item a)

17. Section 5.2 of the submittal states that "restrictions on the use of these cranes (mobile cranes-lattice boom and/or truck) will be imposed to specify the weather conditions under which they may be operated and how and when to secure the mobile cranes in case of inclement weather; and the restrictions are designed to preclude adverse interactions with safety-related SSCs [systems, structures and components]." With respect to the use of the mobile cranes for assembly and disassembly of the OLS, provide a response to the following:

(a) Describe the restrictions for use of the mobile cranes during assembly/disassembly of the OLS.

TVA Response

Use of the mobile cranes for OLS assembly/disassembly will be governed by the following restrictions:

(1) Load handling with the mobile cranes is limited to an approved area around the OLS boom location shown on Figure 5-2 of Topical Report 24370-TR-C-002.

(2) The load imposed on the ground by the crane is limited to the calculated allowable ground bearing pressure of 4 ksf.

(3) Timber mats will be placed as shown on Figure 5-2 in Topical Report 24370-TR-C-002 over safety-related utilities (ERCW pipes).

(4) Loads traveling over safety-related systems, structures and components (SSCs) shall be carried as low to grade as possible. Loads up to 50 kips may be lifted up to 20 ft above safety-related SSCs as long as the safety-related SSCs are protected with 1 ft of timber mat.

Handling of loads in excess of 50 kips over safety-related SSCs requires Engineering evaluation and approval prior to commencement of the lift.

Wind related restrictions on mobile crane operation are detailed in the response to question 17 (b) below.

NRC Question No. 17 (Item b)

(b) What are the minimum wind conditions for operation of the mobile cranes? How was the minimum wind condition for operation determined and what is its basis (e.g., dead weight of the boom with maximum postulated lifted load)?

TVA Response

Load handling operations with the Manitowoc 4100 cranes used for assembly/disassembly of the OLS will cease and the cranes will be put in a safe configuration when winds exceed 35 mph. This wind speed is based on the crane manufacturer’s operating manual. The crane components to be lifted consist of lattice boom sections, which have a small sail area. If other mobile cranes are used during the assembly/disassembly of the OLS, load handling operations will cease when winds exceed the manufacturers maximum recommended wind speed for safe operation.

Mobile crane operations will cease and the cranes will be put in a safe configuration if a tornado watch or warning has been announced in accordance with Procedure AOP-N.02, “Tornado Watch/Warning.”

The rationale for allowing higher allowable operating wind speeds for the mobile cranes relative to that for OLS is provided below.

The OLS supplier has determined that the safe operating wind speed while lifting a SG is 33 mph, which includes a safety factor. The project has made the decision to limit the maximum operating wind speed while the generators are greater than 3 feet above the ground and while outside containment to further increase the margin of safety. As stated in the response to Question 15, the maximum operating wind speed allowed for the OLS is 22 mph when the lifted load is more than 3 ft off the ground and outside the containment and 33 mph when the lifted load is less than or equal to 3 ft off the ground or inside the containment. In addition, the SG lifts will be performed at between 90 percent and ~94 percent of rated crane capacity, thus justifying a reduced wind speed.

The allowable operating wind speed for the Manitowoc 4100 mobile cranes that will be used for erection/disassembly of the OLS is 35 mph. This wind restriction for the operation of the crane is in accordance with the manufacturers crane manual. The operating wind speed of the Manitowoc 4100 was not reduced since the consequences of a drop have been evaluated as stated in response to question 12(a) and have been determined not to have a detrimental affect on safety-related plant SSCs. The fire protection piping in the area can be isolated if damaged and this would have no adverse affects on the ability of the fire protection system to perform its Appendix R requirements due to multiple feeds into the category I buildings. In addition, the lifts to be performed by the Manitowoc 4100 will be made at less than 90 percent of rated crane capacity.

NRC Question No. 17 (Item c)

(c) Describe the safety-related SSCs that could potentially be affected by a dropped load during assembly/disassembly of the OLS. What effects could a load drop, during assembly/disassembly, have on Unit 1/Unit 2 operations?

TVA Response

The SSCs in the vicinity of where the OLS will be assembled/disassembled are the essential raw cooling water (ERCW) system piping, refueling water storage tank (RWST), and fire protection piping. Refer to the response to 17.(f) below for a discussion of the protection being provided to preclude any adverse effects of a load drop.

NRC Question No. 17 (Item d)

(d) Describe how an operator, to include those responsible for operations, will be notified of the minimum wind conditions for operation. What actions will be taken if it is determined that winds near or at the limiting conditions for operations have been reached? How long will it take to perform these actions?

TVA Response

The maximum operating wind speed will be relayed to the operator during the prejob briefing and they are also included on the operating load path drawings. A field engineer that accompanies the person-in-charge (PIC) will monitor weather forecasts and wind speed information from the site meteorological tower and will notify the PIC, as required, as wind/weather conditions change. Typically, lifts will commence only after reasonable assurance is obtained with regard to favorable weather and wind conditions at least for the duration of the lift thereby precluding any limiting conditions. However, in the event that winds increase to near or at the limiting conditions, further actions will proceed to place the crane in a safe and optimum configuration in accordance with the drawings, crane operating manual and site procedures, which will be implemented through the work plan and inspection record (WPIR) for the activity.

NRC Question No. 17 (Item e)

(e) Since the mobile cranes have the potential to interact with safety-related SSCs during assembly/disassembly describe the safe load paths for these cranes. What processes or procedures will be used to ensure that mobile crane operations will remain within the safe load paths?

TVA Response

The approved area around the OLS boom location shown on Figure 5-2 of Topical Report 24370-TR-C-002 is a safe load path as long as the cranes are operated in accordance with the restrictions listed in 17.(a) and 17.(b) above and the protection listed in 17.(f) below is in place.

NRC Question No. 17 (Item f)

(f) Demonstrate that the mobile cranes under seismic load during assembly/disassembly, with its largest postulated load, will not fail and potentially impact safety-related SSCs.

TVA Response

Protection (see Sections 7.5 and Figure 5-2 of Topical Report 24370-TR-C-002) for safety-related SSCs has been designed and will be used. With this protection in place, safety-related SSCs will not be affected by a load drop from or overturning of a mobile crane.

NRC Question No. 18 (Item a)

18. The submittal in Section 4.2(2) states that crane operations will be conducted by highly trained and qualified personnel. Also section 4.2(3) references sections 5.1 and 5.2 as providing the details of operator qualifications that conform to ANSI B30.5. With respect to operator qualifications provide a response to the following:

(a) Describe how the qualification program satisfies the requirements in Section 5-3 of ANSI B30.5.

TVA Response

The qualification of the operators will include the requirements specified in ANSI B30.5. The operators will successfully pass a complete physical, which covers all aspects of the standard prior to obtaining approval for crane operation and site access. The testing will include a complete physical, a MMPI psychological test, and training and testing to site procedures.

All OLS operators are being supplied by the manufacturer and have many years experience operating this crane. In addition, the operators will be trained per applicable portions of TVA Procedure MMDP-2, “Safe Practices for Operation of Overhead Handling Equipment.”

NRC Question No. 18 (Item b)

(b) ANSI B30.5, in Section 5-3, states that only designated operators shall operate the crane. However, designated operators are selected or assigned by the employer or the employer's representative as being qualified to perform specific duties. If operators are, or are not, employed by SQN, what requirements/criteria are used to designate operators as being qualified (e.g., physical faculties and fitness, deviations from physical qualifications, grounds for disqualifications, required safety instruction, written examination, and performance test, as well as specific crane written examination and experience requirements)?

TVA Response

See TVA response to question 18 (Item a) above.

NRC Question No. 19

19. NUREG-0612, Control of Heavy Loads at Nuclear Plants, provides guidelines in Section 5.1.1(7) for crane designs which rely on criteria within ANSI B30.2 and Crane Manufacturers Association of America (CMAA) specification No. 70. Section 2-1 of B30.2 provides criteria for construction and installation and CMAA 70 specifies design stresses, service classification, and structural design, mechanical design, electrical and electrical equipment. However, ANSI B30.5 provides no criteria for crane design. What are the critical load-bearing parts, load controlling parts, and operational safety devices of the OLS and how do the operational safety devices work together to ensure safe load handling (e.g., interlocks, upper hoist limit switch, lower hoist limit switch, rotate limit switch, emergency stop switches, locking devices, overload indicators, radius indicator, and overspeed, pressure, and temperature devices with shutdown capability if any)?

TVA Response

The OLS is designed, built, and tested to criteria based on the following DIN standards:

- DIN 15018 Part 1, Cranes: Steel structures, verification and analyses
- DIN 15018 Part 3, Cranes: Principles relating to steel structures; Design of cranes on vehicles
- DIN 15019 Part 2, Cranes: Stability for non-rail mounted mobile cranes; test loading and calculation
- DIN 15020 Part 1, Lifting Appliances: Principles relating to rope drives; calculation and construction
- DIN 1055 Part 4, Design loads for buildings; Imposed loads – wind loads on structures unsusceptible to vibration

In addition, the following codes are also listed in the crane user manual: ASME B30.5-1994, SAE J987, SAE J765 and CE.

The OLS was tested to 125 percent of its rated load after it was manufactured. ANSI inspectors, along with the DIN inspectors, witnessed this test and have certified the crane.

The OLS has dual engines, dual hydraulic systems and dual computers. It is capable of performing its intended function with one of each system out of operation. In the event that all power and hydraulic systems fail, the load can be safely lowered using a 12-volt car battery and the manual controls.

Beyond the OLS's dual systems, an operational safety device called a redundant load moment safety system is integrated into the computer system, which progressively warns and then disables operations, subsequently allowing only operations, which improve the safety margins.

NRC Question No. 20

20. The topical report provides no information on the haul route from the transport location identified on Figure 5-2 and whether the potential to interact with safety-related SSCs exists along the haul route, and whether those SSCs could either withstand the impact of a dropped SG or will be protected to preclude them from damage. What is the distance between the lay down area and the old and new SG storage area and what is the method used to load test the haul route (civil/structural)? What are the safety-related components that are located along the haul route that could be impacted by a dropped SG? What safety functions/systems would be impacted? What measures are to be taken to preclude a SG drop along the haul route and preclude the identified components from being damaged if a SG drop occurred?

TVA Response

The SG haul route is shown on Figure 1 in the response to Question 8. The distance from the downending/upending (lay down) area to the OSGSF-replacement steam generator storage area (RSGSA) is approximately 2,180 ft. A review of SSCs in the vicinity of this portion of the haul route determined that the only safety-related SSCs are the ERCW ductbanks, manhole (MH) groups 31 and 32, handhole (HH) group 52, and 36 inch diameter ERCW piping. The MH and HH groups are associated with the ERCW ductbanks. There are no safety-related utilities close enough to the portion of the haul route between the replacement steam generator (RSG) barge offload area and the RSGSA to be affected by a load drop.

As noted in Section 6.3 of Topical Report 24370-TR-C-002, Section 9.2.2 of the UFSAR indicates that the ERCW system design function is to supply cooling water to various heat loads in both the primary and secondary portions of each unit. The ERCW ductbanks contain cables associated with ERCW trains A and B for both units. The manholes/handholes were used for pulling the ERCW cables.

The potential for a load drop in the vicinity of the safety-related SSCs will be minimized by operating the transporter at less than 5 mph, provision of a stable road surface with limited grades, and use of a stable single-wide transporter. Additionally, the height of the transporter will be restricted in the vicinity of safety-related SSCs.

Although the SG transporter is considered rugged equipment, it is not specifically designed to withstand external events addressed by 10 CFR 50, Appendix A, GDC 2, which are part of the Sequoyah design basis. The probability of an external event occurring when the transporter is near a safety-related SSC, and which causes a heavy load drop that results in loss of the adjacent SSC is extremely low. However, to conservatively address the worse case consequences, a test weight or SG drop off the transporter was postulated to occur anywhere along the haul route in conjunction with a plant external event.

An evaluation of the impact of a load drop on the nearby safety-related SSCs determined that the ERCW ductbanks are adequate to withstand the impact without any protection. The 36-inch diameter ERCW piping is adequate provided that 2.5 ft of sand fill (or equivalent) is provided along the ERCW pumping station access road. The MH and HH groups are adequate provided that 2.5 ft of wood cribbing is placed along the perimeter on three sides of MH 31A1, MH 32A1, and HH 52A1. With this protection in place, there will be no impact on safety-related SSCs as a result of a load drop from a transporter.

In lieu of performing the haul route load test with a fully loaded transporter, the test will be performed by loading the test vehicle with enough test weights to produce a subgrade bearing pressure equivalent to or greater than that caused by a loaded transporter. The purpose of the load test is to develop a test pressure that will identify any soft spots in the surface course/subgrade requiring repairs. The entire haul route will be load tested prior to the SG transport. The entire haul route need not be tested all at one time; individual segments may be tested at different times. Load drop protection need only be present immediately prior to and during passage of the load (test load or SG).

NRC Question No. 21

21. In accordance with recommendations provided in NUREG-0612, Section 5.1, discuss the potential for accidental dropping of the SG inside the reactor containment building. Discuss the potential consequences that could result from dropping the SG and any compensatory measures that could be implemented to minimize and mange the damage from the drop. Provide rationale for choosing a clearance of 20 feet (ft) above the dome for lifting the SGs when its been analytically determined that at 12.75 ft or greater a dropped SG would perforate the dome and steel containment vessel.

TVA Response

Accidental dropping of a SG inside containment has been evaluated as part of the rigging engineering package and associated 10 CFR 50.59 evaluation. Lifting of heavy loads inside or above the Unit 1 containment with the OLS (PTC Crane) will not commence prior to completion of defueling. Since all fuel will be removed from the containment and the spent fuel pit (SFP) will be isolated from containment, a load drop from the OLS inside or above the containment will not result in; 1) releases 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 spent fuel pool that causes a loss of water and the fuel to be uncovered.

Equipment required for safe shutdown may be affected by a load drop from the OLS inside or above the containment. Since Unit 1 is already shutdown and defueled, loss of this equipment would not affect the ability to shutdown Unit 1. However, some of the equipment that may be impacted is common with Unit 2. Common systems are the ERCW system, component cooling system (CCS), and control air system. To assure that a load drop from the OLS inside or above the containment will not affect the ability to shutdown Unit 2, the isolation valves outside containment for the ERCW system and CCS will be closed prior to lifting heavy loads with the OLS. The isolation valves for the control air system inside containment are located well away from any potential load drops and would not be affected. Since the isolation valves will not be affected, any break in control air lines due to a load drop results in loss of air and failure of the isolation valves in the safe (closed) configuration. Therefore, a load drop from the OLS inside or above the containment will not affect the ability to shutdown either unit.

If a SG drop is postulated to occur while the SG is above the containment shield building dome, it is assumed to fall vertically onto the dome directly below where it is suspended at the time. If the SG were to roll off of the dome it could potentially hit the auxiliary or control buildings and impact the spent fuel pool and/or equipment required to safely shutdown Unit 2. As noted above, with the reactor defueled, outside containment isolation valves for ERCW and CCS closed, and the SFP isolated from the containment, a load drop inside containment will not impact fuel or prevent the safe shutdown of Unit 2. Given the consequences of a SG impacting the auxiliary or control buildings, handling of the SGs must be done in a manner that assures that if a SG drop occurs above the containment dome, it penetrates the dome rather than rolling off of it.

Since it is difficult to predict where the SG will go following an impact from an arbitrary height onto the dome, an analysis was performed to determine the minimum height above the dome a SG would need to be suspended to guarantee that it would penetrate the shield building. This minimum distance between the SG and the shield building dome will be maintained by lifting the SGs vertically through the containment openings until the defined minimum clearance is attained. The SGs will then be translated horizontally to the outer edge of the containment as shown on Figure 5-2 of Topical Report 24370-TR-C-002.

As detailed in Section 7.1 of Topical Report 24370-TR-C-002, a SG drop from a height of 12.75 ft or greater will perforate the concrete shield building dome and steel containment vessel (SCV). A drop from this height ensures complete penetration of the SG through the dome and into the containment building, as opposed to a response characterized by impact with and deflection off the containment dome. To be conservative, a minimum clearance from the shield building dome of 20 ft will be used when lifting the SGs. This 20 ft clearance is within the lifting limit of the OLS.

<u>NRC Question No. 22</u>

22. Explain what is meant by discharge piping in Section 8.3 of the topical report (e.g., is it the discharge to the ultimate heat sink or is it the flow of cooling water to safety and nonsafety related loads)? If discharge is to the safety and nonsafety related loads describe the effects of an essential raw cooling water (ERCW) Train A discharge piping failure for both units on plant operations from a heavy load drop from the maximum postulated lifted load.

What safety-related SSCs will be affected and what compensatory measures will be implemented to minimize and manage the damage from the drop?

TVA Response

The term "ERCW discharge header" as used in Topical Report 24370-TR-C-002 refers to the piping returning water to the ultimate heat sink (UHS) from the various heat exchangers. The term "Supply header" as used in the Topical Report refers to the piping from the ERCW pumps to the various heat exchangers. Refer to the revised Section 8.3 in the Topical Report and to Attachment 1.

NRC Question No. 23

23. The topical report, in Section 8.3 for the Unit 2 ERCW supply piping, determined the peak particle velocity from a drop load using Reference 14 of the topical report. However, Reference 14 indicated that criteria for underground utilities are not available, which includes pipelines. Moreover, Reference 14 indicated that criteria should be based on available controlled tests and not on evaluations. The load used in Reference 14 was a two-ton ball dropped from 40 ft, which is a few orders of magnitude lower than the largest postulated load that can be potentially dropped at SQN (400-500 tons). What assumptions were made, such as soil type, soil compaction, depth of piping, vulnerability of supply piping during the lift (length of time during lift that makes this situation plausible), difference in loads evaluated in Reference 14, and height of lifted load above surface? How were uncertainties accounted for in the calculation considering that the reference provides no criteria to evaluate peak particle velocities in soil for underground utilities? What was the calculated peak particle velocity and pressure 63 ft away from the drop and what design pressure is the piping designed to withstand? Does the compacted soil around the piping act as a missile shield to protect the ERCW supply line piping and if so how was this factored into the evaluation?

TVA Response

The references pointed to in this response are listed at the end of the response.

The pipes being evaluated are the Unit 2 30-inch diameter ERCW pipes (0.375 inches wall thickness, material carbon steel conforming to ASTM A155, KC 60, Class 2 with Fy = 32 ksi) running in the N-S direction on the east side of the Unit 1 shield building. The subject pipe is a flexible pipe. The postulated drop is the drop of 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. The nearest Unit 2 ERCW pipe is located at a distance of ~131 ft in plan view from the load path at the point it crosses the shield building dome parapet wall. The enveloping impact location of the SG after a postulated drop including flop-over after a vertical fall was conservatively estimated as 63 ft from the subject pipes. The soil cover above the pipes is ~2.5 ft. From the subsurface investigation report for the SGR project (Reference (c)), the soil layer near the postulated impact location and at the location of the pipes is stiff clay fill. The soil properties used in this evaluation were primarily based on Reference (c).

The impact from a dropped SG causes waves (body and surface) to propagate in the soil media. These waves are transmitted outward from the impact location (energy source) and are attenuated with distance. Displacement waves move away from the source of a vibration at a constant velocity, called the propagation velocity, that depends in magnitude on the properties of the media and upon the type of wave that is produced. The parameter that is commonly used to describe ground motion is particle velocity. Particle velocity is the velocity of displacement of an individual particle as a vibration wave passes through the particle location. Propagation velocity is simply the rate at which the vibrational disturbance or wavefront moves from the source. Propagation velocity depends on the characteristics of the transmitting medium (soil, rock, etc.), while particle velocity is a function of the amount of energy imparted to the soil at the source, of the distance between the particle and the source, and of any energy losses during transit.

The methodology used for evaluating the buried pipe was as follows:

A. Determine the peak particle velocity of the soil at the location of the pipe

The magnitude of the vibration at a distance due to propagation of shock waves from a source is a function of the energy at the source (effect of source energy) and the distance from the energy source (effect of transmitting media). It has been found by investigators (see References

9, 22, 31 in Reference (a)) that the peak particle velocity is the most useful measure of the vibration magnitude. Combining the effects of distance and energy, the attenuated peak particle velocity (ppv or V_S) of the shock waves at the location of the buried pipe that is quite a distance away from the impact location is determined using the general scaled-distance wave propagation equation of the following form, proposed by Wiss in Reference (a).

$$V_s = K\left(\frac{D}{\sqrt{E}}\right)^{-n}$$

where,

V_S= peak particle velocity, in inches per second;
D = distance, in feet, from the point of impact or energy source
E = impact energy in foot-pounds of the energy source
K = intercept, in inches per second, (value of vibration amplitude at $D/\sqrt{E} = 1\ (ft/lb)^{1/2}$
n = slope or attenuation rate

The above equation can also be expressed in the following convenient form:

$$V_s = K\left(\frac{\sqrt{E}}{D}\right)^{n}$$

The values of the parameters K and n vary and are essentially dependent on the soil type through which the shock waves propagate. The value of n generally lies between 1.0 and 2.0 with a relatively common value of 1.5 (Reference (a)). Figure 5 of Reference (b) (provided as Attachment 2) reports test data from field measurements of particle velocity versus $\sqrt{E}/D$ for different soil types (clay, wet sand, dry sand and rubble). This chart was prepared by Wiss (Reference 2 (provided as Attachment 3) in Reference (b)). From this chart it is noted that the lines for each soil type are linear when plotted to a log-log scale. The values for K and n are determined by fitting the data for clay soil in Figure 5 of Reference (b) into the scaled-distance wave propagation equation. The parameters K and n in the general scaled-distance wave propagation equation, which can be determined from the test data in Figure 5 of Reference (b) for different soil types, are basically a function of the soil type and therefore the data from this chart are applicable and conservative regardless of the magnitude of the impact energy. The values of K and n were determined to be 0.112 and 1.5, respectively. Using values of W = 733 kips (maximum lift weight of a RSG, including attached weights of insulation, trunnions, upper lateral supports and bumpers), H = 135 ft (drop height), and D = 60 ft (distance of impact location from the pipes), the computed value of V_s at the location of the pipes for the subject drop parameters was 19.92 ft/sec.

Further, although the empirical parameters K and n in the scaled-distance wave propagation equation of the form presented by Wiss were determined based on available test data of low intensity wave propagation of relatively minor tremors, its use for a relatively high energy impact of a nuclear steam generator drop is conservative due to higher damping as explained below. The impact energy from a drop, E = (W x H), is conserved after impact as:

$$\begin{aligned} E &= E_{propagated} + E_{dissipated} \\ &= \tfrac{1}{2}\, m_s V_s^2 + E_{dissipated} \end{aligned}$$

where,

m_s = the soil mass effective in ground motion (increases with distance from impact location)
V_s = the soil particle velocity (decreases with distance).

The propagated energy initiates soil motion. In a low intensity impact, only a very small portion of the energy is dissipated and most of the energy is propagated. However, high intensity impacts, in comparison, have much higher damping since a more significant portion of the impact energy will be dissipated at the source point itself by physically displacing the soil in the near vicinity of the impact location where the missile penetrates into the soil and a relatively smaller portion gets propagated as stress waves. Alternatively, the dissipated energy can be regarded as irrecoverable energy due to the extensive localized plastic deformation in the vicinity of the impact. Therefore, the peak particle velocity predicted using the empirical scaled-distance wave propagation will be overestimated since it will correspond to a higher sqrt(E)/D than actually is, and hence the conservatism in the prediction.

B. <u>Determine the free field soil pressure at the pipe-soil interface</u>

Based on one dimensional wave propagation considerations, the ppv (V_S) computed above is then used to estimate the free field soil pressure ($s_{F,}$) on the buried pipe using the relationship between dynamic stress and particle velocity given by the equation (References (d and j):

$$\sigma_F = \rho_s C_{ps} V_s$$

where,

r_s = the density of the soil in which the wave travels
C_{ps} = the propagation velocity of the shock waves (Rayleigh waves in this case) through the media soil; Note that the product r_s C_{ps} is referred to as soil impedance.
V_s = the peak particle velocity at the point of interest in the media (e.g. location of the buried pipe)

The above evaluation assumes the energy is transmitted in a homogeneous, isotropic, elastic half-space. Although soils are not ideally elastic, they behave in a reasonably elastic manner especially at distances away from the impact location. The impact from a dropped SG causes waves to propagate in the soil media. These waves are distributed as body waves and surface waves. The greatest portion (~67%) of the energy imparted to the soil is transmitted as Rayleigh or surface waves (R-waves) followed by shear waves (~26%) (References (g), (h) and (j)). The ERCW pipes are located relatively near the surface. The shock waves that could load the pipe will be the waves propagating horizontally along the surface soil layer. For these reasons surface (Rayleigh) wave velocity will be used for C_{ps} in the above equation. The shear wave propagates at a velocity, C_s, given by (Reference (i), Chapter 3) as:

$$C_S = \sqrt{\frac{G}{r_S}}$$

where,

G = shear modulus
r_S = mass density of the soil material

The velocity of propagation is slightly slower than the shear wave velocity and is taken as $0.95C_s$ (Reference (i), Chapter 3). The estimated free field soil pressure associated with the traveling shock wave at the location of the pipe was 395 psi.

C. <u>Evaluate the buried pipe based on the free field soil pressure on the pipe</u>

For flexible buried pipes, due to their flexibility, the primary performance limit or failure mode under shock wave loading is excessive diametric deformation (deflection) that could result in reversal of curvature of the wall from (Chapter 4 of Reference (e) and Reference (f)). Reversal of curvature is a deflection phenomenon and will not occur if deflection is controlled. Reference (e) provides guidance regarding the dynamic load factor (DLF) and deflection evaluation for shock wave loading of buried flexible piping. Reference (e) recommends use of a DLF value of 1.20 (on the free-field pressure magnitude) in conjunction with the free-field static pressure loading for the determination of maximum soil pressure on the <u>pipe</u>. The resulting pipe radial displacement in the direction of wave loading is determined using the modified Spangler equation for flexible pipes (Chapter 4 of Reference (e)).

$$\Delta X = \frac{g_B W_c r^3}{EI + 0.061 E_{sr} r^3} \frac{1}{0.913}$$

where,

E = modulus of elasticity of pipe wall
I = moment of inertia of pipe wall
r = radius of pipe
Esr = pipe-soil interaction modulus
W_C = DLF x s_F x (2r)
g_B = bedding factor

The internal pressure (design pressure of ERCW pipe is 160 psig) in the pipe was conservatively neglected. Per Chapter 4 of Reference (e) and Chapter 3 of Reference (f), a steel pipe will be in a state of impending failure by reversal of curvature at a deflection of about 20 percent of the pipe diameter. Since the postulated drop of the SG is an extreme event whose occurrence is highly improbable, a deflection of up to 10 percent will be considered acceptable under the resulting shock wave loading and allows a reasonable margin of safety against failure/collapse of the pipe. Thus, adequacy of the pipe against collapse is judged on the basis of a 10 percent maximum radial deflection criterion. This criterion is thought to be fairly conservative, especially considering that the internal pressure of the pipe (which will counteract the wave loading) is neglected. The deflection in the subject evaluation was determined to be 9 percent. The apparent circumferential stress in the pipe wall can be estimated as pd/(2t) = (1.2 x 395 psi) x 30 inches / (2 x 0.3125 inches) = 22.75 ksi against a minimum yield strength of 32 ksi.

The evaluation includes the following conservatisms:

(i) The internal pressure of water in the ERCW pipe (design pressure is 160 psig), which counteracts the effects of shock wave loading, was neglected.

(ii) Although the design thickness of the pipe wall is 0.375 inches, the pipe wall thickness was taken as 0.3125 inches for calculations.

(iii) The load path for the SGs when they are near the periphery of the dome is in a northerly direction. Due to the slope of the dome, the direction of the swing, and configuration of the channel end nozzles, the direction of fall is likely to be in a northerly direction in which case the distance of the impact location from the ERCW pipes will be well over 100 ft. However, it was postulated that the fall takes place in an easterly direction, thereby reducing the distance of the 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 impact location from the pipe used in the computations is quite conservative.

(iv) The scaled energy equation as applied to the response of high energy impact is conservative (see discussion in Section A above).

(i) The time taken for the SG to traverse the load path above the dome near its periphery will be small (~ 5 minutes for each generator lift). Therefore, the time duration during which the postulated drop is plausible is very small.

The following references were used in developing the above evaluation for the buried pipe:

(a) Wiss, J.F., Construction Vibrations: State-of-the-Art, Journal of the Geotechnical Engineering Division, ASCE, Volume 107, No. GT2, February 1981, pp 167-181. (same as Reference 14 in Topical Report 24370-TR-C-002)

(b) Lukas, Robert G., Densification of Loose Deposits by Pounding, Journal of the Geotechnical Engineering Division, ASCE, Volume 106, No. GT4, April 1980, pp 435-446. (same as Reference 15 in Topical Report 24370-TR-C-002)

(c) TVA Document SQ-RPT25.92, Revision 00, Replacement Steam Generator Project Foundation Soil Sample Analysis Report, Unit 1.

(d) Wong, F.S., and Weidlinger, P., Damping of Shallow – Buried Structures due to Soil-Structure Interaction, The Shock and Vibration Bulletin 52, Part 5 of 5, May 1982, pp149-154, Naval Research Laboratory, Washington D.C.

(e) Bulson, P.S., Buried Structures, Static and Dynamic Strength, Chapman and Hall, London, 1985.

(f) Moser, A.P., Buried Pipe Design, McGraw Hill Inc., 1990.

(g) Heckman, W.S., and Haggerty, J.D., Vibrations Associated with Pile Driving, Journal of the Construction Division, ASCE, Volume 104, No. 004, December 1978.

(h) Winterkorn, H.F., and Fang, H.Y. (Editors), Foundation Engineering Handbook, Van Nostrand Reinhold Company, 1975, Chapter 23.

(i) Wu, T.H., Soil Dynamics, Allyn and Bacon, Inc., Boston, 1971.

(j) Dowding, Charles H., Construction Vibrations, Prentice Hall, 1996.

<u>NRC Question No. 24</u>

24. Section 8.3 of the topical report indicated that the ERCW duct banks would be negatively impacted from an OSG or replacement SG (OSG/RSG) drop. What safety-related equipment/functions would be impacted from a dropped OSG/RSG? What is the depth of the duct banks below the surface and what is the maximum pressure the duct banks can withstand without risk of failure? What were the assumptions in the analysis and what were the soil pressures 1 ft above, at the duct bank surface, and 1 to 3 ft below the duct banks as a

result of dropping an OSG/RSG? What is the depth of soil to be added to account for a potential load drop? Specify what soil type, total area to be covered, and compaction requirements for the additional fill, and provide a drawing indicating the locations where fill will be added.

TVA Response

The ERCW ductbanks that are the subject of this question are: (1) Ductbank between manhole MH12 and handhole HH3 (called ductbank DB1); and (2) Ductbank between manhole MH12 and handhole HH29 (called ductbank DB2). See Figure 5-2 of Topical Report 24370-TR-C-002 for location of the ductbanks. They are both well over 200 ft in length. The critical postulated impact was from a flop-over fall after the SG has been dropped from the OLS, the load being carried at a height of 3 ft above grade along the load path at or near the ductbank locations. From TVA drawing 10N251, the grade above the ductbanks in the fall zone of a dropped generator varies from 704 ft to 707 ft. Based on the subsurface investigation performed for the SGR, the soil around the ductbanks is clay fill. The soil properties used in the evaluation were based on the above subsurface investigation and from the UFSAR.

The highest elevation of top of ductbank DB1 is 698.42 ft. The minimum grade elevation above this ductbank is 704.5 ft. The highest elevation of top of ductbank DB2 is 695.5 ft. The minimum grade elevation above this ductbank is 704.5 ft.

Appendix A of NUREG-0612 identifies certain considerations that should be included in analyses of postulated load drops. The methodology used in evaluating the ductbanks under the dynamic impact loading and its conformance with the applicable NUREG-0612, Appendix A considerations, is as described below:

As indicated above, a flop-over fall after a postulated SG drop from a height of 3 ft above grade, is the load drop that causes the most severe impact to the ERCW ductbanks. The worse case locations along the SG load path for impacting the ERCW ductbanks were evaluated. The impact energy from a flop-over fall of the SG about its base is estimated using principles of dynamics. The depth of penetration of the dropped SG (steam dome portion) into the soil and the resulting contact-pressure (pulse) time history were estimated considering the bearing resistance of the soil stratum overlaying the duct bank using Meyerhoff's bearing capacity equations. Suitable attenuation of the surface pressures were considered based on Boussinesq's equation thereby obtaining the spatial distribution of the impact loading on top of the ductbank. The depth of penetration into soil was estimated as 1.63 ft. The maximum attenuated pressure on top of the ductbanks from the impact loading due to a flop-over fall of the SG were estimated to be 107psi and 81psi for ductbanks DB1 and DB2, respectively.

The duct banks were then analyzed dynamically as beams on an elastic foundation subjected to the attenuated pressure time-history loading. A free-free boundary condition is considered at both ends of these ductbanks because the presence of 1/2 inch compressible expansion joint material at the ductbanks end connections with the attached pull-boxes/manholes.

The total response of the ductbank was calculated by performing modal superposition of the response of the first 25 modes of vibration. Response parameters such as deflection, shear and bending moment were thus obtained and the acceptability of the response was then assessed, based on ultimate capacities.

ERCW ductbanks DB1 and DB2 were shown to remain adequate to withstand impact loading due to flop-over effect after a postulated SG drop from the OLS provided the grade elevation above these ductbanks in the fall zone were at least 707 ft. The critical response parameter was the bending moment. The maximum bending moment under impact loading in ductbank DB1 was determined to be 535 k-ft against its ultimate capacity of 608 k-ft. The maximum bending moment under impact loading in ductbank DB2 was determined to be 368 k-ft against its ultimate capacity of 597 k-ft. It is noted that an evaluation of ductbank DB1 using the soil depth above it as the minimum existing grade elevation (~EL 704.5 ft) showed that the bending moment exceeded the capacity slightly. Therefore, it was decided to conservatively protect the ductbanks by raising the grade level above both ductbanks to EL 707 ft in the fall zone of the SG.

This will require areas above the ductbank, within the fall zone, with grade elevation below 707 ft to be raised to 707 ft using any earthfill placed in a standard way. The areas where fill may be required are shown as the cross-hatched area on Figure 5-2 of Topical Report 24370-TR-C-002. The depth of fill required will vary from 0 ft to 2.5 ft. Since this is a protection for impact loading and a reasonable moment margin being available, there are no specific compaction requirements, because the energy will be dissipated by displacing the soil even if it is not well compacted. If well compacted, the energy will be further attenuated through the additional soil depth. Timber mats, having good energy absorbing properties, may also be used in lieu of earthfill. Provision of earthfill and/or timber mats as indicated above assures that the ERCW ductbanks will remain structurally adequate and the safety function of the ERCW circuits in the ductbank will not be adversely affected as a result of the postulated SG drop. Since the ERCW circuits in the ductbank remain functional, other equipment is not required to mitigate the effects of the load drop.

The assumptions and methodology used to determine the radiological consequences of a postulated SG drop are addressed in the response to Question 8. No spent fuel is impacted by any postulated load drops from the OLS.

NRC Question No. 25

25. What impact will the closing of valves 1-26-575 and 1-26-653, as discussed in Section 8.8 of the topical report, have on the operability of the high pressure fire protection system? What compensatory measures are going to be implemented during the periods of valve closure? For mobile cranes operating during assembly/disassembly of the OLS is there adequate depth of cover for fire protection piping to prevent mechanical injury?

TVA Response

The piping from valve 1-26-575 to valve 1-26-653 comprises one of the 4 feeders to the auxiliary building fire protection ring header. The auxiliary building ring header design requirements are that no more than one of the feeders be out of service. Normal plant processes will be used to document the isolation of the feeder. Therefore, there is no impact on operability of the HPFP from the isolation of this piping segment. The only action required from the isolation of this piping segment is to prevent the isolation of a second feeder to the auxiliary building ring header. Current plant administrative processes address these controls and will be used to control this activity during the SGR heavy load lift compensatory measures.

As indicated in Appendix A to Topical Report 24370-TR-C-002, the fire protection piping inside the ERCW pipe tunnel will be isolated prior to commencement of load movements with the OLS. The purpose of this action is to minimize the potential contribution of water from fire protection piping on flooding of the ERCW tunnel due to failure of the fire protection piping inside the ERCW tunnel as a result of a load drop from the OLS. Isolation of this piping segment will also eliminate any possibility of depressurizing the HPFP system due to the postulated load drop, thus reducing the actions that must be performed following a load drop. As indicated above, isolation of this portion of the fire protection piping will not affect the operability of the fire protection system.

Underground fire protection piping in the yard areas where the mobile cranes are operating has been evaluated for the surcharge loads created by the mobile cranes. This piping is not adversely affected by these surcharge loads. As indicated in the fire protection system design criteria document, sectionalizing valves are provided to isolate potential faults. A fault in the fire protection piping due to a mobile crane load drop is no different in its consequences than a fault created by other means. Therefore, the consequences of a load drop from a mobile crane would be mitigated by closure of the appropriate valve(s). <u>An evaluation of the adequacy of soil cover over the fire protection piping was not required, since the consequences of a mobile crane failure or a load drop from a mobile crane were no different than other fire protection piping faults.</u>

<u>NRC Question No. 26</u>

26. Although safe load paths have been identified on Figure 5-2 of the rigging and heavy load handling topical report the staff believes that it will be difficult for the operator to stay within the safe load path during the various lifts. Describe the communications plan, administrative controls, crane operator actions, and crane automatic actions used to control the lift within the safe load path identified in figure 5-2 of the topical report.

<u>TVA Response</u>

The safe load paths can be followed by the OLS instrumentation. The instrumentation accurately indicates the radius of the load. The slewing of the OLS will be directed by the Mammoet/RI superintendents under the direction of the person in charge. For the initial pick, the boom will be located over the load using a total station surveying system. The load path is designated as being at a certain radius for which there is instrumentation in the cab that accurately locates the load. In addition to the instrumentation the load path will be marked on the ground. The rigging operation will be directed by the PIC who will be in constant radio communication with the crane operators and load tenders inside containment. A field engineer will be with the PIC who will be in constant communication with the operator in the control room. Figure 5-2 presented in Topical Report 24370-TR-C-002 is only a schematic designed to illustrate the load path in a general way. The actual implementation drawing precisely defines each segment of the load path.

NRC Question No. 27

27. How much time will expire during the movement of an OSG along the load path (from the containment to the transporter) where interaction with safety-related SSCs could occur? How much time will expire during the movement of the RSGs along the load path (from the transporter to containment) where interaction with safety-related SSCs could occur? What is the total time to move the OSGs and RSGs between the transporter and inside containment? What is the total time the SGs will be in a position to drop and cause damage to the safety-related SSCs (consider SSCs that may be impacted along the haul route from the transporter location to the storage facility)?

TVA Response

We anticipate that from the time an OSG clears the containment dome until it is positioned to start downending on to the transporter will be approximately 2 hours. This time is also true for a RSG once it is upended and ready to start towards containment until it is ready to pass through the containment dome opening. Safety-related SSCs (e.g., ERCW piping and ductbanks) could potentially be impacted by a SG drop for a duration of approximately 1 hour during this portion of the lift. As described in Topical Report 24370-TR-C-002, protection and compensatory measures will be in place during this portion of the lift to prevent damage to and/or mitigate the consequences of damage to these SSCs.

The time to downend or upend a SG is anticipated to be approximately 2 hours. No safety-related SSCs could be impacted during this portion of the lift by a SG drop.

The anticipated time to haul an OSG once it is ready for transport until it is outside the OSGSF, is approximately 4 hours. Although there are safety-related SSCs (ERCW piping and ERCW ductbanks and associated manholes and handholes) buried adjacent to the haul route, as detailed in the response to Question 20, protection will be provided prior to movement of the SGs along the haul route such that these SSCs will not be damaged as a result of a load drop from the transporter.

NRC Question No. 28

28. An OSG/RSG drop over Unit 1 ERCW would require realignment of the component cooling water system from Unit 2 to provide spent fuel pool cooling. With Unit 1 defueled (full core off load to the spent fuel pool) how long will it take to reach the limiting temperature for the spent fuel pool? The licensee has committed to realign the component cooling water system from Unit 1 to Unit 2 to provide spent fuel pool cooling in the event of a load drop. What actions are necessary (automatic and manual) and how long will it take to complete the realignment?

TVA Response

Topical Report 24370-TR-C-002 Section 8.3 has been revised to incorporate improvements in the compensatory measures arising from the development of an ERCW system hydraulic model to determine system response from a postulated heavy load drop. Attachment 1 provides additional details of the revised compensatory measures. The hydraulic model analysis has demonstrated that there is no need to realign the Spent Fuel Pool Cooling load. Design flow rates will be available at all times to the appropriate heat exchangers, before and following the worse case load drop damage.

NRC Question No. 29

29. The licensee has committed to develop and issue plant procedures to delineate specific actions required in case of a heavy load drop. What will be the principle attributes of the plant procedures? When will the procedures be completed, who will require training on these procedures, and how far in advance will training be completed relative to heavy lift operations?

TVA Response

The actions for a heavy load drop will be contained within an abnormal operating procedure (AOP). The major concern with a heavy load drop is the potential effect on ERCW to the operating Unit 2 and the potential for auxiliary building flooding. The AOP will contain specific guidance to address a total ERCW flow blockage due to ERCW pipe crimping as well as a complete pipe rupture. The guidance will include proper parameters to monitor for evaluation of ERCW flow to Unit 2 with applicable shutdown criteria and guidance to maintain safe plant conditions. The AOP will also contain specific guidance for monitoring and controlling auxiliary building flooding that may occur from a pipe rupture. The AOP will be entered and implemented just prior to a heavy load lift occurring with the operating crew remaining in the AOP during the duration of the heavy lift. All of the operating crews will receive training on this procedure during a cycle of operator requalification training that will be conducted in early 2003 prior to the Unit 1 SGR outage. In addition, 'just-in-time' refresher training will be conducted to specific applicable crew(s) prior to each heavy lift. The AOP will be completed in time to support the training that will occur during requalification training.

NRC Question No. 30

30. The licensee has committed to isolate shared systems with Unit 2 or verify that they are capable of being isolated following a load drop, prior to handling a load over the containment with the outside lift system. What systems are shared between Unit 1 and Unit 2 that could be impacted from a load drop over/in the vicinity of the containment? What Unit 2 safety-related functions could be impacted from such a load drop? How much time do the plant operators have to isolate these systems and how long will it take to perform the isolation functions?

TVA Response

A review has been performed to identify any SSCs necessary to maintain safe shutdown that are shared with Unit 2 and located inside of the Unit 1 containment that could potentially be impacted by the drop of a heavy load inside of the Unit 1 containment during the defueled condition. Prior to the use of the OLS for handling of heavy loads inside and above the Unit 1 containment during the defueled condition, the ERCW system and CCS will be isolated with valves located outside of Containment. In addition, the spent fuel pool (SFP) and the spent fuel pool cooling system shall be isolated from the Unit 1 containment. The isolation valves for the control air system inside containment are located well away from any potential load drops and would not be affected. Since the isolation valves will not be affected, any break in control air lines due to a load drop results in loss of air and failure of the isolation valves in the safe (closed) configuration.

NRC Question No. 31

31. What compensatory measures will be taken to minimize leakage through the temporary Unit 1 pipe tunnel wall from affecting safety-related equipment in the auxiliary building?

TVA Response

As indicated in Section 8.2 of Topical Report 24370-TR-C-002, a wall will be installed in the ERCW tunnel near the auxiliary building interface. Since the wall has been designed for the hydrostatic head generated if the tunnel was completely filled with water and an impact load associated with the rushing water just after a pipe break, leakage through the wall is not expected following a load drop that results in the failure of piping inside the tunnel. Installation of this wall will be completed prior to movement of heavy loads that could cause a failure of the piping and tanks that penetrate the ERCW pipe tunnel.

UFSAR Section 9.3.3.7 states that the auxiliary building has a passive sump that collects water from annulus drain sumps, and blowout panels located in the floors of the pipe chases and the containment spray and RHR pump rooms. Any leakage through the temporary pipe tunnel wall will eventually drain to the passive sump. Per UFSAR Section 6.3.2.11, the passive sump has a capacity of 209,000 gallons and a water level sensor in the passive sump alarms in the main control room. In addition, TVA plans to have available temporary pumping equipment onsite to remove excess water from the auxiliary building sump. Prior to the commencement of heavy load lifts with the OLS, the passive sump level will be verified to be less than 12 inches.

NRC Question No. 32

32. What components are included in the weight of the lifted loads? List the loads to be lifted and whether the lifted loads are calculated or estimated. What means will be used to verify the weight of the lifted loads in the field?

TVA Response

The generators will be lifted with rigging devices attached as well as any equipment (nozzle closure plates, insulation, upper lateral support, etc.) that will be attached during movement.

The lifted weight for the OSGs includes the following components:

- Generator (calculated)
- Lifting device (calculated)
- Internal water and sludge (conservatively estimated based on past projects)
- Nozzle cover plates (calculated)
- Lower lateral bumper blocks (calculated)
- Upper lateral support (calculated)
- Insulation (calculated)
- Rigging (calculated)

The lifted weight of the new SGs includes the following components:

- Generator (calculated – will be confirmed during offloading upon arrival at site)
- Lifting trunnions (calculated – will be confirmed upon delivery to site)
- Lower lateral bumper blocks (calculated – will be confirmed after removal)
- Upper lateral support (calculated – will be confirmed upon delivery to site)
- Insulation support rings (calculated – will be confirmed upon delivery to site)
- Rigging (calculated).

The OLS has a load cell incorporated into the crane that will be able to confirm the weight as each lift is performed. The OLS will lift the generators a few inches off their support and then hold. At this point the weight of the load will be confirmed and a systems check will be performed on the OLS prior to movement.

NRC Question No. 33

33. In Appendix A to the letter dated April 15, 2002, there is an item to "...develop and issue plant procedure(s) to delineate specific actions required in case of a heavy load drop." How will this condition, drop of the load, be communicated to the nuclear plant operators or site personnel?

TVA Response

During the heavy load lifts, personnel observing the load lift will be in direct communication with the main control room to relay status information of the lift to the operating crew. In addition, personnel will be in direct communication with the main control room to monitor for auxiliary building flooding should a heavy load drop occur.

NRC Question No. 34

34. Page 12 of the topical report states that "The input spectrum used for the horizontal direction is an amplified response spectrum at ground surface for an average soil depth to bedrock of 30 ft. soil deposit and reduced to correspond to the minimum design basis from Reference 27 which provides 5% damped free field top of soil response spectra curves for the Sequoyah Nuclear Plant for soil depths of 40 ft. and 20 ft." Define or explain the meaning of "the minimum design basis." Was the amplified response spectrum input at the ground surface or 30 ft below it? How was the amplified response spectrum "reduced to" as you stated? Explain in detail the way that you convolved the rock motion up through soil layers to obtain the amplified ground motion. Include details on the soil properties (seismic velocities, densities, soil modules and damping values, etc.) and soil layer thicknesses.

TVA Response

Section 2.5.2.4 of the UFSAR provides discussion on the chronological sequence of development of the Sequoyah seismic design basis spectra at top of bedrock. The seismic safe shutdown earthquake (SSE) “minimum design basis spectrum” at top of bedrock for Sequoyah Nuclear Plant, as stated in Section 2.5.2.4 (p 2.5-21) of the UFSAR, is the modified Housner spectrum based on a peak acceleration (ZPA) of 0.18g and are indicated as “Minimum Design Spectra” in Figures 2.5.2-11 through 2.5.2-14 of the UFSAR. Further from Section 2.5.2.4 of the UFSAR, it is noted that TVA used a more conservative arithmetically averaged response spectra generated by four artificial records as the SSE design response spectrum. These spectra are indicated as “Actual Design Spectra” in UFSAR Figures 2.5.2-11 through 2.5.2-14. Figures 2.5.2-11 through 2.5.2-14 of the UFSAR thus illustrate the relationship between the minimum design response spectra and the actual design spectra for different damping ratios.

The seismic evaluation of the OLS (PTC Crane) is based on an appropriate ground spectrum corresponding to the minimum SSE design basis spectra. It is also noted that since the OLS is a temporary system that will be in service for a short period of time and will be loaded for a much smaller period of time, the use of a spectrum based on the minimum seismic design basis of the plant is very conservative. Table 3.7.1-1 of the Sequoyah UFSAR specifies a maximum damping of 5% for Category I bolted steel structures for SSE. Regulatory Guide 1.61 allows 7% for bolted steel structures for SSE. In order to keep the analysis conservative, the OLS seismic analysis is based on 5% damping response spectra.

The OLS is supported on a concrete ring foundation seated on a large number of piles anchored to bedrock. Based on borehole data taken during soil investigation for the SGR project, the average depth of soil deposit above bedrock at the location of the OLS is approximately 30 ft. Since the OLS will be supported on top of a ~ 30 ft thick soil deposit above bedrock, the response spectra used in the analysis is an amplified spectrum at ground surface corresponding to the “minimum design basis” spectrum (see Section 2.5.2.4 and Figure 2.5.2-14 of UFSAR) for SSE at top of bed rock, as explained below.

The input spectrum used for the horizontal direction is an amplified response spectrum at ground surface. For a given soil deposit, the amplified ground spectrum is essentially a function of the depth of soil deposit. Reference 27 in Topical Report 24370-TR-C-002 provides 5 percent damped free field top of soil operational basis earthquake (OBE) response spectra curves for Sequoyah Nuclear Plant for soil depths of 40 ft and 20 ft. It is noted that the ground spectra developed in Reference 27 in Topical Report 24370-TR-C-002 are an average based on the four artificially generated time histories used to develop the more conservative “actual design spectra” (see Section 2.5.2.4 and Figure 2.5.2-14 of UFSAR). Reference 27 in Topical Report 24370-TR-C-002 further makes reference to TVA Report CEB-80-15, Rev. R0, “Preliminary Response Spectra for

Ground Motion in Area of Diesel Generator Building and Cooling Towers”. A 10 percent broadened SSE ground response spectrum for 5 percent damping for 30 ft depth of soil corresponding to the “minimum design basis spectra” in Figure 2.5.2-14 of the UFSAR was developed from the 20 feet and 40 feet curves in Reference 27 in Topical Report 24370-TR-C-002 as follows:

(i) The OBE ground spectra for 30 ft depth of soil was approximated by averaging the 20 ft and 40 ft response spectra curves on sheet 2 of Reference 27 in Topical Report 24370-TR-C-002. It is noted that this is conservative.

(ii) The SSE ground spectra for 30 ft depth of soil was obtained by multiplying the OBE curve obtained in step (i) above by 2 (see Section 2.5.2.4 of UFSAR).

(iii) The SSE ground spectrum obtained in step (ii) above is further reduced to correspond to a time history corresponding to the “minimum design basis” spectrum for a given frequency by multiplying by a factor given by the ratio of acceleration value from the minimum design spectra to the corresponding acceleration value from the actual response spectra for that frequency.

(iv) The frequency axis is broadened by 10 percent (+ or -) to obtain a 10 percent broadened SSE ground horizontal response spectra for use in the seismic evaluation of the OLS.

The amplified input horizontal spectra for the OLS analysis, developed as explained above, were input at ground surface. Since the OLS is supported on a concrete ring foundation seated on a large number of piles that are supported well into bedrock, the vertical response spectrum used for the crane seismic analysis was the minimum design basis vertical spectrum for 5 percent damping from Figure 2.5.2-14 of the UFSAR. The vertical response spectrum used is 2/3rd (per Section 2.5.2.4 of UFSAR) the horizontal minimum design spectrum.

The bedrock motion was amplified upward through the soil in Reference 27 in Topical Report 24370-TR-C-002 and TVA Report CEB-80-15. The amplified spectra from these references, used for developing the response spectrum for the OLS analysis, were developed based on a soil structure interaction evaluation methodology described in Section 3.7.1.6 of the UFSAR, extracts of which are reproduced below:

"For Category I structures (see Table 3.7.1-1) founded upon soils the rock motion was amplified to obtain the ground surface motion by considering the soil deposit as an elastic medium and making a dynamic analysis of a slice of unit thickness using only the horizontal shearing resistance of the soil. A damping ratio of 10 percent is used for the soil. The four artificial earthquakes mentioned in Section 2.5.2.4 were considered as the input motion at the top of rock. Once the time history of surface accelerations was known, a response spectrum was produced for the analysis of the soil-supported structure. The ground surface response spectrum determined by a linear amplification of the bedrock motion was broadened by $\pm$10 percent in order to obtain a design response spectra. The broadened curve was used as input to the dynamic seismic analysis."

NRC Question No. 35

35. On page 13 it is stated that "Rigging operations will not be performed when wind speeds exceed the maximum operating wind speed for the OLS." What is the wind speed measured in miles per hour considered to be the maximum operating wind speed? How was the maximum operating wind speed derived? Was there a stability analysis for the crane performed by considering the effects of the maximum operating wind speed on the crane and SG? If yes, provide the analysis results. If not, provide your justifications for the choice of the maximum operating wind speed.

TVA Response

The maximum wind speed allowed during operation of the OLS (PTC Crane) when the lifted load is more than 3 ft off the ground is 10 m/s (22 mph) in any direction measured at the boom tip. The maximum wind speed allowed during operation of the OLS when the lifted load is at 3 ft or less off the ground is 15 m/s (33 mph) in any direction measured at the boom tip. See the response to Question 15 for a discussion of how this wind speed was derived. The stability analysis performed indicates that the OLS will be maintained at worse case 80% of the tipping load.

NRC Question No. 36

36. What daily inspections will be performed for any of the cranes proposed to lift the heavy loads during the SGR?

TVA Response

Once the OLS is assembled, daily checks of the engine and hydraulic, pneumatic, electrical and mechanical systems will be performed. These engine and system checks will verify areas such as proper fluid levels and operating pressure, and the working of components such as the air-dryer, control panel, and brakes. All limit switches and the load moment indicator will also be checked daily. Further, a visual inspection will be performed to look for possible malfunctions such as leakage, locking of pins/rods, rust formation, failure of welded joints, and damage to hoisting ropes.

NRC Question No. 37

37. How many qualified crane operators will there be on this project? During each heavy load lift discuss where the person-in-charge (PIC) will be positioned. Discuss any personnel who will be assisting the PIC and their training levels, include where these individuals will be positioned during each heavy load lift.

TVA Response

Rigging International (Mammoet) will have three (3) dedicated operators for the OLS. The operators will be working on 9-hour shifts, thus allowing a 1/2-hour at the start and close of their shift to be briefed and to brief the other operators. The Rigging International (RI) PICs will be the RI Superintendent, the RI Project Engineer, or the RI Rigging Superintendent. Each is qualified by experience to direct these lifts. See the response to Question 17.(4) for additional information on the PIC.

The PIC monitors the signal men controlling the lift and directs them as necessary. The physical location of the PIC during a lift with the OLS will vary depending on the load being lifted. The PIC and signal men will position themselves as field conditions dictate in order to have the best vantage point to observe the lift. For example, there will be three separate signal men controlling the various steps of an OSG lift; one inside containment and two outside containment. Only one of these three signal men will be in control of the lift at a time. The OLS operator will be instructed, prior to commencement of a lift, who the signal man is and when the signal man will be transferring his responsibility to another signal man. It will be made clear to the operator which signal man has control of the lift at all steps along the way. The operator will also be told that anyone can stop the lift at any time if they see an interference or any item which is out of place. The signal man will control the lift by being the only individual that the operator will listen to, via a dedicated radio channel or dedicated line, to start any operation involving the OLS.

During removal of an OSG, three signal men will control the lift as described below:

- The Bechtel signal man (located inside containment) will have control of the lift from the start of the lift until the OSG is completely above the top of the steam generator compartment roof inside containment. At this point he will inform the operator that the RI signal man on the containment dome has control.

- The RI signal man on the containment dome will be positioned where he can see the OSG and direct the lift from the time the OSG is above the steam generator compartment roof until the OSG is in position to be lowered to the ground. Note that the signal man will position workmen as needed to help him watch the lift. Once the OSG is in position to lower to the ground, the RI signal man on the containment dome will turn over the lift to another RI signal man positioned on the ground close to the lowering area. The operator will be informed by the signal man on the containment dome that he is turning over responsibility to the signal man on the ground.

- The RI signal man on the ground will control the lift until the OSG is downended onto the transporter.

NRC Question No. 38

38. Discuss the OLS crane software qualification, include any industry standards or guidelines applicable.

TVA Response

At all times, the OLS operator is in control of load movement. The OLS software prevents load movement outside of specified limits. This is accomplished through the use of limit switches and load cells. Examples of movements that are limited in this manner are:

- Anti two-block switch - prevents raising the lifting block into the boom tip
- Boom back stop switch - prevents the boom from being boomed back to far
- Jib preventer switch - prevents the jib from being boomed up to far
- Minimum and maximum radius switches - will be set during erection based on load path for loads to be moved
- Load cells to indicate the lifted load - these will be tested during the load test
- Safe load indicator (SLI) system - is tied into the load cell and the min/max radius switches

The OLS SLI software was designed by Krüger Systemtechnik, a leading specialist in designing crane SLI software.

NRC Question No. 39

39. The topical states that a postulated load drop from the OLS has the potential for disabling ERCW and other SSCs located in the load path. The analysis does not discuss the risk impact on core damage frequency or large early release frequency for heavy lift operations or of a heavy lift load drop. Using Regulatory Guide 1.174 and 1.177, as applicable, provide an evaluation of the risk of a random crane failure and crane failures in conjunction with a design basis event (loss of offsite power, high winds/tornado, or seismic, as applicable). Provide a discussion on any compensatory measures, and/or operator actions that are assumed in the above analysis. Include the probability of a load drop from non-single failure proof cranes (outside lift system, mobile cranes (lattice boom and truck)) and the number of anticipated lifts. Also provide the total time that the old and RSGs, reactor shield building sections, SG compartment sections, containment dome steel sections and large crane components will be in a position to damage SSCs. Include a discussion of potential failure of SSCs during transport of the SGs to and from the staging area prior to heavy load lift activity.

TVA Response

The discussions in Topical Report 24370-TR-C-002 represent an integrated program by TVA to assess and manage the risks to an operating Unit 2 during the Unit 1 SGR lift operations. The topical's approach was based on a philosophy similar to that provided in NUREG-0612 (Section 5.3, Safety Evaluation) in that years of design, planning, and training have gone into adequate measures to reduce the potential for accidental dropping of heavy loads. While it was not possible to find a practical load path that avoided travel over all safe shutdown equipment, the proposed path has been chosen and planned for to reduce the potential for impact on safe shutdown equipment should a drop occur. Lastly, compensatory measures have been proposed so as not to result in the loss of required Unit 2 safe shutdown functions.

Beyond those provisions, TVA has made additional provisions to decouple certain events as load drop initiators. As was described in Section 5.1 of Topical Report 24370-TR-C-002, the OLS has been evaluated for seismic loads while unloaded and while loaded with a steam generator. As was described in the response to Question 15 the OLS has mandatory wind speed restrictions for operation. The instruments used to impose these restrictions are described in the response to Question 10. The OLS is not dependent upon offsite power, so the OLS is already decoupled from loss of offsite power as a load drop initiator.

As noted in Section 5.2 of Topical Report 24370-TR-C-002, mobile cranes used in the OLS assembly/disassembly have limitations on the areas in which they can operate. Their usage has been evaluated and shown to have no adverse interactions with safety-related SSCs when operated in accordance with these limitations and the weather imposed restrictions noted in the Topical Report and in the response to Question 17.

While a numeric estimate of the impact of the SGRO lifts on core damage frequency and large early release frequency has not been made, the provisions made in acknowledgment of the NUREG-0612 issues were directed at achieving a level of safety at least commensurate with plant safety during more routine plant operations.

The OLS will be used for 22 lifts that may result in damage to safety-related SSCs if the load were to be dropped while over or near these SSCs. Of the safety-related SSCs that may be affected, the only one required to be operable during these lifts is the ERCW system. Each of the loads moved during these 22 lifts will be in a position to potentially affect the ERCW system for approximately one hour. Therefore, the total time that the ERCW system is potentially at risk during the 22 OLS lifts is approximately 22 hours.

As noted in Attachment 1 a hydraulic analysis of the ERCW system for a load drop in the zone of influence was performed and documented in TVA calculation MDQ00006720000095. This analysis shows that direct Unit 2 safe shutdown systems will receive the design ERCW flow rates and will be able to continue to perform their function indefinitely with no operator action. Those functions that have a high impact on core damage frequency such as Reactor Coolant Pump seal injection and seal cooling will continue to function as designed (Component Cooling Water system is undamaged and receiving its design flow rate). Design flow rates are also available for the Auxiliary Feedwater Pumps. Attachment 1 also identifies certain components that receive flow from the 1A and 1B ERCW supply headers that are indirect Unit 2 safe shutdown components and may not receive their design flow rates. Actions and timeframes to restore their function are identified. Any immediate actions are taken from the control room. Other actions are not required for a minimum of 18 hours.

Transport of the SGs along the haul route is discussed in the response to Question 20. As discussed in the response to Question 20, with the protection described in place, there will be no impact on safety-related SSCs as a result of a load drop from a transporter.

ATTACHMENT 1

OUTLINE FOR COMPENSATORY MEASURES
HEAVY LOAD DROP PROTECTION

DISCUSSION

Due to physical proximity, several piping segments are in jeopardy of being broken or crimped by a postulated heavy load drop from the outside lift system (OLS). These lines include the Unit 1 B-Train (1B) essential raw cooling water (ERCW) supply header, the Unit 1 A-Train (1A) ERCW supply header, the A ERCW discharge header, and the Unit 1 primary water storage tank (PWST) and refueling water storage tank (RWST) , and their associated piping. A postulated pipe break of the ERCW system could occur in the yard (i.e., underground) or in a pipe tunnel. A postulated rupture of the RWST and PWST could occur such that the water also goes into the pipe tunnel or onto the ground in the yard. Additionally, a fire protection supply line is present in the tunnel. Of these, the lines that have potential consequences for safe operation of Unit 2 are the ERCW supply and return headers. Since the consequences of ERCW pipe ruptures or crimping are potentially serious for Unit 2, compensatory measures will be written to re-direct required ERCW system flow and ensure safe shutdown of Unit 2. The compensatory measures will be implemented using an abnormal operating procedure (AOP).

The zone where the potential for damage to the ERCW supply and return headers exists is the load path between the reactor building openings and the upending/downending area for the SGs starting at ~7 feet from the inside of the parapet wall until the upending/downending area is reached. For the shield building concrete sections, the steel containment vessel and steam generator compartment roof concrete sections, the zone is between the reactor building openings starting at ~7 feet from the inside of the parapet wall and until the load is 3 ft above grade. Refer to Figure 5-2 in Topical Report 24370-TR-C-002 for details on the load paths. If a load drop occurs in this zone, preparations will immediately commence for an orderly shutdown of Unit 2.

Analysis of this postulated event is documented in TVA calculation MDQ00006720000095. This analysis has shown that all direct Unit 2 safe shutdown systems will receive the design ERCW flow rates and will be able to continue to perform their function indefinitely with no operator action. Those functions that have high impact on core damage frequency such as reactor coolant pump (RCP) seal injection and seal cooling will continue to function as designed.

Certain components that receive flow from the 1A and 1B ERCW supply headers are indirect Unit 2 safe shutdown components, and may not receive their design flow rates. The following listing is the indirect Unit 2 safe shutdown components that might not receive their design flow rates following a postulated heavy load drop:

- Emergency diesel generators
- ‘A’ auxiliary air compressor
- Main control room chillers
- Component cooling system pump space coolers
- Electrical board room chillers
- ‘A’ 6.9-kV shutdown board room chiller
- Cooling to auxiliary building gas treatment system.

The emergency diesel generators will be aligned to their alternate source from the control room immediately (i.e., 10 minutes) upon reported heavy load drop in the critical zone. For the other components above, the limiting response time to restore the design functions is a minimum of 18 hours. The 18 hours is based on the time it takes for the control room to reach its upper temperature limit. The required actions following a load drop to align the alternate water sources to these components can easily be accomplished within the timeframe available.

In order to obtain the 18-hour timeframe, a number of plant alignment changes are being performed as prerequisites to the heavy load lifts. However, caution is being used such that no prerequisite would adversely impact items required to be OPERABLE by the technical specifications. The prerequisite actions have the purpose of simplifying and reducing the actions needed after a load drop. In all cases, the operator actions needed in the event of a heavy load drop are simple and few.

A temporary wall will be erected at the entrance to the pipe tunnel from auxiliary building to contain the water. The temporary wall will be fitted with a sight glass and instrument connection, which will allow detection and quantification of the water accumulating behind this wall. Means will be provided to quantify any leakage through the wall.

In recognition of the plant consequences of a postulated load drop event, Sequoyah plant staff will be examining closely other scheduled maintenance tasks as well as any failures that may arise, per the requirements of 10 CFR 50.65(a)(4).

The actions contained in this compensatory measure will ensure that Unit 2 can be safely brought to cold shutdown and maintained in cold shutdown in the unlikely event of a heavy load drop damaging the ERCW piping as outlined in Topical Report 24370-TR-C-002.

ACTIONS PRIOR TO COMMENCEMENT OF OLS HEAVY LOAD LIFT

Specific actions required to be completed prior to commencement of an OLS heavy load lift that passes near or over ERCW supply and/or discharge headers.

1. Ensure that the temporary wall in the Unit 1 ERCW pipe tunnel is intact, all openings are sealed, and that a sight glass and pressure gauge are installed in the wall.

2. Develop criteria to quantify water accumulation behind the wall.

3. Ensure the auxiliary building passive sump level is less than 12”.

4. Install a temporary weir or develop other criteria to enable quantification of the leakage entering the auxiliary building from the pipe tunnel.

5. Install temporary pressure and flow gauges at appropriate locations in the auxiliary building to monitor Unit 1 ERCW supply header pressures. Place temporary instruments at:

    Differential pressure gauge at 1A and 1B component cooling system (CCS) pump space cooler. If the differential pressure gauge reads less than 70 inches, the coolers are inoperable.

    Pressure gauge at A and B main control room chiller drain valve. The chiller operation is in doubt if the A-train gauge reads less than 20 psig or the B-train pressure gauge reads less than 30 psig.

6. Close 1&2-FCV-67-22 & 24, ERCW cross-tie valves.

7. Throttle full open 0-67-552, 0-67-551, 0-FCV-67-152, and 0-FCV-67-151, and place clearance on the power to 0-FCV-67-152.

8. Station Operations personnel to visually monitor the crane activities.

9. Station Operations personnel to be available to go to the ERCW pump station in order to isolate 1-FCV-67-489 (B1B-B ERCW strainer isolation) and 1-FCV-67-492 (A1A-A ERCW strainer isolation).

10. Station Operations personnel to be available to monitor temporary gauges in the auxiliary building and to observe for leakage through the temporary wall.

11. Immediately prior to any heavy load lift, mark the ERCW header pressures and flows on the main control room indicators. Also, mark the Unit 1 RWST level and the PWST level on the main control room indicators.

12. Ensure that no air filters, herculite, etc., is covering the grating over the passive sump or the handrails around the opening.

13. Isolate the high pressure fire protection (HPFP)/flood mode pump pipe by closing valves 1-26-575 and 1-26-653.

14. Throttle supply header manual isolation valves 1-67-727A and 1-67-727B to pre-determined position

15. It is preferred that the 'B' shutdown board room (SDBR) chiller be running. This is a preferred action.

16. Connect hose from turbine building space cooler to ERCW at station air compressors (SAC). Use check valve at ERCW pipe, valve line in ahead of time.

17. Get the flood mode spool piece ready to install. Preference is to install on Train A. Set up valve alignment in AOP such that 'A' SDBR and 'A' auxiliary control air (ACA) can be fed. Final determination of which train to connect to depends on damage sustained.

18. Throttle valves 0-67-1500 & 1501 & 546C, and revise throttling of existing throttled valves 0-67-1506 and 0-67-1509. This is a preferred action to reduce the potential for cavitation. There is no actual effect on the compensatory measures if this action is not performed.

19. Have two running ERCW pumps per train.

20. Isolate ERCW, CCS, and spent fuel pool (SFP) from the Unit 1 reactor Building.

ACTIONS FOLLOWING A LOAD DROP

Specific actions to be accomplished after a heavy load drop from the OLS are as follows:

Immediate actions:

- Any load drop in the zone where the potential for piping damage exists, commence an orderly shutdown of Unit 2 in accordance with technical specifications.

- The four alternate supply valves for the standby emergency diesel generator will be opened immediately to preclude damage to the diesel generators were a start signal generated due to some reason unrelated to the load drop. These valves are opened from the control room. These valves are being opened as a precautionary measure should a diesel generator be started.

- The other immediate operator action is to ensure that there are at least two running ERCW pumps per train. The operator verification consists of observing the pump handswitches. If the required number of pumps is not running then these will be started from the control room handswitch.

The control room actions will be completed within 10 minutes of control room notification of a heavy load drop.

Other actions

- Rupture or crushing of the 1A and/or 1B ERCW supply header

  If flows to the equipment on the 1A and/or 1B ERCW supply header drop to less than that needed to support equipment operation, alternate water supplies will be used for that equipment. The time required to place the alternate water supply in service is less than the time available to restore this equipment to service. If the alternate supplies are used, then the leak will be isolated by available valves to increase margins. Isolation is not required to support any safety function.

  If the incident involves a loss of function of the main control room chiller or the space cooler for the component cooling pumps, then alternate cooling water supplies will be used. Criteria in terms of actual flow rates and pressures to monitor for indications of damage has been determined and placed in the abnormal operating procedure that will be used during this event. The instruments used are not in the control room, but are easily accessible and can be quickly read and compared with the pre-established criteria. In the event of a heavy load drop, these instruments will be monitored and the readings communicated to the control room. If the readings indicate that the function of equipment important to Unit 2 safe shutdown is in jeopardy, then actions will be taken to ensure full functionality of the equipment.

  In order to supply cooling water to the components normally fed from the 1A ERCW supply header, the following actions will be performed in sequence:

- Evaluate whether to supply the equipment from the B-train ERCW or from the raw cooling water system. The evaluation criteria consists of determining if there is detectable damage to the B-train ERCW. If there is no damage to Train B ERCW components then raw cooling water is recommended to be used. Time required to reach decision point will be less than one hour from the load drop.

- In order to supply raw cooling water to the ERCW headers, a flood mode spool piece is installed in the piping between the two systems. When the spool piece is installed, the manual valves on either side of the spool piece are opened. The time required to install the spool piece and open the required valves is less than four hours.

- In order to supply the 1A ERCW header from the 2B ERCW header, valve 1-FCV-67-81 is closed, then 1-FCV-67-147 is opened. These valves are motor operated valves manipulated either locally or from the valve breaker. The time required to manipulate these valves is less than one hour.

In order to supply cooling water to the components normally fed from the 1B ERCW supply header, the following actions will be performed in sequence:

- Evaluate whether to supply the equipment from the A-train ERCW or from the raw cooling water system. The evaluation criteria consists of determining if there is detectable damage to the A-train ERCW. If there is no damage to Train A ERCW components then raw cooling water is recommended to be used. Time required to reach decision point will be less than one hour from the load drop.

- In order to supply raw cooling water to the ERCW headers, a flood mode spool piece is installed in the piping between the two systems. When the spool piece is installed, the manual valves on either side of the spool piece are opened. The time required to install the spool piece and valve it in will be less than four hours.

- In order to supply the 1B ERCW header from the 2A ERCW header, valve 1-FCV-67-82 is closed, then 1-FCV-67-424 is opened. These valves are motor-operated valves manipulated either locally or from the valve breaker. The time required to manipulate these valves is less than one hour.

The flood mode spool piece described above for use is an existing component used to tie the ERCW system and the raw cooling water system together in various plant conditions including loss of downstream dam and floods above plant grade, as described in UFSAR Sections 2.4 and 9.2.2. Existing plant procedures will be used to install the spool piece. For the location of the flood mode spool piece connections on the ERCW system refer to Figure 6-1 in Topical Report 24370-TR-C-002.

Of the plant equipment that might not receive adequate cooling water flow until required actions are complete the most limiting component is the control room chillers. The timeframe available to restore cooling water to the control room chillers is greater than 18 hours until the control room temperatures will reach the value at which equipment operation is affected (Reference TVA Calculation MDQ00003120020119). The time required to complete the required actions is substantially less than the time available to complete them.

- Rupture of the A ERCW discharge header

  No immediate actions are necessary, monitor conditions at the temporary wall in the pipe tunnel.

- Crimping of the A ERCW discharge header

  No specific actions are required, monitor conditions at the temporary wall in the pipe tunnel.

ATTACHMENT 2

DENSIFICATION OF LOOSE DEPOSITS BY POUNDING

(JOURNAL OF THE GEOTECHNICAL ENGINEERING DIVISION)

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JOURNAL OF THE GEOTECHNICAL ENGINEERING DIVISION

Densification of Loose Deposits by Pounding

By Robert G. Lukas,[1] M. ASCE

Introduction

Certain types of marginal sites can be improved to the point where one-story to four-story structures can be supported by conventional spread footing foundations. The improvement consists of densifying loose soil or fill deposits by means of pounding. The pounding process used to date has consisted of dropping a weight of 2 tons–6 tons (1.8 metric tons–5.4 metric tons) from heights of 30 ft–35 ft (9.2 m–10.7 m) to impact into the soil thereby causing densification to depths ranging from 10 ft–20 ft (3.1 m–6.1 m).

This process has been successfully used on eight project sites under the writer's supervision. At five of the sites, the subsurface conditions consisted of building rubble and miscellaneous fill overlying a medium strength natural clay or clayey silt deposit. A natural loose fine sand was present at two sites and one project consisted of a shopping center constructed on a former garbage dump. This paper examines the ground subsidence observed during the pounding process, the degree of densification achieved with depth below grade, ground vibrations associated with pounding and the performance of the structures which were supported upon the densified soils.

Description of Projects

The pertinent features of each of the eight projects are summarized in Table 1. Typically, the pounding was used to densify the upper loose deposit thereby enabling the structural loads to be supported at grade. In the case of buildings, spread footings were normally supported within the densified deposit utilizing a bearing pressure of 3,000 psf (144 kPa). In Projects 1 and 3, the site densification was undertaken to minimize future maintenance problems associated with constructing a pavement or slab-on-grade over a loose deposit.

Note.—Discussion open until September 1, 1980. To extend the closing date one month, a written request must be filed with the Manager of Technical and Professional Publications, ASCE. This paper is part of the copyrighted Journal of the Geotechnical Engineering Division, Proceedings of the American Society of Civil Engineers, Vol. 106, No. GT4, April, 1980. Manuscript was submitted for review for possible publication on July 17, 1979.

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The earliest densification projects were undertaken with whatever weight was available and in most cases this consisted of a 2-ton (1.8-metric tons) wrecking ball. This weight worked reasonably well on building rubble formations but the rounded shape was not suited for densification of other fill or natural soil deposits. The densification conducted after 1976 was generally done with a

TABLE 1.—Description of Projects

Project number (1)	Project description (2)	Date (3)	Substrata densified (4)	Weight, in tons (5)	Drop, in feet (6)	Average ground depressions, in inches (7)	Coverage (8)
1	Freight terminal truck parking area	1971	10 ft of rubble with large voids	2	30	Tight areas—6 Loose areas—12	Grid at 3 ft center to center
2	Four-Story building	1975	9 ft of cinders and sand over 3 ft of rubble	2	25	3–9	Entire footing areas
3	Floor slab loaded to 2,300 pounds per square foot	1976	13 ft of loose fine sand	4.8	12	4–6	Grid at 10 ft center to center
4	Two-Story shopping center	1976–1978	Upper 15 ft–20 ft of 60 ft of miscellaneous fill	6	35	Typical—12 to 18 Occasional—18–36	Grid at 7 ft Spacing plus footings
5	Two-Story parking garage	1977	15 ft of building rubble	3.4	25	12-15	Grid at 7 ft center to center
6	Refinery racks	1978	Loose fine sand from 5 ft–13.5 ft	6	30	Typical—12 Occasional—18	Grid at 6 ft center to center
7	Two-Story parking garage	1978	7 ft of rubble fill over 6 ft of sandy silt	4	25	Typical—12 Occasional—32–47	Grid at 5 ft center to center
8	One-Story truck terminal building	1979	5 ft–16 ft of miscellaneous fill over saturated clayey silt	6	40	Typical—12–15 Occasional—24–36	Grid at 7 ft plus footings

Note: Sites 1, 2, 5, 7, and 8 underlain by medium strength clay; and sites 3 and 6 underlain by medium dense to dense sand. 1 ft = 0.305 m; 1 ton = 907 kg; 1 in. = 25.4 mm.

heavier weight such as a 3.5 ton–6 ton (3.2 metric tons–5.4 metric tons) size which has a flat bottom.

The amount of ground depression as a result of pounding is listed in Col. 7 of Table 1. This value represents an average range throughout the project and the individual craters were many times this amount. The depth of ground displacement by itself does not indicate the degree of improvement being attained but it does serve as a practical field guide.

The coverage applied to each site is shown in Col. 8 of Table 1. At some projects, the primary concern was improvement only at concentrated load points so pounding was undertaken at the footings. The weight was dropped on a grid basis throughout the footing area plus a short distance beyond the edges. On other projects, there was concern that the floor slab as well as the footings could settle so the entire building area plus a short distance beyond the edges was pounded on a grid basis with the distance between impact points being about 4 ft–10 ft (1.2 m–3.1 m). At two projects, the grid pounding was followed by pounding at individual footing locations thereby effecting double coverage at these locations. At each pounding location, the weight was dropped seven to nine times.

Improvement versus Depth

The primary purpose for using the pounding procedure is to achieve a significant densification at depths greater than can normally be achieved by compaction equipment or heavily-loaded proofrolling devices. Menard and Broise (1) have proposed the following formula as the first-step indicator of the required energy to achieve densification to a predetermined depth:

$$W \times H = D^2 \quad \text{(1)}$$

in which W = weight, in metric tons; H = height of drop, in meters; and D = depth of improvement, in meters.

To investigate the amount of densification, borings were made at the project sites before and after the pounding process had been undertaken. These borings included Standard Penetration Resistance tests or pressuremeter tests, or both. The Standard Penetration Tests were generally used in the relatively uniform deposits such as natural sandy soils and the pressuremeter tests in the nonhomogeneous deposits such as miscellaneous fill materials. At four of the project sites, sufficient borings and tests were made to measure the degree of improvement as a function of depth. The results of these tests performed before and after pounding are shown on Figs. 1–3.

For the hammers in the range of 3.5 tons–6 tons (3.2 metric tons–5.4 metric tons) falling through a distance of 25 ft–40 ft (7.6 m–12.2 m), the improvement in soil properties was found to extend to levels on the order of 15 ft–20 ft (4.6 m–6.1 m) below grade. At and below this level, either the Standard Penetration Resistance Value or the limit pressure was found to be approximately the same after densification as it was initially. A comparison of the depth of improvement by Eq. 1 to the depth of improvement as measured from Standard Penetration or pressuremeter tests is presented in Table 2. These data indicate that the depth to which improvement occurs is only on the order of 65%–80% of the depth predicted by Eq. 1. The improvement of the soil properties was not uniform throughout and was greater at the upper levels diminishing to slight improvements at the deeper level.

One of the most beneficial effects of pounding is to collapse voids or to

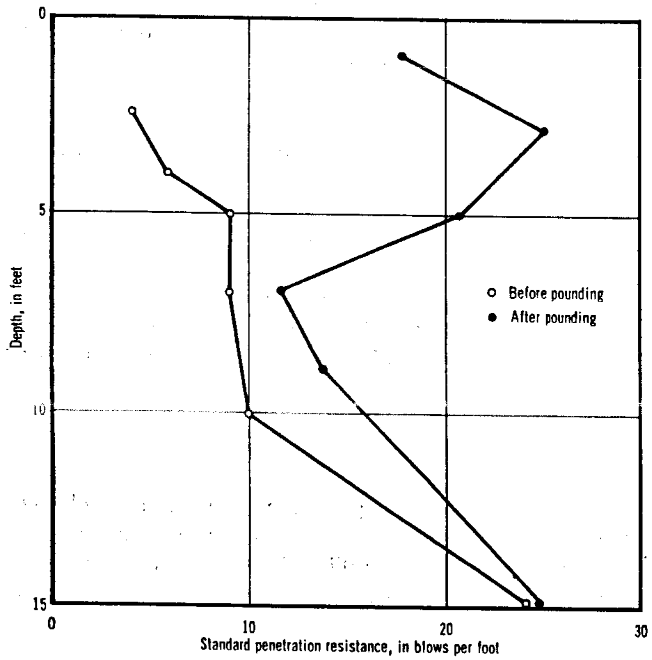

FIG. 1.—Standard Penetration Resistance Versus Depth: Site 3 (1 ft = 0.305 m)

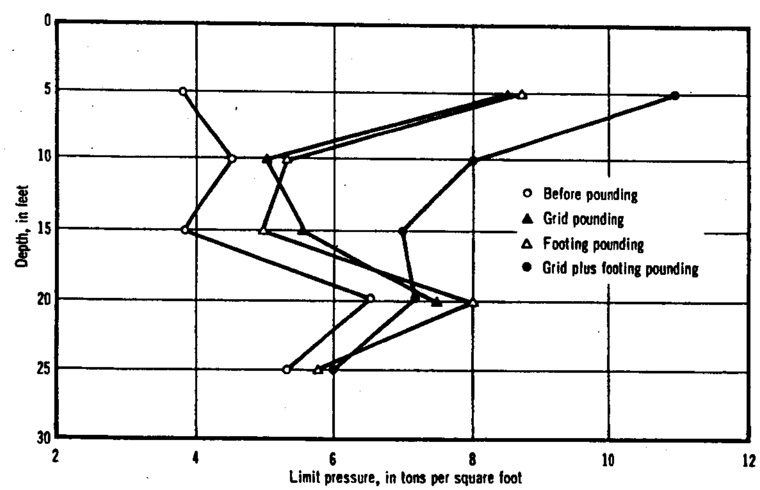

FIG. 2.—Limit Pressure versus Depth: Site 4 (1 ft = 0.305 m; 1 ton/sq ft = 95.8 kPa)

densify very loose layers. This is shown in Fig. 3(*a*). Within the depth range of 8 ft–14 ft (2.4 m–4.3 m) below ground surface, the initial investigation indicated an extremely loose deposit of sand with the Standard Penetration Resistance Value on the order of one blow per foot. After site densification, the Standard Penetration Resistance Value near the center and edge of this deposit increased

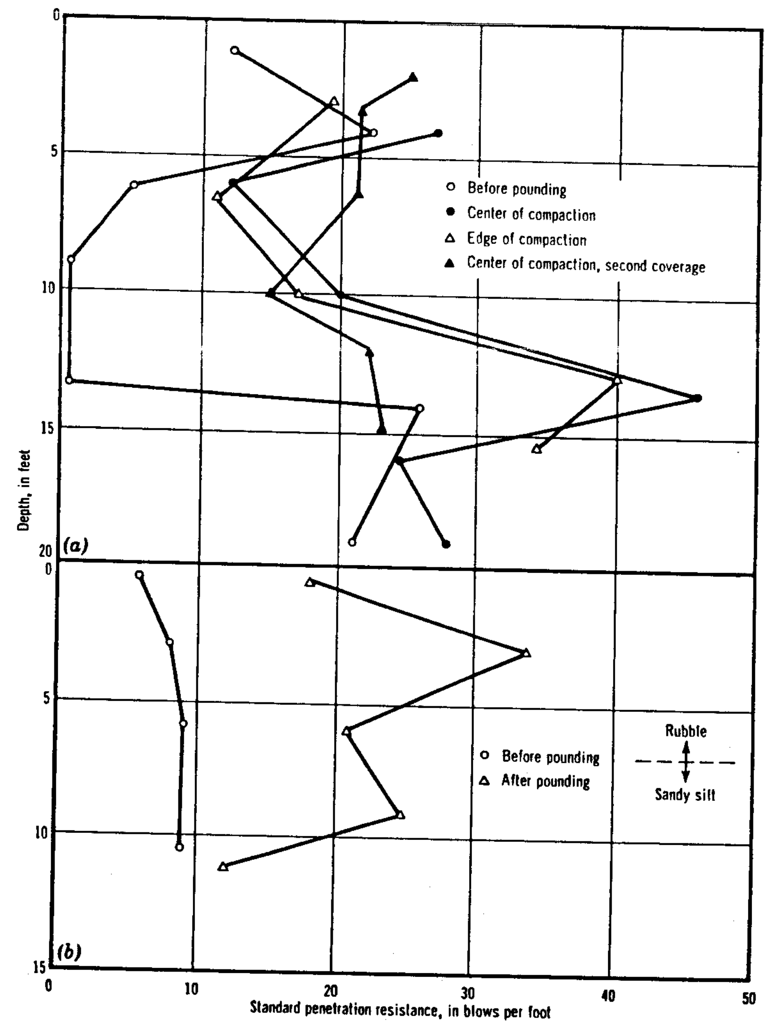

FIG. 3.—Standard Penetration Resistance Versus Depth: (*a*) Site 6; (*b*) Site 7 (1 ft = 0.305 m)

to 15 blows per ft–20 blows per ft. Within the upper portion of this deposit where the Standard Penetration Resistance Value was initially on the order of 22 blows per foot, the Standard Penetration Resistance Values after pounding were still only on the order of 20 blows per ft–27 blows per ft.

This data also indicates that the depth of improvement does not appear to increase with additional coverages. At Site 6, which is represented by Fig. 3(*a*), the depth of improvement was approx 15 ft (4.6 m) for single and double coverage. A similar phenomena occurred at Site 4 as represented by Fig. 2. In both areas the additional coverage improved the degree of compaction achieved in the upper levels.

Densification Mechanism

At seven project sites, the densification was undertaken in materials that were relatively free draining and not fully saturated. Densification of the deposit was due to compaction wherein the air within the void spaces was compressed or expelled and large voids were collapsed. The improvement was immediate and the process could be described as dynamic compaction.

TABLE 2.—Improvement with Depth

Site (1)	Depth of improvement, in feet: Predicted from Eq. 1 (2)	Depth of improvement, in feet: Measured (3)	Ratio: measured/predicted (4)
3	13	10	0.77
4	25	20	0.80
6	24	16	0.67
7	17	11	0.65

Note: 1 ft = 0.305 m.

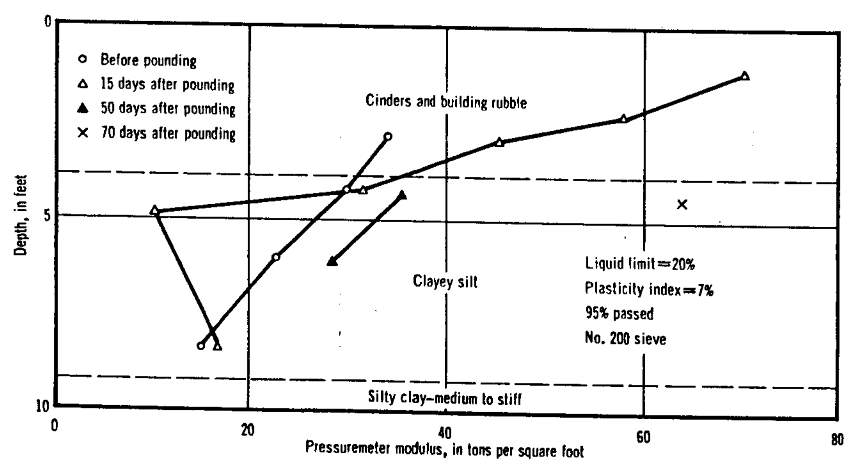

FIG. 4.—Pressuremeter Tests in Clayey Silt: Site 8 (1 ft = 0.305 m; 1 ton/sq ft = 95.8 kPa)

At two projects, double coverage was applied with a 6-ton (5.4 metric tons) weight dropping 35 ft–40 ft (10.7 m–12.2 m) with 9 tamps per impact point. The data obtained from this study indicate that the depth of soil affected by pounding was approx 75% of the value computed from Eq. 1. The energy applied was assumed to be a maximum at ground surface and decrease hyperbolically to zero at this depth. Dividing the total energy applied at ground surface by the volume of soil computed as described, the unit energy applied at ground surface computes to 12,343 ft-lb/cu ft (60,311 kg-m/m^3) which is almost identical to Standard Proctor ASTM D-698 energy.

At Site 8, densification was required in areas where the saturated clayey silt soils were present below 5 ft (1.5 m) of rubble fill. Ground depressions occurred after impact but the ground surface behaved in a spongy manner and the soils liquefied. Shortly after pounding, water was observed to partially fill the craters. Measurements indicated that the ground water rose to a level 3-ft higher than normal and a period of 6 weeks elapsed before the water returned to the original position.

The liquefaction that occurred at Site 8 within the saturated clayey silt, is illustrated in Fig. 4. The pressuremeter modulus 15 days after pounding was lower than tests performed before pounding. After 50 days, the pressuremeter modulus improved to about 25% higher than the initial value. After 70 days, the modulus at the surface of the clayey silt was about double the original value. Samples taken 50 days after pounding indicated that the average water content of the silt dropped from 22%–19%. At Site 8, densification of the clayey silt deposit appears to be due to consolidation following liquefaction.

Ground Induced Vibrations

During the pounding process, a considerable amount of the energy is transmitted into the ground directly below the point of impact to densify the soil. However, some of the energy is transmitted through the ground to locations off the site. One of the concerns with regard to the pounding process is whether any damage could occur to buildings or utilities located beyond the edges of the site being densified.

At Sites 2, 4, and 5, the densification process took place in a relatively congested area adjacent to occupied structures. At Site 2, densification took place immediately adjacent to a one-story auto repair building and within 40 ft (12.2 m) of a 20-story high rise structure. The ground vibrations could be felt in both of these buildings but they were not of significant magnitude to cause damage even though the auto structure was a 50-yr old building. At Site 4, densification took place 20 ft (6.1 m) behind the retaining wall. The wall was measured to laterally deflect 1/8 in.–1/4 in. (3.2 mm–6.3 mm) at the top, but rebounded after each impact. In a restaurant building located about 75 ft–100 ft (22.8 m–30.5 m) away, the chandeliers were observed to swing for a period of about 5 sec–10 sec after impact, but no other adverse conditions were observed.

Site 5 is located in a downtown business district area adjacent to a 40-story high rise and across a city street from a three-story old railroad terminal building. For this project, the particle velocity was measured with two Sprengnether seismograph units. One unit was stationed on the sidewalk at the property line at a point 30-ft (9.2-m) distant from the point of impact and the second unit was moved to different locations around the site and included readings taken within the three-story railroad building where the tenants were complaining of vibrations. The results of the readings obtained and the distances from the point of impact are summarized in Table 3. All of the readings are below 2 in./sec (51 mm/s) which for low frequencies has been generally accepted as the level above which damage to residential structures could occur (2). After each impact, the wave frequency was measured in the range of 10 Hz–20 Hz but there was a complete decay before the next impact.

The seismic velocity readings have been plotted on Fig. 5 which relates scaled energy factor to particle velocity. The scaled energy factor is defined as the square root of the energy applied to the ground in foot pounds divided by the distance from the point of measurement to the point of impact. The chart was prepared by Wiss (2) to predict particle velocity resulting from pile driving operations when the subsoils consisted of wet sand, dry sand, and clay. At

TABLE 3.—Record of Vibration Measurements

Location (1)	Distance from point of impact, in feet (2)	Particle velocity, in inches per second (3)	$\sqrt{\text{Energy, in foot-pounds}}$/Distance, in feet (4)
1. Sidewalk at north property line	30	0.696	13.8
2. Sidewalk adjacent to railroad building	108	0.174	3.8
3. Street on west side of project	70	0.270	5.9
4. At grade beyond south edge of property	200	0.085	2.0
5. First floor of railroad building	155	0.051	2.7
6. Basement of railroad building	120	0.070	3.4
7. Second floor of railroad building	115	0.040	3.6
8. Roof of railroad building	115	0.055	3.6

Note: 1 ft = 0.305 m.; 1 in. = 25.4 mm; 1 lbf = 4.45 N.

Site 5, the subsurface profile consists of building rubble. Points 1 to 4 of Table 3 define a new line on Fig. 5 which can be labeled as rubble fill. These 4 points were observed measurements made at ground surface at various distances from the point of impact. All the measurements taken within the building fall within the range that indicates perceptible vibration and this agrees with the reaction of the tenants. No damage occurred within this building even though the site densification took place over a period of about 3 weeks. The readings taken immediately adjacent to the area being densified indicates an objectionable range of ground vibrations but this instrument was located at the property line where no structures or permanent facilities were located.

One of the advantages of plotting the seismograph readings on a plot like Fig. 5 is that the data can be extrapolated to determine the distance from the

point of impact where damage to a structure could occur. The generally accepted safe level for particle velocity to prevent damages to residences is 2 in./sec (51 mm/s) (2). Extrapolating the line labeled building rubble to an intersection with 2 in./sec (51 mm/s) would result in a scaled energy factor of about 41. For the amount of energy applied at this site, the anticipated distance at which the particle velocity would be 2 in./sec (51 mm/s) computes to be 10 ft (3.1 m). If the impact energy were changed to 6 tons (5.4 metric tons) and a drop

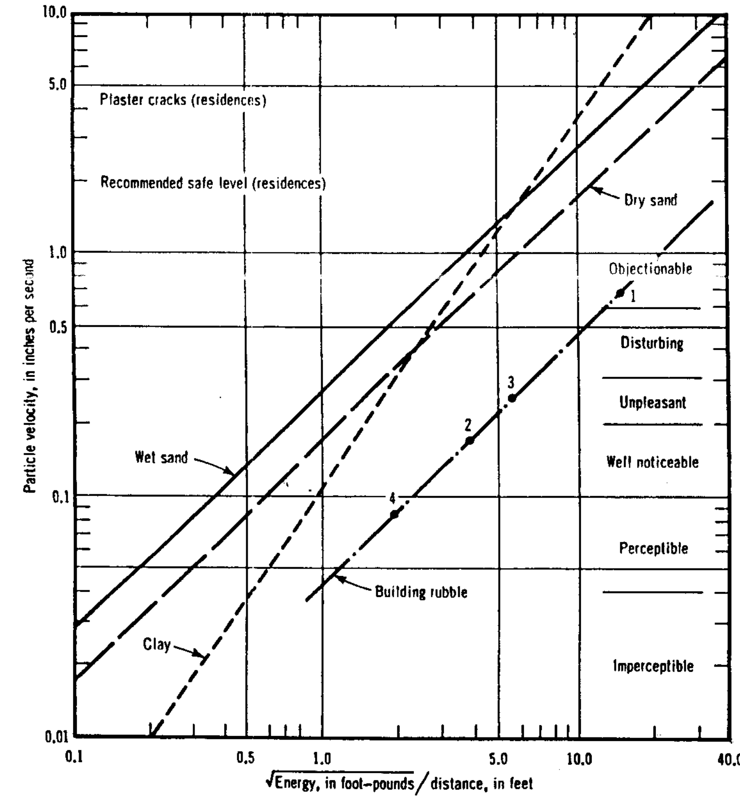

FIG. 5.—Scaled Energy Factor Versus Particle Velocity: Site 5

height of 40 ft (12.2 m), the distance beyond which the particle velocity is predicted to be less than 2 in./sec (51 mm/s) computes to be 17 ft (5.2 m).

For future projects, it would appear worthwhile to take measurements with a portable seismograph at varying distances from the point of impact during driving and then to plot the data on a chart such as Fig. 5 to develop the relationship between particle velocity and scaled energy for that particular site. This data could then be extrapolated to determine the appropriate distances that the points of impact should be kept from nearby structures to prevent damage.

Limitations

Some fill deposits were found to resist densification and had to be removed and replaced with a better material. This included fill containing a high proportion of wood, pockets of sawdust, and high water content organic soils.

Most materials respond to the pounding process by an improvement of the properties. However, there is a limitation as to how much property improvement can be achieved and this must be kept in mind when designing structures to be supported on these deposits. As an example, a localized area of Site 4 consisted of cinders, glass and clay fill. This deposit was densified by pounding and achieved a pressuremeter modulus of only 40 tsf–50 tsf (3.8 MPa–4.8 MPa), whereas, a pressuremeter modulus of 70 tsf–90 tsf (6.7 MPa–8.6 MPa) was typically achieved in other areas of the project. Additional pounding was undertaken in this area to further improve the properties of the soils but the modulus could not be improved. At Site 6, represented by Fig. 3(*a*), the Standard Penetration Resistance of the sandy soil at the 4 ft (1.2 m) level remained at about 20 blows/ft after single and double coverage.

Pounding of fine grained saturated soils should be approached with caution. The experience gained at one project site indicates that the degree of improvement attained is limited and occurs at a slow rate.

Structural Performance

The performance of Sites 1–3 and Sites 5–7 have been checked only by visual inspections. In all of these sites, no visual effects of settlement were observed. At Site 4, two of the shopping center buildings were monitored for settlement. At this site, there is 60 ft (18.3 m) of fill consisting primarily of an old refuse dump and miscellaneous fill that had been dumped over the years. Within Building A, 23 columns were monitored and within a period of 6 months after completion of the structure, the maximum observed settlement was 1/2 in. (13 mm). The typical column settlement was 1/4 in. (6.3 mm) or less. Within Building B, 67 columns were monitored and within 2 months after completion of the building, the average settlement ranged from 1/4 in.–9/16 in. (6.3 mm–14.5 mm). The settlement occurred as the column loads were applied and stopped when the structures were completed. The buildings were designed to take additional settlement due to potential future decomposition of the underlying organic matter within the fill deposits. Fortunately, the refuse which had been placed at this site was deposited 30 or more years ago and most of the organic decomposition has already occurred. In addition, open burning was undertaken at this pit when the refuse was dumped so a large part of the fill consisted of ashes and decomposed material. The column loads for both of these buildings are on the order of 300 kips (1,335 kN). Building A was completed in 1977 and Building B in 1978 and to date, the performance has been satisfactory.

At Site 8, footing settlement of 1 in.–2 in. (25 mm–51 mm) was recorded in an area where saturated clayey silt soils were present at footing level. This settlement occurred before any structural loads were applied to the footings and the settlement is attributed to dissipation of pore pressures following pounding. The footings were constructed 2 weeks–4 weeks after pounding and settlement continued until 6 weeks–8 weeks after pounding. The structural loads were applied 12 weeks after pounding and no measureable settlement occurred when these loads were applied.

Practical Applications

There are many marginal sites especially in urban areas. These marginal sites frequently consist of land that has been filled to raise the grade over soft ground deposits or where buildings have been wrecked and the rubble has been left in place to fill the former basement areas. The pounding process has proven to be practical and economical for improving these sites to support structures of one story–four stories in height. The costs of pounding wherein the site was improved to levels of 10 ft–15 ft (3.1 m–5.3 m) below grade have ranged from \$0.50/sq ft–\$1.00/sq ft. Alternative designs have been priced as more expensive. Removal and replacement with compacted fill assuming 10 ft (3.1 m) of existing fill depth has been priced at three to five times site improvement costs. The cost for extended foundations depends upon the length of foundation required. At Site 4, deep foundations were priced ten times site improvement costs while at Site 7, the cost ratio was 3.5.

Conclusions

On the basis of the data obtained in conjunction with the construction of eight projects, plus the performance of the structures afterwards, it can be concluded that:

1. The pounding process which consists of dropping a heavy weight through a predetermined distance to impact into the soil is a practical way of densifying certain marginal sites. In partly saturated materials above the water table densification is due to compaction plus a collapse of any large voids which may be present therein. In saturated clayey silt, densification is due to consolidation following liquefaction.
2. The depth of improvement was observed to levels of 10 ft–20 ft (3.1 m–6.1 m) below ground surface for weights on the order of 2 tons–6 tons (1.8 metric tons–5.4 metric tons) which were dropped through distances of 30 ft–35 ft (9.2 m–10.7 m) with 7 tamps per location–9 tamps per location. The depth of improvement was approx 65%–80% of the square root of the product of the weight in metric tons and the drop in meters. The number of coverages applied to the area does not appear to affect the depth of improvement.
3. The energy imparted to the improved zone is approximately equal to the Standard Proctor (ASTM D-698) energy when a 6-ton (5.4-metric ton) weight is dropped a height of 35 ft–40 ft (10.7 m–12.2 m) with 9 tamps per impact point.
4. When the weight impacts into the soil, ground vibrations are transmitted off the site. A method of estimating the particle velocity at a distance from the point of impact is described in the main text. For building rubble, the distance from the point of impact to the location where the particle velocity will be 2 in./sec (51 mm/s) computes to 17 ft (5.2 m) for a weight of 6 tons (5.4 metric tons) falling 40 ft (12.2 m).
5. Each material that is densified achieves a maximum or limited improvement.

This must be kept in mind when designing structures to be supported on these deposits.

Acknowledgments

The writer is indebted to the field engineering personnel who monitored the pounding operations and assisted in making field adjustments as this method of densification was developed and improved. In particular, Norman Seiler who was involved with five projects and Sylvio Pollici who was involved with one project, are deserving of special mention.

Appendix I.—References

1. Menard, L., and Broise, Y., "Theoretical and Practical Aspects of Dynamic Consolidation," *Geotechnique*, Vol. 25, No. 1, 1975.
2. Wiss, J., "Damage Effects of Pile Driving Vibration," *Highway Research Record Number 155*, 1967.

Appendix II.—Notation

The following symbols are used in this paper:

D = depth of improvement, in meters;
H = height of drop, in meters; and
W = weight of hammer, in metric tons.

JOURNAL OF THE GEOTECHNICAL ENGINEERING DIVISION

Cone Penetration in Soil Profiling

By Mohsen M. Baligh,[1] M. ASCE, Vitoon Vivatrat,[2] and Charles C. Ladd,[3] F. ASCE

Introduction

The primary objectives of a soil exploration program are to determine the nature of the subsurface stratigraphy (i.e., the extent, thickness and location of the different soil layers) and those engineering properties of the layers pertinent to foundation design. Accurate information on soil stratification and variability in properties is necessary for the geotechnical engineer to interpolate reliably between data obtained from widely-spaced boreholes, plan the final testing program, select adequate spatial distributions of soil parameters and hopefully reduce the risk of inadequate foundation performances.

The most common U.S. practice for soil investigations involves the Standard Penetration Test for soil identification and empirical correlations with engineering properties and undisturbed sampling for various laboratory strength and consolidation testing. The quasi-static (Dutch) cone test is widely used in Europe and many parts of the world for soil exploration (Sanglerat, 1972; ESOPT, 1974), but has had relatively limited acceptance in the U.S. The Dutch cone test enables essentially continuous measurements of cone resistance, q_c, and sleeve friction, f_s, as the cone is pushed into the soil. These data are generally interpreted, with varying degrees of reliability, on the basis of empirical correlations to: (1) Identify soil types; (2) estimate the undrained shear strength of clays and the friction angle and compressibility of sands; and (3) predict the point and shaft resistances of piles (Schmertmann, 1975; Mitchell and Gardner, 1975; Lunne, et al., 1976; and Meyerhof, 1976). Another type of cone penetration test, the piezometer probe, independently developed by Wissa, et al. (1975)

Note.—Discussion open until September 1, 1980. To extend the closing date one month, a written request must be filed with the Manager of Technical and Professional Publications, ASCE. This paper is part of the copyrighted Journal of the Geotechnical Engineering Division, Proceedings of the American Society of Civil Engineers, Vol. 106, No. GT4, April, 1980. Manuscript was submitted for review for possible publication on January 2, 1979.

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<u>ATTACHMENT 3</u>

DAMAGE EFFECTS OF PILE DRIVING VIBRATION

Damage Effects of Pile Driving Vibration

JOHN F. WISS, Wiss, Janney, Elstner and Assoc.

•PILE DRIVING, like dynamite blasts, nuclear blasts, and sonic booms, is a source of vibration which is frequently alleged to cause damage to structures. Unlike blasts, however, pile driving vibrations are produced by mechanical energy that is limited by the capabilities of the mechanical system. For example, a 5,000-lb ram falling freely from a height of 3 ft cannot deliver more than 15,000 ft-lb of energy on impact. Similarly, the maximum energy available from a double-acting steam hammer is limited by the steam pressure, the area of the piston, and the stroke.

On impact, the energy of the ram is imparted to the pile. It is distributed between rebound of the ram, elastic distortion of the pile, elastic and plastic deformation of the cushioning material, penetration of the pile, and elastic and plastic deformation of the earth surrounding the pile. The elastic deformation of the soil is propagated through the earth materials as elastic waves. The distribution of the available impact energy to the sources previously mentioned consists of interrelated functions, but the most important factor is the resistance of the soil to penetration by the pile. In a soft, easily penetrated soil, most of the energy is used in advancing the pile, and the least amount in the elastic deformation of the soil. In very hard, resistant soil the converse is true.

It is convenient to visualize the wave motion at the surface of the earth as being similar to the ripples produced on a smooth surface of water when a stone is thrown in. The wave length of the earth waves from pile driving is approximately 200 ft; this is the distance from the crest of one wave to the crest of the succeeding wave. Structures supported on the surface ride such waves in the same manner as a cork or box floating on the ripples of the water. Deeply embedded structures respond to a lesser degree in proportion to the orbital diameter of the earth particle motion which decreases exponentially with depth. For example, a structure embedded 200 ft below the surface would receive virtually no vibration. One at 100 ft would receive $\frac{1}{32}$th of the vibration experienced by a point on the surface. Regardless of depth, the magnitude of vibration intensity varies with the amount of energy transmitted to the soil, the physical properties of the soil, and the distance that the wave has traveled from the source.

Many instruments are capable of measuring the vibration intensities resulting from pile driving. Basically, such systems consist of a vibration sensor which converts the physical motion of the earth or structure into electrical signals. These in turn are sufficiently strengthened by an electronic amplifier to drive a galvaniometer and produce a recording of vibration vs time. It is essential to record the vibration, because the impulses are transient, and the response of meters is not fast enough to follow the vibrations accurately. It is also important to record simultaneously the vibratory motion in three mutually perpendicular directions. Although the impact force is generally in the vertical direction, the maximum earth or structural vibration is not necessarily vertical.

The instrument most commonly used for measurement of earth or structural vibration resulting from pile driving is the portable three-component seismograph. This unit is a mechanical optical system which utilizes seismic principles, is portable and battery operated, and produces a recording of displacement in three mutually perpendicular directions vs time. It is ideally suited for field recordings of the vibrations associated with pile driving.

Paper sponsored by Committee on Construction Practices—Structures and presented at the 45th Annual Meeting.

Figure 1. Sprengnether portable seismograph and equivalent complement of electronic equipment and transducers.

Figure 1 shows the Sprengnether portable seismograph which we have used extensively, and an equivalent complement of electronic equipment and transducers. Typical recordings of vibration from pile-driving operations are shown in Figure 2.

The damage potential of pile-driving vibrations depends on the displacement and the frequency of the vibration. Neither of these two characteristics alone will damage a structure. Concerning displacement, it is common knowledge that a structure can be uniformly jacked through several feet without causing damage. Likewise, with regard to frequency, normal sound, in passing through a wall, can vibrate the wall at high frequencies (several thousand cycles per second) without

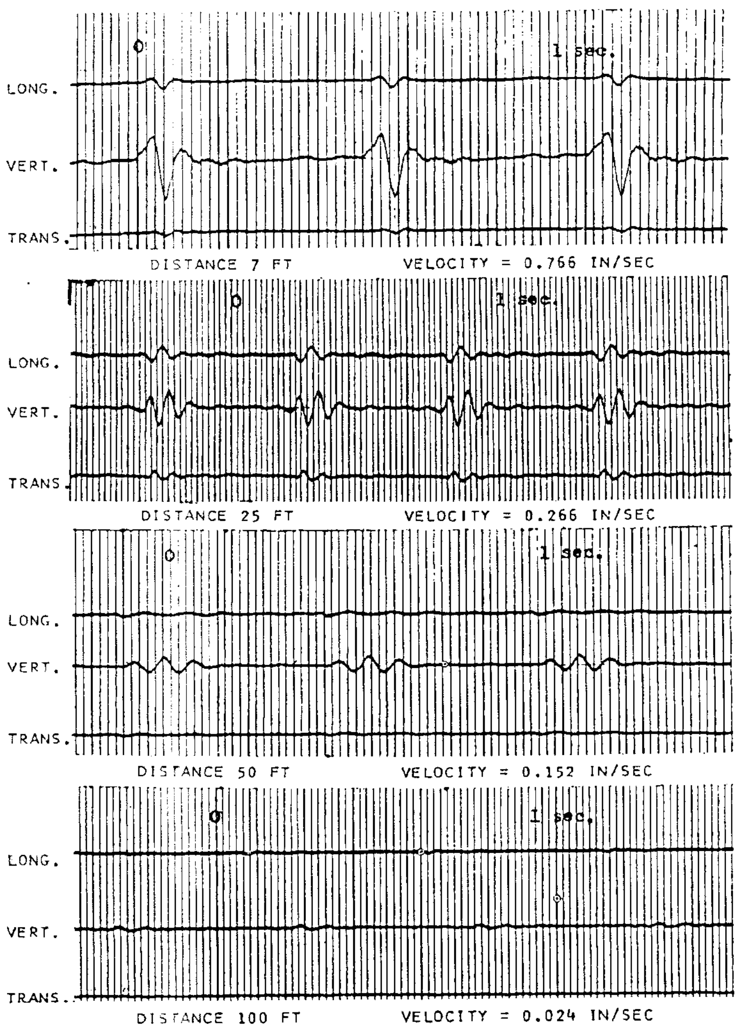

Figure 2. Typical earth vibrations from pile driving.

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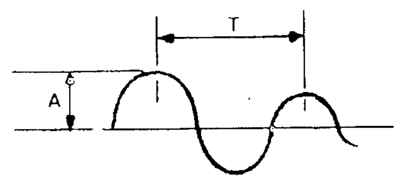

A = AMPLITUDE OR DISPLACEMENT (INCHES)

T = TIME (SECONDS) FOR ONE CYCLE

f = FREQUENCY (CPS) = 1/T

V = PARTICLE VELOCITY (INCHES PER SECOND)

$$V = 2\pi f A$$

TYPICAL SOIL FREQUENCIES

(PILE DRIVING)

ALLUVIAL FILL	5-10 CPS
CLAY	15-25 CPS
SAND	30-40 CPS

Figure 3. Particle velocity in alluvial fill, clay, and sand.

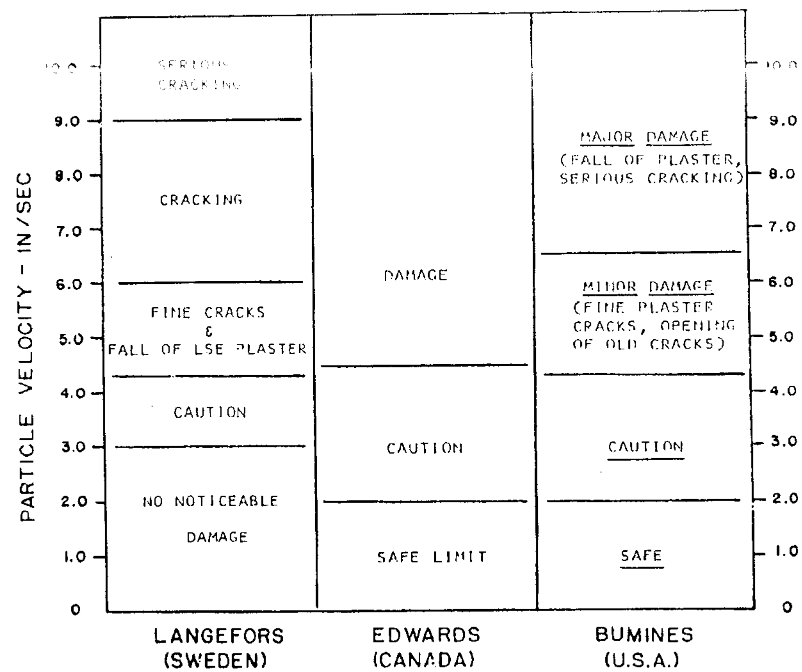

Figure 4. Comparison of damage criteria, residential-type structures.

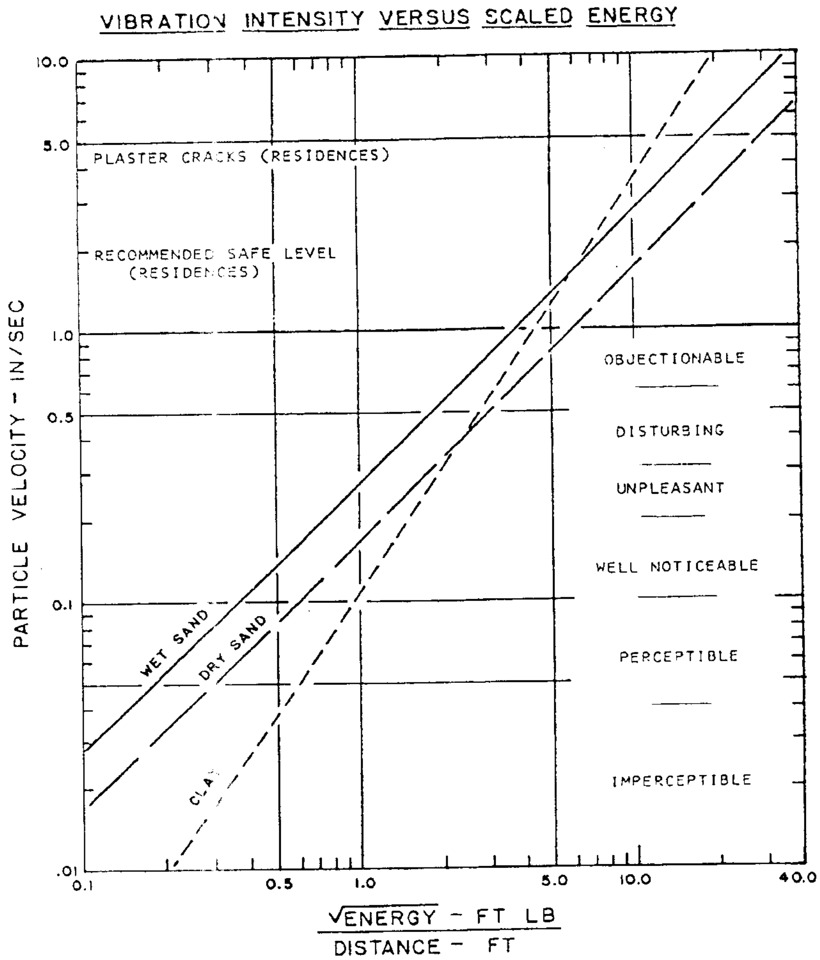

Figure 5. Maximum vibration intensities expected from pile driving on wet sand, dry sand, and clay.

causing damage. It is a combination of displacement (amount of motion) and frequency which causes damage. The particle velocity of earthborne vibration is the best measure of damage potential because it combines displacement and frequency in the most significant manner. Particle velocity (Fig. 3) can be expressed as $2\pi f A$, in which f is frequency (cps) and A is amplitude (displacement). Impact vibrations produced by pile driving have characteristic frequencies depending on the type of soil. A loose alluvial fill has natural frequencies of about 5 to 10 cps, clay soils vary between 15 and 25 cps, sand between 30 and 40 cps.

Several investigators in this country and abroad (including the U.S. Bureau of Mines) have found that particle velocities in excess of 4.0 in./sec are required to cause plaster cracks in dwellings. Figure 4 shows a comparison of the results of several of the investigations. With appropriate conservatism, the investigators agree that a vibration level of 2.0 in./sec (particle velocity) is safe with regard to plaster cracks in residential-type structures.

The effect of ground motion on an engineered structure can be computed by commonly used methods in the earthquake engineering field. The structure is considered a lumped mass-spring dashpot system, and its response to a series of impacts can be calculated. Based on observation and experience, it can be stated that ground motion particle velocities below 4.0 in./sec are well within the safe range for engineer structures.

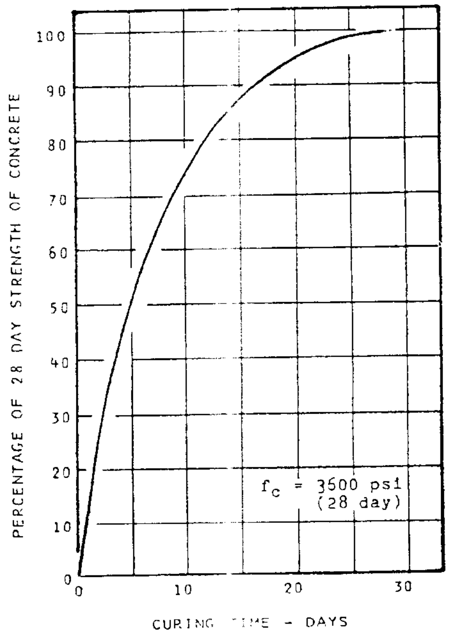

Figure 6. Strength of concrete vs curing time.

Figure 5 shows the maximum vibration intensities to be expected from pile driving in several soils on which extensive data have been obtained by the author. The data are plotted on log-log paper in which the abscissa is $\sqrt{E/D}$. This scaled energy factor permits use of the graphs with any size of pile driver; E is the foot-pounds of energy delivered by the hammer, and D is the seismic distance, in feet, from the pile tip to the location of interest. The vibration intensity (particle velocity) varies as the square root of the energy of the hammer. Figure 5 also indicates the levels at which vibration damage may be expected and the normal human evaluation of pile driving vibration. In several investigations, vibrations resulting from the driving of sheet piling, wood piles, and H piles were measured. For all practical purposes there is no difference in the vibration produced, all other variables being constant.

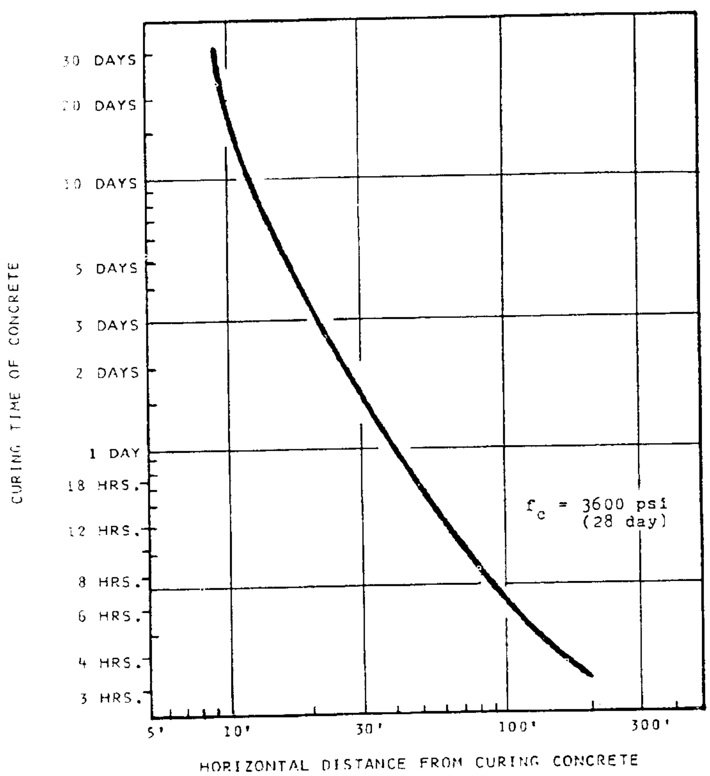

Figure 7. Limiting safe distance vs curing time of concrete for pile driver rated at 15,000 ft-lb of energy.

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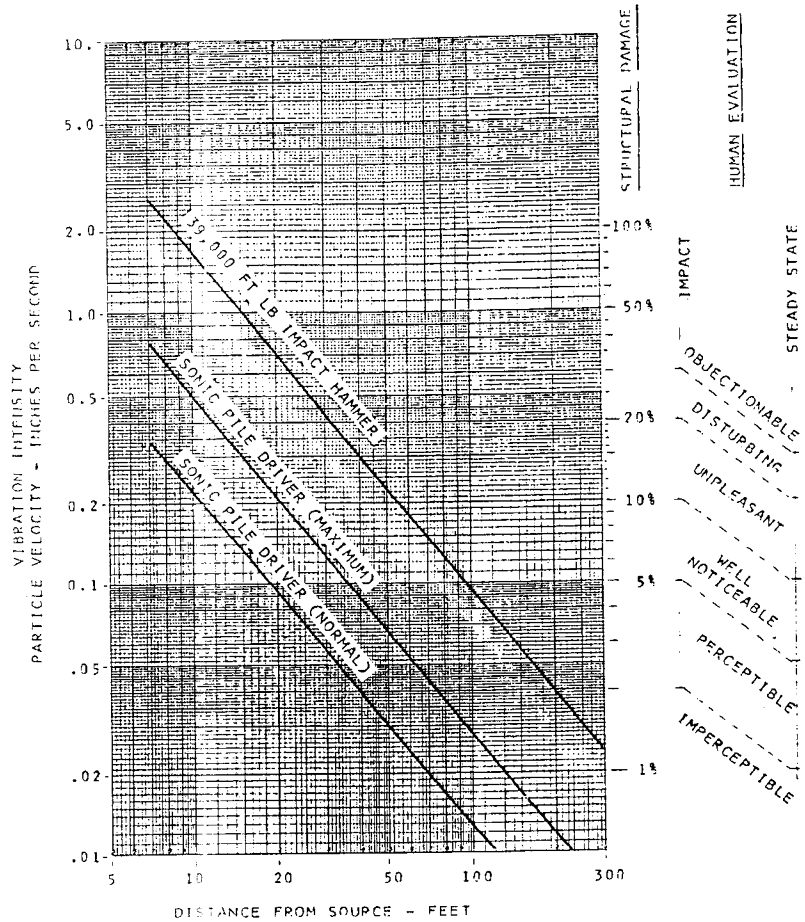

Figure 8. Vibration intensity vs distance.

Another problem of common interest on a construction project involves the case in which piles are to be driven at the same time that concrete is being placed. The question has frequently been raised as to whether the pile driving might have a detrimental effect on "green" concrete. Until more is known about concrete technology, it is doubtful that a rigorous analysis of such effects can be made.

As a practical matter, the following reasoning has been used by the author in the past, and although the magnitude of the safety factor has not been determined, there has been no evidence to indicate that the approach is not conservative.

Assuming that 5.0 in./sec (particle velocity) is conservatively a safe vibration level for cured concrete, and recognizing the rate at which green concrete attains strength, it is then possible to relate the permissible safe vibration level to the time since placing the concrete. When the decrease of vibration with distance has been evaluated for a particular site, the distance at which pile driving may be permitted (for a certain size hammer) can then be determined as a function of curing time.

Assume, for purposes of illustration, that a 3,600-psi concrete (28-day strength) has been specified on a particular project. The percentage of 28-day strength of concrete vs curing time is shown in Figure 6. This curve shows that the concrete has approximately 5 percent of its strength in 12 hr (one-half day), or 10 percent in 24 hr (one day). Thus, the vibration intensity should not exceed this same percentage of a particle velocity of 5.0 in./sec; limiting values of vibration are, therefore, 0.25 and 0.5 in./sec, respectively. If the soil is basically a clay, these vibration particle velocities correspond to an $\sqrt{E/D}$ of 2 and 3, respectively (Fig. 5). If a 15,000-ft-lb pile driver is used, the closest permissible distances are 61.5 and 41.0 ft, respectively.

By the foregoing method a curve can be developed in which the limiting safe distance for pile driving vs curing time of concrete can be determined (Fig. 7). This curve is represented as a typical evaluation. For a specific site, pile driver, and concrete, limiting distances and curing time should be based on measured vibration intensities and concrete strength determinations, especially where short curing times are involved.

In closing, some brief comments on the vibration produced by the sonic pile driver and by other vibratory pile drivers are pertinent. In contrast to the impact hammer, which excites the soil at its natural frequency and the vibrations die out before the next blow, the sonic and vibratory pile drivers force the soil to vibrate at the continuous frequency (rpm) of the driver. These units can be speed controlled over a limited frequency range. Investigations of a sonic pile driver driven at frequencies between 90 and 120 cps, and a vibratory pile driver adjustable between 16 and 21 cps resulted in the following observations.

The normal vibration levels from the sonic driver may by one order of magnitude lower than those of an impact pile driver. However, the vibration varies continuously and occasionally attains intensities approximately one-half of the levels produced by a comparable impact hammer. Further, because the vibration is of a steady-state rather than a transient character, the human evaluation is usually more pronounced—by a factor of 2 (Fig. 8). The other vibratory pile driver investigated produced vibration levels of the same order of magnitude as a comparable impact pile driver.

With a steady-state excitation the possibility of resonance response in building components (especially panels) may become of significant importance. In the case of the transient vibrations produced by an impact pile driver, the duration of the transient is sufficiently short (0.2-0.3 sec) that a resonance buildup of structural components is not likely. The safe level of intensity for a steady-state vibration could conceivably be between one-half and one-fifth of the safe level for transient excitation; this is due to the possible magnification at resonance which depends primarily on the inherent damping characteristics of the structure.

ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 1
DOCKET NO. 327

TOPICAL REPORT NO. 24370-TR-C-002,REVISION 3
"RIGGING AND HEAVY LOAD HANDLING”

SEQUOYAH UNIT 1 STEAM GENERATOR REPLACEMENT

RIGGING AND HEAVY LOAD HANDLING TOPICAL REPORT

REV.	DATE	REASON FOR REVISION	BY	EGS	PE
3	12-24-02	Updated to Reflect Responses to NRC RAIs	[signature]	MRA	[signature]
2	4/12/02	Incorporated TVA Comments	SWK	MRA	CCG for JVS
1	3/6/02	Incorporated TVA Comments	SWK	MRA	JVS
0	2/14/02	Issued for TVA use	SWK	DLK	JVS

BECHTEL

JOB NO.: 24370

DOCUMENT NO.: 24370-TR-C-002

SEQUOYAH UNIT 1

STEAM GENERATOR REPLACEMENT

RIGGING and HEAVY LOAD HANDLING

TOPICAL REPORT

Table of Contents

Appendices

Figures

1.0 Abstract

In response to NRC Generic Letters 80-113 (Reference 18) and 81-07 (Reference 19), TVA established a program for the control of heavy loads at Sequoyah. This program, which addresses the guidance provided in NUREG-0612 (Reference 12), was reviewed by the NRC and incorporated into plant Procedure 0-MI-MXX-000-026.0 (Reference 8). During the upcoming Steam Generator Replacement (SGR) at Sequoyah Unit 1, which will occur during the Unit 1 Cycle 12 refueling outage, heavy loads exceeding those anticipated by Reference 8 will be handled using new safe load paths. In some cases, the load paths traverse over safety-related equipment supporting operation and safe-shutdown capability for Unit 2, which will remain in operation during the Unit 1 Steam Generator Replacement Outage (SGRO).

As defined in NRC Bulletin 96-02 (Reference 13), licensees planning to perform activities involving the handling of heavy loads over safety-related equipment while the reactor is at power and involving a potential load drop accident that has not previously been addressed in the FSAR should submit a license amendment request to the NRC. Following recent revisions to 10CFR50.59, the Bulletin's guidance was supplemented by NRC Regulatory Issue Summary 2001-03 (Reference 20), which states that, "The fact that the load is larger or is moving in a different load path than previously evaluated would enter into the risk assessment required by 10CFR50.65(a)(4) and determine under what plant conditions the load lift should occur."

This Topical Report documents the provisions made to ensure that heavy load handling activities associated with the Unit 1 SGRO can be accomplished without impacting the safe operation of Unit 2. These provisions support the risk assessment required by 10CFR50.65(a)(4) and an application for a one-time license amendment associated with the operability of the Essential Raw Cooling Water (ERCW) System. As concluded in Appendix B, these provisions and one-time license amendment do not involve a significant hazards consideration. Actions required to support the conclusions of this Topical Report are detailed in Appendix A.

2.0 Introduction

This Topical Report provides a description of and technical justification for the use of cranes and rigging of heavy loads over safety-related structures, systems, and components (SSCs) in support of the Sequoyah Unit 1 SGR. The cranes and the heavy loads addressed in this Topical Report are:

- Outside Lift System (OLS) (i.e., Mammoet PTC Heavy Lift Crane)
- Mobile (lattice boom and truck) cranes
- Large crane components
- Old and replacement steam generators
- Reactor shield building dome and steam generator compartment roof concrete sections
- Containment vessel dome steel sections

The activities addressed in this Topical Report are:

- Assembly, use, and disassembly of the OLS.
- Use of the mobile cranes for assembly/disassembly of the OLS.

- Removal of reactor shield building dome and steam generator compartment roof concrete sections and containment vessel dome steel sections.
- Removal of the old steam generators (OSGs) and installation of the replacement steam generators (RSGs).
- SSC protection from external events and postulated load drops.

The OLS is commercially designed and, therefore, is considered as non-safety related. The OLS was not specifically designed to withstand the external events addressed by 10CFR50, Appendix A, General Design Criterion (GDC) 2 that are a part of the Sequoyah design and licensing basis. However, due to the size of the OLS and because of the OLS location and proximity to the Containment, Auxiliary Building, Essential Raw Cooling Water (ERCW) piping, Refueling Water Storage Tank (RWST), Main Steam (MS) piping, and Feedwater (FW) piping, the OLS was evaluated as indicated below for those external events that might cause it to collapse when these SSCs are required to be operable.

The OLS was analyzed for both loaded and unloaded configurations for structural adequacy with design basis earthquake (DBE) loads imposed. Details of this seismic evaluation are provided in Section 5.1. As also discussed in Section 5.1, administrative controls will be imposed to restrict crane use and orientation under high winds or severe weather conditions.

This Topical Report also documents the load path provisions, equipment protection techniques, operator training, and compensatory measures that will ensure that OLS assembly/disassembly and load handling with the OLS is performed safely.

3.0 Objectives

This Topical Report provides the technical basis for a one-time Operating License (OL) change applicable to the Unit 1 Cycle 12 refueling outage that establishes that lifting of heavy loads will not affect ERCW system operability provided that the load movements are performed in accordance with this Topical Report and prescribed compensatory measures.

4.0 Regulatory Requirements/Criteria for Handling of Heavy Loads

Detailed below are regulatory requirements/criteria that are relevant to the handling of heavy loads over safety-related equipment. Since the load handling activities described in this topical report do not involve handling of loads over or near spent fuel, requirements related specifically to load handling over fuel are not addressed. Following each requirement/criteria is an *italicized* reference to where the requirement/criteria is addressed within this topical report.

4.1 SRP Section 9.1.5 – Overhead Heavy Load Handling Systems

Standard Review Plan (SRP) Section 9.1.5 addresses the reviews of overhead heavy loads handling systems performed by the NRC to assure conformance with the requirements of 10CFR50, Appendix A, GDC 2, 4, 5, and 61. The heavy load handling system is considered acceptable if the integrated design of the structural, mechanical, and electrical elements, the manual and automatic operating controls, the safety interlocks and devices, and the load handling instructions, inspections, maintenance and testing, provide adequate system control for the specific procedures of handling operations, if the redundancy and diversity needed to protect against malfunctions or failures are provided, and if the design conforms to the relevant requirements of the following regulations:

1) GDC 2, as related to the ability of structures, equipment, and mechanisms to withstand the effects of earthquakes. Acceptance is based in part on meeting position C.1 of Regulatory Guide 1.29 for safety-related equipment and position C.2 for non-safety related equipment, and positions C.1 and C.6 of Regulatory Guide 1.13.

   As detailed in Section 5.1, the OLS has been evaluated for seismic loads while unloaded and while loaded with its heaviest load (a steam generator). This seismic evaluation determined that the OLS will not collapse or result in a drop of the load during a seismic design basis safe shutdown earthquake event for the lift configurations to be used for the Sequoyah Unit 1 SGR.

   Per Section 5.2, use of the mobile cranes for OLS assembly/disassembly is limited to an area within 60 ft. of the OLS boom location shown on Figure 5-2. However, mobile crane usage beyond 60 ft. from the OLS boom location may be allowed if Engineering evaluation shows no adverse impact to nearby safety-related SSCs. Protection (see Figure 5-2) for safety-related SSCs is provided, as necessary, to ensure that Unit 1 and Unit 2 can be safely shut down and/or maintained in a safe condition in the unlikely event of a seismically induced load drop during use of these cranes for assembly/disassembly of the OLS.

2) GDC 4, as it relates to protection of safety-related equipment from the effects of internally generated missiles (i.e., dropped loads). Acceptance is based in part on meeting positions C.3 and C.5 of Regulatory Guide 1.13.

   Safety-related SSCs that may be affected by a load drop from the OLS or mobile cranes are described in Section 6. As detailed in Section 8, these SSCs have been evaluated and where necessary, protective or compensatory measures have been determined to mitigate the effects of a load drop induced SSC failure.

3) GDC 5, as related to the sharing of equipment and components important to safety, between Units 1 and 2.

   As detailed in Section 6.3, ERCW is the only shared system that could be affected by load drops from the OLS. Equipment that may be affected by a load drop is detailed in Section 8.3. As indicated in Appendix A, plant procedures will be developed to delineate specific actions required in case of a heavy load drop.

4) GDC 61, as related to the safe handling and storage of fuel.

   Conformance to this GDC is not applicable, as the load handling detailed herein will not involve moving fuel or moving loads over fuel.

Other specific criteria necessary to meet the relevant requirements of GDC 2, 4, and 61 are detailed in NUREG-0612.

4.2 NUREG-0612 – Control of Heavy Loads at Nuclear Power Plants

Section 5.1 of NUREG-0612 provides guidelines for the control of heavy loads. The objectives of these guidelines, in part, are 1) to assure that the potential for a load drop is extremely small or 2) radioactive releases resulting from damage caused by the load drop are less than 1/4 of 10CFR100 limits (i.e., less than 75 rem thyroid and 6.25 rem whole body) and to ensure that damage to equipment in redundant safe shutdown paths is not sufficient to preclude safe shutdown.

The evaluation of the radiological consequences of dropping an OSG is described in Section 7.1.

The NUREG reflects an overall philosophy that provides a defense-in-depth approach for controlling the handling of heavy loads; i.e., prevent as well as mitigate the consequences of postulated accidental drops. Part of this defense-in-depth approach involves 1) providing sufficient operator training, handling system design, load handling instructions, and equipment inspections to assure reliable operation of the handling system and 2) defining safe load paths through procedures and operator training so that to the extent practical heavy loads being carried over or near safe shutdown equipment are avoided. Where a load path that avoids safe shutdown equipment cannot be defined, alternative measures may be taken to compensate for this situation.

As detailed in Section 7, for the large equipment lifts discussed in this Topical Report, a safe load path has been chosen that minimizes potential interactions with critical equipment. For the lifts that must traverse safe shutdown equipment, compensatory measures will be implemented in the unlikely event of a load drop.

Section 5.1.1 of NUREG-0612 states that all plants should satisfy the following for handling heavy loads that could be brought in proximity to or over safe shutdown equipment:

1) Load paths should be defined for the movement of heavy loads to minimize the potential for heavy loads to impact safe shutdown equipment. These load paths should be defined in procedures, shown on equipment layout drawings, and clearly marked in the area where the load is to be handled.

   Safe load paths for the loads to be handled by the OLS have been identified as shown on Figure 5-2. Criteria for operation of mobile cranes used in the assembly/disassembly of the OLS have been developed as detailed in Section 5.2.

2) Procedures should be developed to cover load handling operations for heavy loads to be handled in proximity to safe shutdown equipment. These procedures should include identification of required equipment, inspections and acceptance criteria required before movement of the load, the steps and proper sequence to be followed in handling the load, the safe load path, and other special precautions.

   Rigging operations using the OLS and mobile cranes will be controlled and conducted by highly trained and qualified personnel in accordance with approved procedures. The entire operation has been evaluated by engineering personnel and documented by calculations, engineering drawings, and procedures.

Drawings showing the safe load paths have been developed. Assembly and disassembly of the OLS will be performed in accordance with the crane manufacturer's procedures and drawings. Tornado initiated crane failures or load drops will be precluded through implementation of procedures to suspend load handling when high winds or severe weather/tornado conditions are anticipated. As indicated in Appendix A, procedures to implement compensatory measures required to mitigate the effects on ERCW system operation of a postulated load drop will be developed and personnel will be trained in their use.

3) Crane operators should be trained, qualified, and conduct themselves in accordance with ANSI B30.2 Chapter 2-3 guidelines.

   ANSI B30.2 is applicable to overhead gantry cranes. The appropriate guidance for the mobile cranes is ANSI B30.5. The operator training detailed in Sections 5.1 and 5.2 of this topical report conforms to the guidelines of ANSI B30.5, Chapter 5-3.

4) Special lifting devices should satisfy the guidelines of ANSI N14.6, as modified by NUREG-0612.

   The rigging operations addressed in this Topical Report do not use special lifting devices as defined by ANSI N14.6.

   As described in Section 5.1, the OLS attachments and rigging meet the requirements of ASME NQA-1-1997, Subpart 2.15 and the applicable ASME B30 series standards. The attachments and rigging used to attach the OLS to the SGs have been previously load tested in accordance ASME NQA-1, Subpart 2.15 or have a previous load history that exceeds the loads to be lifted.

5) Lifting devices that are not specially designed should be installed and used in accordance with the guidelines of ANSI B30.9, as modified by NUREG-0612.

   As described in Section 5.1, the OLS attachments and rigging meet the requirements of ASME NQA-1-1997, Subpart 2.15 and the applicable ASME B30 series standards. This includes ANSI B30.9 as modified by NUREG-0612.

6) The crane should be inspected, tested, and maintained in accordance with ANSI B30.2, as modified by NUREG-0612.

   ANSI B30.2 is applicable to overhead gantry cranes. The appropriate guidance for the mobile cranes is ANSI B30.5. The crane inspections, testing, and maintenance detailed in Sections 5.1 and 5.2 of this topical report conform to the guidelines of ANSI B30.5, as modified by NUREG-0612.

7) The crane should be designed to meet the applicable criteria and guidelines of Chapter 2-1 of ANSI B30.2 and of CMAA-70.

   ANSI B30.2 is applicable to overhead gantry cranes. The appropriate guidance for the mobile cranes is ANSI B30.5. The manufacturer's user manual for the OLS also refers to ANSI B30.5. The crane designs detailed in Sections 5.1 and 5.2 of this topical report conform to the guidelines of ANSI B30.5, which meets the intent of ANSI B30.2 and CMAA-70.

Section 5.1.5 of NUREG-0612 states that in addition to the above requirements from Section 5.1.1, the effects of load drops should be analyzed (in accordance with the guidelines of Appendix A to NUREG-0612) and the results should indicate that damage to safe shutdown equipment is not sufficient to preclude safe shutdown.

Appendix A of NUREG-0612 states, in part, that analyses of postulated load drops should as a minimum include the following considerations:

1) The load is dropped in an orientation that causes the most severe consequences.

   The consequences of a postulated load drop from the OLS or the mobile cranes are detailed in Section 7. Where it was not possible to protect SSCs in the vicinity of the load drop, the worse case failure of these SSCs was postulated.

2) The load may be dropped at any location in the crane travel area where movement is not restricted by mechanical stops or electrical interlocks.

   As detailed in Section 7.1, loads drops along the entire load path have been postulated and evaluated. The load path is maintained by strict administrative controls. These administrative controls will be in the form of notes on drawings and procedural steps contained in controlled work packages.

3) X/Q values for determining the radiological consequences of a heavy load drop should be derived from analysis of onsite meteorological measurements based on 5% worst meteorological conditions.

   The meteorological conditions and the X/Q values used to determine the doses resulting from a postulated drop of an OSG are detailed in Section 7.1.

4) Analyses should be based on an elastic-plastic curve that represents a true stress-strain relationship.

   As detailed in Sections 7 and 8, when appropriate, the analyses are based on the true material characteristics.

5) The analysis should postulate the “maximum damage” that could result (i.e., the analysis should consider that all energy is absorbed by the structure and/or equipment that is impacted).

   Where it was not possible to analytically show that a SSC would survive the impact of a postulated load drop, the SSC was assumed to fail to the point where it could no longer perform its design function. If this failure could result in an adverse impact on other SSCs, this impact was accounted for in assessing whether compensatory measures were required to restore the affected functions.

6) Credit may not be taken for equipment to operate that may mitigate the effects of the load drop if the equipment is not required to be operable by the Technical Specifications when the load could be dropped.

No credit has been taken for equipment not required to be operable by the Technical Specifications.

4.3 NRC Bulletin 96-02 – Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment

This bulletin requires licensees planning to handle heavy loads over safety-related equipment while the reactor is at power that involve a potential load drop accident that has not been previously evaluated in the FSAR or a change to the Technical Specifications, to submit a license amendment request in advance of the planned load movement so as to afford the NRC sufficient time for review and approval.

Since the postulated load drops could adversely affect safety-related components that are addressed in the Technical Specifications, this Topical Report has been prepared to support NRC review and approval of an amendment to the Unit 2 Operating License to add a one-time condition for conduct of heavy load lifts associated with the Unit 1 steam generator replacement (Reference Section 8.3).

4.4 NRC Regulatory Issue Summary 2001-03 – Changes, Tests, and Experiments

Attachment 1 to Regulatory Issue Summary 2001-03, Issue 7, states, "With respect to [Bulletin] 96-02, if a heavy load movement is part of a maintenance activity, there is no 10CFR50.59 evaluation needed. The fact that the load is larger or is moving in a different load path than previously evaluated would enter into the risk assessment required by 10CFR50.65(a)(4) and determine under what plant conditions the load lift should occur. If the heavy load lift is not maintenance related, and so requires a 10CFR50.59 evaluation, the licensee should follow the requirements of the revised rule to determine whether prior NRC approval is needed.

This Topical Report documents the provisions made to minimize and control the risks associated with the subject lifts. While the lifts are associated with a maintenance activity for Unit 1, it is TVA's intent that Unit 2 continues normal operation during the Unit 1 SGRO. Because of the potential interactions of the Unit 1 activities upon Unit 2 safety, and to clarify the operational issues associated with the plant Technical Specifications, a license amendment based upon this Topical Report will be requested.

5.0 Description of Cranes and Heavy Loads

The cranes described herein are commercially available equipment and are not specifically designed as single failure proof, nor are they specifically designed to withstand the external events that are a part of the plant licensing basis. Since this rigging equipment will carry large and heavy loads in the vicinity of safety-related SSCs, it must be demonstrated that the installation, use, and removal of this rigging equipment does not adversely affect the safety function of these SSCs or that alternative means of performing the SSC safety function are available.

5.1 Outside Lift System

The OLS will consist of a Mammoet Platform Twin-Ring Containerized (PTC) Heavy Lift Crane (see Figure 5-1), which is a commercially designed crane. The maximum rated load for this crane is 1763.2 tons (1600 metric tons), however this will vary with crane configuration and lift radius. The rated load for the crane configuration proposed for the Sequoyah SGR ranges from 440.8 tons (400 metric tons) to 517.9 tons (470 metric tons), depending on the lift radius. The OLS meets or exceeds ASME NQA-1 Subpart 2.15 design requirements, and its load charts and operating restrictions consider applicable dead, live, wind, impact, and out-of-plumb lift loads. The OLS, supplied with standard load charts for its various boom configurations, has a rated load capacity certified by the manufacturer and has been load tested during its production; this meets the load test requirements of ASME NQA-1, 1997 Edition, Subpart 2.15, Section 601.2. In addition, after the OLS has been erected it will be load tested by lifting a 275 ton (550 kip) test load assembly with the OLS boomed out to a radius where the test load represents 110% of the OLS rated capacity at this radius. OLS lifts of the loads described in this topical report will be performed after Unit 1 is defueled and will be completed prior to the start of refueling. The OLS load test may be performed with Units 1 and 2 in any mode (Reference 24). The OLS will be located in an area between the Service Building, the Unit 1 RWST and the Unit 1 Containment, as shown on Figure 5-2.

The OLS consists of a main A-frame boom, which is pinned to and rides on wheel trucks at its base, and has a jib boom and 2 stay beams pinned to its top end. The main boom is stabilized by a counterweight system including a backmast boom that also rides on wheel trucks. The OLS wheel trucks ride on the base ring supported by built-in outrigger support rings/plates, which enable the OLS to be self-leveling, as shown on Figure 5-3.

OLS attachments that have been specially designed for SG rigging purposes will be connected to the steam generator during Modes 5 or 6 or the defueled condition while the OSG is still within its compartment. The OLS will be attached to the SGs, Shield Building concrete sections, steel Containment vessel sections, and SG compartment concrete sections using slings, cables, spreader beams, etc. attached to the OLS load block. The OLS attachments and rigging meet the requirements of ASME NQA-1-1997, Subpart 2.15 and the applicable ASME B30 series standards. The attachments and rigging used to attach the OLS to the SGs have been previously load tested in accordance ASME NQA-1, Subpart 2.15 or have a previous load history that exceeds the loads to be lifted. Rigging will be inspected prior to use in accordance with approved procedures and rigging operations will be controlled and conducted by highly trained and qualified personnel in accordance with approved procedures.

Personnel involved in operating the OLS will receive the following instruction:

- Operators will receive the applicable Sequoyah site-specific training specified in Appendix C of MMDP-2, “Safe Practices for Overhead Handling Equipment” (Reference 9).
- Personnel will undergo hands on training with the equipment before a load is attached to the equipment.
- Prior to a lift, detailed pre-lift meetings will be conducted.
- Direction to the operators during each OLS lift will be given by technical representatives of the equipment owner and the SGR contractor rigging specialist.

During the lifting operation, the exact location of boom tip and load block will be monitored by two independent methods. Instrumentation internal to the crane provides continuous readout of crane and boom orientation and the location of the boom tip and load block. In addition, the boom tip will be continuously monitored from a remote survey station independent from the crane instrumentation. This survey station will have the necessary data input to monitor and calculate the boom tip location relative to the interfacing structures and components. The individual directing the rigging operations will be in constant communication with both the crane operator and the surveyor manning the remote survey station. These controls will be utilized to ensure that the exact location of the load is known and compliance with design requirements is maintained.

Assembly and disassembly of the OLS will be performed in accordance with the crane manufacturer's procedures and drawings and may be performed with Unit 1 and Unit 2 in Modes 1-6 or defueled. The assembly/disassembly process will require the use of mobile cranes and other equipment as detailed in 5.2. During assembly and disassembly of the OLS, the main boom will lay in an area to the north of the Unit 1 Containment as shown on Figure 5-2. The orientation of the main boom during assembly/disassembly along with the restrictions on mobile crane usage and SSC protection provisions in 5.2 ensure that Unit 1 and Unit 2 can be safely shut down and/or maintained in a safe condition in the unlikely event of a load drop during assembly/disassembly of the OLS.

The OLS has been evaluated for seismic loads while unloaded and while loaded with a steam generator (SG) as detailed in Reference 21. A SG is the heaviest load that will be handled by the OLS. This seismic evaluation determined that the OLS will not collapse or result in a drop of the load during a seismic design basis Safe Shutdown Earthquake (SSE) event for the lift configurations to be used during the Sequoyah Unit 1 SGR. Therefore, use of the crane for the Sequoyah Unit 1 SGR will not result in Seismic II/I interaction issues on the SSCs located in the vicinity of the OLS.

Reference 21 developed a GT-STRUDL 3-D lumped mass finite element model using beam/truss elements to analyze the critical lift configurations of the OLS for SSE loads. NRC Regulatory Guide (RG) 1.61 allows 7% damping for bolted steel structures for the SSE. However, this analysis conservatively used 5%, which is consistent with Table 3.7.1-1 of the UFSAR. The OLS seismic analysis was performed using the response spectrum method in both the loaded and unloaded conditions.

The seismic analysis of the OLS is based on an appropriate ground spectrum corresponding to the plant's minimum SSE design basis spectra. The OLS will be supported on a concrete ring foundation seated on a large number of battered piles anchored to bedrock. Based on soil borings the average depth of soil deposit at the location of the OLS is 30 ft. The input spectrum used for the horizontal direction is an amplified response spectrum at ground surface for an average soil depth to bedrock of 30 ft. under the crane foundation. This amplified spectra was obtained by interpolation for a 30 ft. soil deposit and reduced to correspond to the minimum design basis from Reference 27 which provides 5% damped free field top of soil response spectra curves for the Sequoyah Nuclear Plant for soil depths of 40 ft. and 20 ft. It is noted that the amplified ground spectra documented in Reference 27 are an average based on the four artificially generated time histories used to develop the more conservative "actual design spectra" (see Section 2.5.2.4 and Figure 2.5.2-14 of the UFSAR). A 10% broadened amplified SSE horizontal ground response spectrum for 5% damping for 30 ft. depth of soil corresponding to the "minimum design basis spectra" in Figure 2.5.2-14 of the UFSAR was thus developed from the 20 ft. and 40 ft. curves in Reference 27 and used as the input horizontal spectrum. Since the OLS will be supported on a concrete ring foundation seated on a large number of battered piles that are supported well into bedrock, the vertical response spectrum used for the crane seismic analysis was the minimum design basis vertical spectrum for 5% damping from Figure 2.5.2-14 of the

UFSAR. The vertical response spectrum used is 2/3rds (per Section 2.5.2.4 of UFSAR) of the horizontal minimum design spectrum.

Soil springs were calculated to simulate soil-structure interaction at the foundation. The response spectra loadings were applied simultaneously in two horizontal directions and the vertical direction. Modal responses were combined using the NRC Ten-Percent Method. Co-directional responses were combined using the Square Root of the Sum of the Squares (SRSS) method.

The seismic evaluation of the OLS determined that the calculated stresses are less than the maximum allowable stresses (0.9 F_y) and the minimum safety factor against overturning is 1.1.

To further demonstrate the capability of the OLS, Reference 21 also determined the "whip-lash" effect a loss of lifted load would have on the OLS. Reference 21 determined that the whip-lash effect resulting from a postulated drop of a load from the OLS will not cause instability of the boom masts in the reverse direction, i.e. the masts will not flip over backwards and impact SSCs (e.g., Auxiliary Building, Control Building, etc.) behind the OLS.

Rigging operations will not be performed when wind speeds exceed the maximum operating wind speed for the OLS. This wind speed will be measured using an anemometer on the crane boom tip. If wind speeds increase during a rigging operation such that the wind speed may exceed the maximum operating speed, rigging operations will be suspended and the unloaded OLS will be secured by implementing administrative controls specified by the manufacturer in Reference 7. These administrative controls define the allowable mainmast and jib angles, and the slew drive and load block configurations, and are dependent on the wind speed.

To eliminate the effects of wind conditions beyond the maximum operating wind speed, a lift will not commence if analysis of weather data for the expected duration of the lift indicates the potential for wind conditions in excess of the maximum operating wind speed. Further, should there be an unexpected detrimental change in weather while the OLS is loaded, the lift will be completed and the OLS will be placed in its optimum safe configuration or the load will be grounded and the crane will be placed in a safe configuration.

Based on the above discussion, the conditions that could result in credible crane failure modes or load drops (i.e., operator errors, use of improper rigging or inappropriate slings, and crane component failures) have been minimized or eliminated through the training of rigging personnel, use of engineer developed procedures for the load lifts, performance of engineering evaluations of the OLS and rigging components, and inspection and testing of the OLS. In addition, an OLS failure or load drop due to a tornado or seismic event has been eliminated. The tornado initiated OLS failure or load drop will be eliminated through implementation of procedures to preclude load handling when high winds or severe weather/tornado conditions are anticipated. The seismic induced crane failure or load drop has been eliminated by showing that the OLS will not collapse or drop a load while loaded or unloaded during the SSE. Given the training, procedures, evaluations, inspections, and testing involved in use of the OLS, it is highly unlikely that the OLS will fail or drop a load. However, as required by NUREG-0612, load drops from the OLS have been postulated and the potential consequences of these postulated drops evaluated as detailed in Sections 7 and 8.

5.2 Mobile Cranes

Mobile (lattice boom and/or truck) cranes will be used in the assembly/disassembly of the OLS. These cranes will be used when Unit 1 and 2 in are in any operating mode or when Unit 1 is defueled. The lattice boom and truck cranes are commercially designed, ruggedly constructed, cranes with a main boom. The crane with its main boom is stabilized using a counterweight system. The design of the lattice boom and truck cranes meets ASME/ANSI Standard B30.5-2000 design requirements and their rated capacity considers applicable loadings. The lattice boom and truck cranes have been load tested during their production and will have a current certification.

Use of the mobile cranes for OLS assembly/disassembly is limited to an area within 60 ft. of the OLS boom location shown on Figure 5-2. Mobile crane usage beyond 60 ft. from the OLS boom location may be allowed if Engineering evaluation shows no adverse impact to nearby safety-related SSCs. Restrictions on the use of these cranes will also be imposed to specify the weather conditions under which they may be operated and how and when to secure the mobile cranes in case of inclement weather. These restrictions are designed to preclude adverse interactions with safety-related SSCs. Protection (see Figure 5-2) for safety-related SSCs is provided, as necessary, to ensure that Unit 1 and Unit 2 can be safely shut down and/or maintained in a safe condition in the unlikely event of a load drop during use of these cranes for assembly/disassembly of the OLS.

Personnel involved in operating the mobile cranes will receive the following instruction:

- Operators will receive Sequoyah site-specific training as specified in Reference 9.
- Personnel will undergo hands on training with the equipment before a load is attached to the equipment.
- Prior to lifts over safety-related SSCs, detailed pre-lift meetings will be conducted.
- Direction to the operators will be given by technical representatives of the equipment owner, as required.

The mobile cranes will not be operated in high winds or weather conducive to tornadoes and will be relocated away from safety-related SSCs under these conditions. The mobile cranes are not designed to withstand seismic events.

Based on the above discussion, it is highly unlikely that a load will be dropped from a mobile crane. However, as required by NUREG-0612, load drops from a mobile crane has been postulated and the potential consequences of a postulated drop evaluated as described in Sections 7 and 8. None of these consequences lead to the need to invoke the one-time Operating License change or impose the ERCW compensatory measures during lifts by the mobile cranes.

5.3 Outside Lift System Components

The OLS will arrive at the Sequoyah site in standard containers. These containers will be moved to the OLS assembly/disassembly area (see Figure 5-2) on tractor-trailers. The OLS will be assembled/disassembled in accordance with Reference 7 while both units are in Modes 1-6 or defueled. As described in Reference 7, the heaviest individual component is the lower counterweight tray at 27.8 tons (55.6 kips). The heaviest assembled component lifted during the erection process is the main mast at 135 tons (270 kips). The largest ballast blocks used are 10.9 tons (21.8 kips).

The crane components will be off-loaded from the tractor-trailers using the lattice boom and truck cranes discussed in Section 5.2, and forklifts. During the offload process, the components will be lifted slightly higher than the trailer bed and lowered to the ground. Offloading locations will be picked to minimize the potential for impacting ERCW piping. When that is not possible, timber mats (as shown on Figure 5-2) will be used to distribute the impact from a load drop such that the ERCW piping will not be affected. None of these consequences lead to the need to invoke the one-time Operating License change or impose the ERCW compensatory measures during lifts by the mobile cranes.

5.4 Old & Replacement Steam Generators

The existing Westinghouse Model 51 OSGs will be removed and new RSGs furnished by CENP-Westinghouse will be installed. The RSGs are form, fit and function replacements of the OSGs and are similar in orientation and overall physical dimensions to the OSGs. The enveloping weight for the steam generator lifts has been determined to be 424.6 tons (849.2 kips). This enveloping weight includes the steam generator, rigging, attached upper lateral restraint, and attached insulation.

Movement of the OSGs/RSGs out of/into Containment will be performed with Unit 1 in the defueled condition and Unit 2 at power. Coordination with Operations is required prior to commencement of SG movement activities.

Once lifted clear of the Containment roof, the OSGs will follow designated load paths over the top of the Containment roof as shown on Figure 5-2. Rigging and lifting of the OSGs will be performed by trained personnel, will be strictly controlled and conducted in accordance with approved procedures, and will be restricted to the load paths described herein. Once the bottom of the OSG reaches a suitable height above the ground the OLS will rotate and move the OSG to the downending area where footpad attachments will be attached to the lower portion of the OSG. The OSGs will be maneuvered to a downending device designed to receive the footpad attachment and facilitate the downending operation. This downending device allows each OSG to be pivoted and downended directly onto its transport/storage saddles, which will be staged on the transporter. Downending equipment and the downending foundation area have been designed for the applicable loads in accordance with ASME NQA-1, Subpart 2.15. Reference 22 determined that the loads on the downending foundation are less than 150 tons (300 kips) and the soil bearing pressure from the foundation is less than the allowable pressure. Once the OSG has been set on the saddles located on the transporter, the footpad attachments will be removed with the assistance of a construction crane. Each OSG will be handled in an identical manner (but with slightly different load paths over the Containment roof) and the RSGs will be handled in a similar manner, but reverse order. However, the OLS attachments, footpad attachments, and saddles will be different for the RSGs.

5.5 Reactor Shield Building Concrete, Steam Generator Enclosure Concrete, and Containment Vessel Steel

Two holes (approximately 20 ft. by 45 ft.) will be created by cutting through the Shield Building dome and Containment vessel dome to allow removal of the OSGs and installation of the RSGs. Rigging of the Shield Building concrete and Containment vessel steel will occur only during the defueled condition. The OLS will be used to remove/replace the cut concrete and steel sections. The Containment vessel steel sections will weigh no more than 15 tons (30 kips). The Shield Building concrete sections will weigh less than 132.5 tons (265 kips).

The SG compartment roof and the Main Steam whip restraint beams below the roof will be cut and removed as one piece in each of the four compartments. The diameter of the openings is 18 to 20 feet. The cut sections of concrete from the SG compartments weigh less than 65 tons (130 kips). The OLS will be used to remove/replace the cut sections of concrete. Removal/replacement of the cut sections of concrete will take place during the defueled condition.

Movement of the above loads will be performed with Unit 1 in the defueled condition and Unit 2 at power. Coordination with Operations is required prior to commencement of heavy load movement activities.

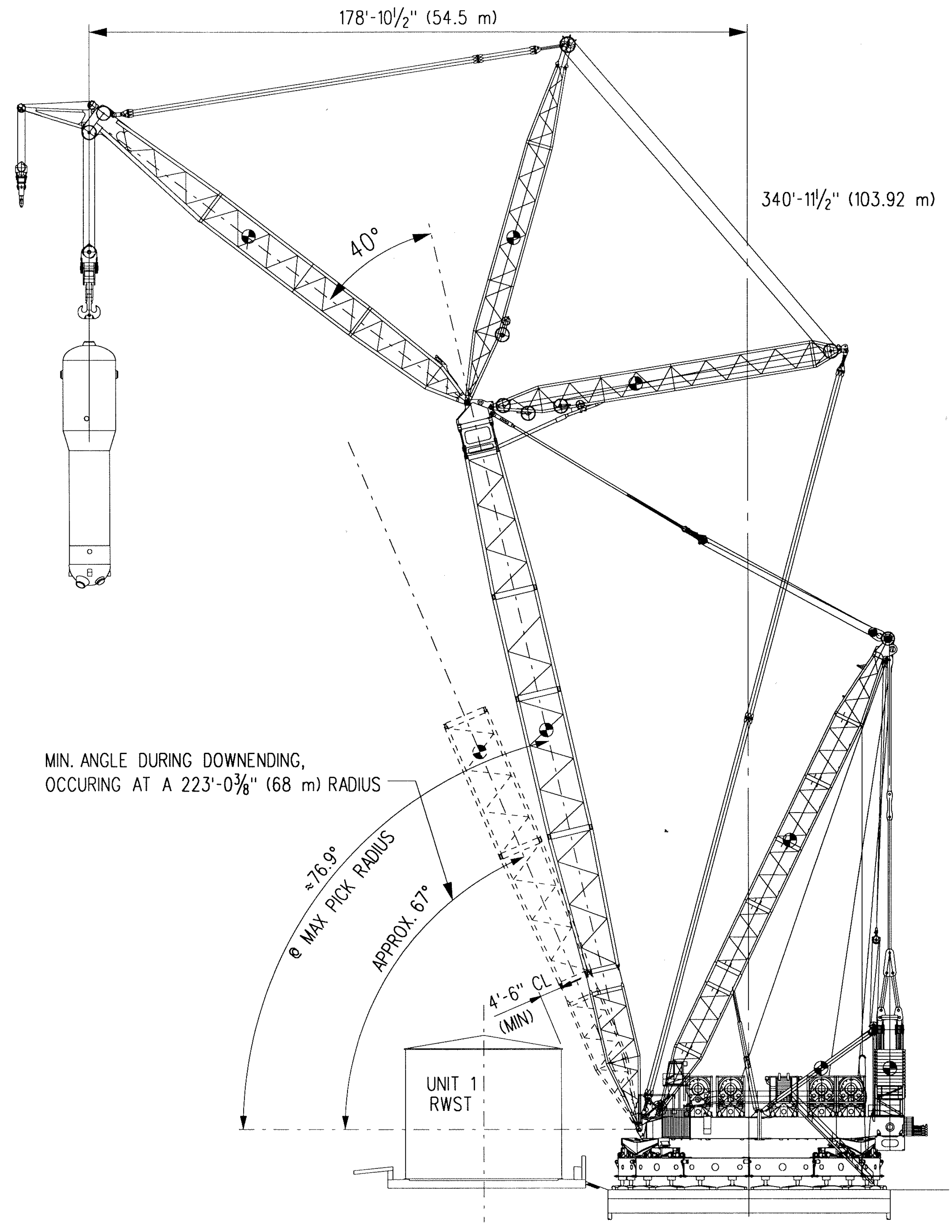

Figure 5-1 – Outside Lift System Elevation

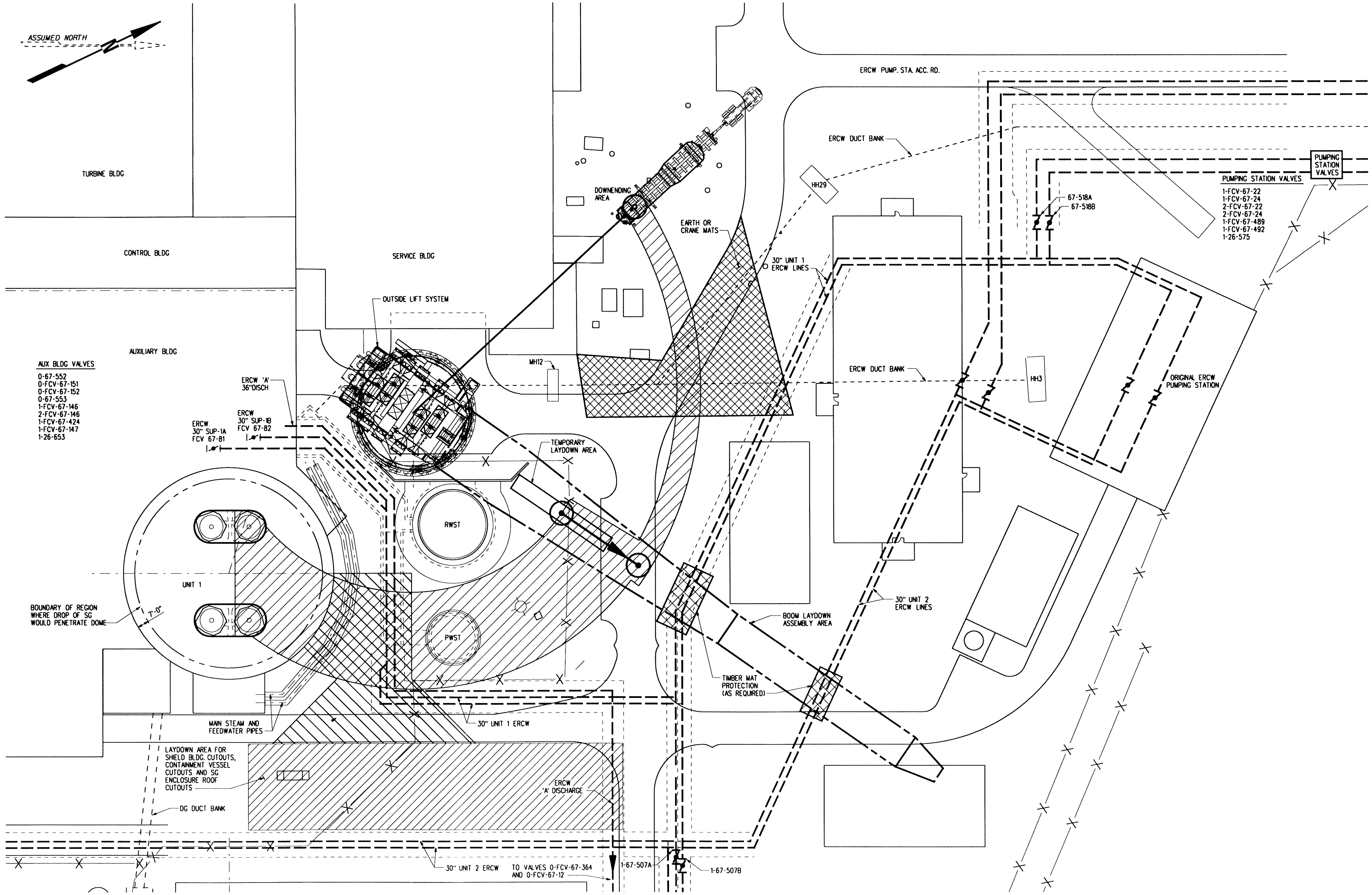

Figure 5-2 – Outside Lift System Location

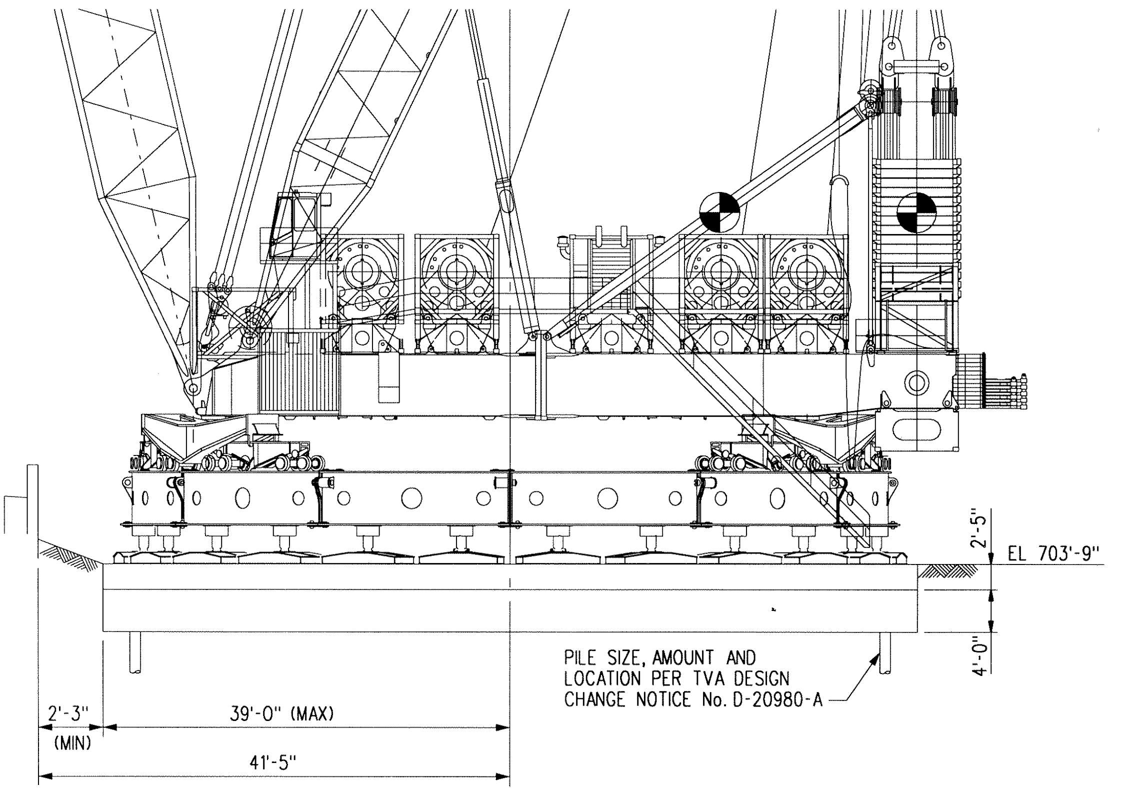

Figure 5-3 – Outside Lift System Base Elevation

6.0 Description of SSCs Potentially Affected by a Postulated Load Drop

To support the Unit 1 SGR, movement of heavy loads in the vicinity of, and over, safety-related equipment required to support operation of both units is required in Modes 1 through 6 and while defueled. The SSCs that are potentially affected from either equipment impact or a heavy load drop impact are identified in this section. The potentially affected design functions and operability requirements of these SSCs are also addressed. As detailed in Sections 7 and 8, the movement of loads in the vicinity of and over these SSCs has been evaluated and found acceptable based on the capability of the SSC to withstand the impact, protection being provided, and/or compensatory measures being implemented.

6.1 Containment

The Sequoyah Unit 1 Containment consists of a free-standing Steel Containment Vessel (SCV) surrounded by a free-standing concrete Shield Building. The SCV and Shield Building are designed to Seismic Category I standards to remain functional during and after a SSE. The design function of the SCV, as indicated in UFSAR Sections 3.8.2.1, 6.1 and 6.2.4, is to provide an essentially leak-tight barrier to the release of fission products to the environment. As described in UFSAR Section 3.8.1.1, the Shield Building is a reinforced concrete structure. The design function of the Shield Building is to protect the SCV from external events and to act as the principal structure that limits doses from radioactivity inside the Containment. These design functions are not required while the reactor is defueled.

Unit 1 Technical Specifications (TSs) 3/4.6.1.1, 3/4.6.1.6, and 3/4.6.1.7 specify the integrity requirements for the SCV and Shield Building during Modes 1-4. The bases for TSs 3/4.6.1.1, 3/4.6.1.6, and 3/4.6.1.7 indicate that the safety design basis for Primary Containment is that the Containment must withstand the pressures and temperatures of the limiting design basis accident without exceeding design leakage rates.

Unit 1 TS 3/4.6.2.2 requires that two independent trains of lower Containment vent coolers be operable with two coolers in each train in Modes 1-4. The bases for TS 3/4.6.2.2 indicate that the operability of the lower Containment vent coolers ensures that adequate heat removal capacity is available to provide long-term cooling following a non-LOCA event.

Unit 1 TS 3/4.6.3 requires that each Containment isolation valve be operable in Modes 1-4. The bases for TS 3/4.6.3 indicate that operability of the Containment isolation valves ensures that the Containment atmosphere will be isolated from the outside environment in the event of a release of radioactive material to the Containment or pressurization of the Containment.

Unit 1 TS 3/4.9.4 defines the required status of Containment Building penetrations during movement of irradiated fuel within the Containment. The bases of TS 3/4.9.4 indicate that the requirements on Containment Building penetration closure and operability ensure that a release of radioactive material within Containment will be restricted from leakage to the environment.

6.2 Auxiliary Building

The Auxiliary Building will not be directly impacted by the evaluated load drops. However, a potential effect from the postulated load drops is flooding of the Auxiliary Building through the ERCW tunnel. The impact of potential flooding on the Auxiliary Building is addressed in Section 7.1. Measures that mitigate this flooding are detailed in Section 8.

As described in UFSAR Section 3.8.4.1.1, the Auxiliary Building is a part of the Auxiliary Control Building. It is a multi-story reinforced concrete structure that provides housing for Unit 1 and 2 Engineered Safety Features equipment. The Spent Fuel Pit and Fuel Transfer Canal are also housed in the Auxiliary Building. The Auxiliary Building is designed to Seismic Category I standards and will remain functional during and after a SSE. The exterior concrete walls above grade are designed to resist the design basis tornado missiles. Since the Auxiliary Building is shared between Unit 1 and Unit 2, these design bases are required whenever either unit is in Modes 1-4 or fuel is stored in the Spent Fuel Pool.

6.3 Essential Raw Cooling Water System

As described in UFSAR Section 9.2.2.2, the ERCW system consists of eight pumps, four water traveling screens, four screen wash pumps, and four strainers located within the ERCW pumping station, and associated piping and valves. The safety-related portion of the ERCW system is designed to Seismic Category I standards and will remain functional following the SSE. Water is supplied to the Auxiliary Building from the ERCW pumping station through four independent sectionalized supply headers designated as 1A, 1B, 2A, and 2B. Four ERCW pumps are assigned to train A and four are assigned 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. This allows one supply header to be out of service (e.g., for strainer maintenance), subject to the Ultimate Heat Sink limitations of TS 3/4.7.5. Section 9.2.2 of the UFSAR indicates that the ERCW system design function is to supply cooling water to various heat loads in both the primary and secondary portions of each unit. A simplified flow diagram of the ERCW system is provided as Figure 6-1. Figure 6-1 also depicts the impact locations of the postulated load drop of an SG based on the load path indicated on Figure 5-2. Note that three ERCW lines run in parallel under the load path resulting in three impact locations on Figure 6-1.

The ERCW system piping is arranged in four headers (1A, 1B, 2A, and 2B) each serving certain components in each unit as follows:

1. Each header supplies ERCW to one of the two Containment Spray heat exchangers associated with each unit.
2. The primary cooling source for each of the Diesel Generator heat exchangers is from the Unit 1 headers. Each diesel also has an alternate supply from the Unit 2 headers of the opposite train.
3. The normal cooling water supply to Component Cooling System (CCS) heat exchangers 1A1 and 1A2, 2A1 and 2A2, and 0B1 and 0B2, is from ERCW headers 2A, 2A, and 2B, respectively.
4. Each A and B supply header in each unit header provides a backup source of Feedwater for the turbine-driven Auxiliary Feed Pumps in the respective unit.

5. Each of the two discharge headers provides a backup source of Feedwater for the motor-driven Auxiliary Feedwater Pumps in each unit.
6. Headers 1A and 1B provide ERCW cooling water to the Control Room and Control Building electrical board room air-condition systems.
7. Each A and B header in each unit supplies ERCW cooling water to the Auxiliary Building ventilation coolers for safeguard equipment, the Containment ventilation system coolers, the Reactor Coolant Pump (RCP) motor coolers, the control rod drive vent coolers, and the Containment instrument room cooler's water chillers in the respective unit.
8. Headers 1A and 1B provide a normal and backup source of cooling water for the Station Air Compressors.
9. Headers 1A and 2B provide ERCW cooling water for the Shutdown Board room air-conditioners and Auxiliary Control Air Compressors.
10. Headers 2A and 2B provide ERCW cooling water for the Emergency Gas Treatment room coolers and boric acid transfer and Unit 2 Auxiliary Feedwater Pump space coolers.
11. Headers 1A and 1B provide ERCW cooling water for the CCS pumps and Unit 1 Auxiliary Feedwater Pump space coolers.
12. Under flood conditions, each header would provide water to the Spent Fuel Pit heat exchangers, Reactor Coolant Pump thermal barriers, ice machine refrigeration condensers, and sample heat exchangers, and the Residual Heat Removal heat exchangers as needed.

The headers are arranged and fitted with isolation valves such that a rupture in a header can be isolated and will not jeopardize the safety functions of the other headers. The layout of ERCW piping and key isolation valves relative to the heavy load paths is provided on Figure 5-2. The operation of two pumps on one plant train is sufficient to supply cooling water requirements for the 2-unit plant for unit cooldown, refueling, or post-accident operation. However, additional pumps may be started, if available, for unit cooldown or refueling. Two pumps per train operate during the hypothetical, combined accident and loss of normal power if each Diesel Generator is in operation. In an accident the Safety Injection signal automatically starts two pumps on each train, thus providing full redundancy. This arrangement assures adequate cooling water under both normal and emergency conditions.

TS 3/4.7.4 (both units have the same TS requirements) requires that at least two independent ERCW loops be operable in Modes 1-4. The bases of TS 3/4.7.4 indicate that the operability of the ERCW system ensures that sufficient cooling capacity is available for continued operation of safety-related equipment during normal and accident conditions. The Unit 1 systems that require ERCW are not required to be operable while the reactor is defueled.

6.4 Refueling Water Storage Tank

As discussed in UFSAR Section 3.8.4.1.4, the Refueling Water Storage Tank (RWST) is a Seismic Category I structure, but is not tornado missile protected. Pipes from the RWST to the Auxiliary Building are housed in reinforced concrete tunnels. A storage basin is provided around the RWST to retain a quantity of borated water in the event the RWST is ruptured by a tornado missile or other initiating event.

The design function of the RWST, as indicated in UFSAR Sections 5.5.7.2.2, 6.3.2.2 and 6.3.3.12, is to provide borated water for (1) filling the Refueling Canal during refueling and (2) the Safety Injection, Residual Heat Removal, and Containment Spray pumps during the Emergency Core Cooling System (ECCS) function. These design functions are not required while the Reactor is defueled.

UFSAR Table 6.3.2-3 provides the minimum storage volume for the accumulators and RWST. As indicated in UFSAR Section 6.3.2.6, this minimum storage volume is sufficient to ensure that after a RCS break, sufficient water is injected and is available within the Containment to permit recirculation flow to the core, and to meet the net positive suction head requirements of the RHR pumps.

Unit 1 TS 3/4.5.5 requires the RWST to be operable in Modes 1-4. The bases for TS 3/4.5.5 indicate that the operability of the RWST as part of the ECCS ensures that a sufficient supply of borated water is available for injection by the ECCS in the event of a LOCA.

6.5 Primary Water Storage Tank

As indicated in UFSAR Section 12.1.2, the Primary Water Storage Tank (PWST) is one of the outside tanks used to store low-level radioactive liquids. It is a non-seismic, non-tornado missile protected, non-safety related tank. Section 11.2.3 of the UFSAR indicates that the PWST has a high level alarm and an overflow line that discharges to the ERCW pipe tunnel.

6.6 Main Steam Lines

UFSAR Section 10.3 describes the Main Steam supply system. The system is designed to conduct steam from the Steam Generator outlets to the High Pressure Turbine, the Condenser Steam Dump system, and to other components. Downstream of the Main Steam Isolation Valves (MSIVs), the steam lines follow the outside perimeter of the Shield Building until they enter the Turbine Building.

As described in UFSAR Section 10.3.2.1, the MSIVs and Main Steam Bypass Isolation Valves are provided to protect the plant following a break in the steam header downstream of the MSIVs. UFSAR Section 3.5.5 states that tornado missile protection is not required for the portion of the Main Steam piping downstream of the MSIVs.

Unit 1 TS 3/4.7.1.5 requires that four MSIVs be operable in Modes 1-3. The bases for TS 3/4.7.1.5 indicate that the operability of the MSIVs ensures that no more than one Steam Generator will blowdown in the event of a steam line rupture.

6.7 Feedwater Lines

As described in UFSAR Section 10.4.7.1, the Condensate Feedwater system is designed to supply a sufficient quantity of feedwater to the Steam Generator secondary side inlet during normal operating conditions and to guarantee that feedwater will not be delivered to the Steam Generators when feedwater isolation is required. The portion of the system from the Steam Generators back through the check valve and isolation valve is designed as TVA Class B.

Unit 1 TS 3/4.7.1.6 requires that four Main Feedwater Isolation Valves (MFIVs), four Main Feedwater Regulating Valves (MFRVs), and four MFRV Bypass Valves be operable in Modes 1-3. The bases for TS 3/4.7.1.6 indicate that isolation of the Main Feedwater system is provided when required to mitigate the consequences of a steam line break, feedwater line break, excessive feedwater flow, and loss of normal feedwater (and station blackout) accident.

6.8 Fire Protection System Piping

Section 12.1 of Part II of the Sequoyah Fire Protection Report (FPR) indicates that the High Pressure Fire Protection (HPFP) system water supply is common to both units and consists of one electric motor driven fire pump and one diesel engine driven fire pump. Each pump takes suction from its own 300,000 gallon potable water storage tank which is supplied by the local municipal utility. Each pump is connected to the HPFP system looped yard main by a separate supply line that can be isolated.

A fire protection water distribution system is provided to serve both units and is cross-tied between the units. Sectional isolation valves are provided so that maintenance may be performed on portions of the loop while maintaining fire fighting capability. The sectional isolation valves in the underground loop are locked or sealed in position and surveillance is performed to ensure proper system alignment.

The HPFP system is also connected to the two fire/flood mode pumps (old fire pumps) which can be utilized by opening the normally closed valves which isolate them from the system. These pumps are not required for the HPFP system to fulfill its design bases.

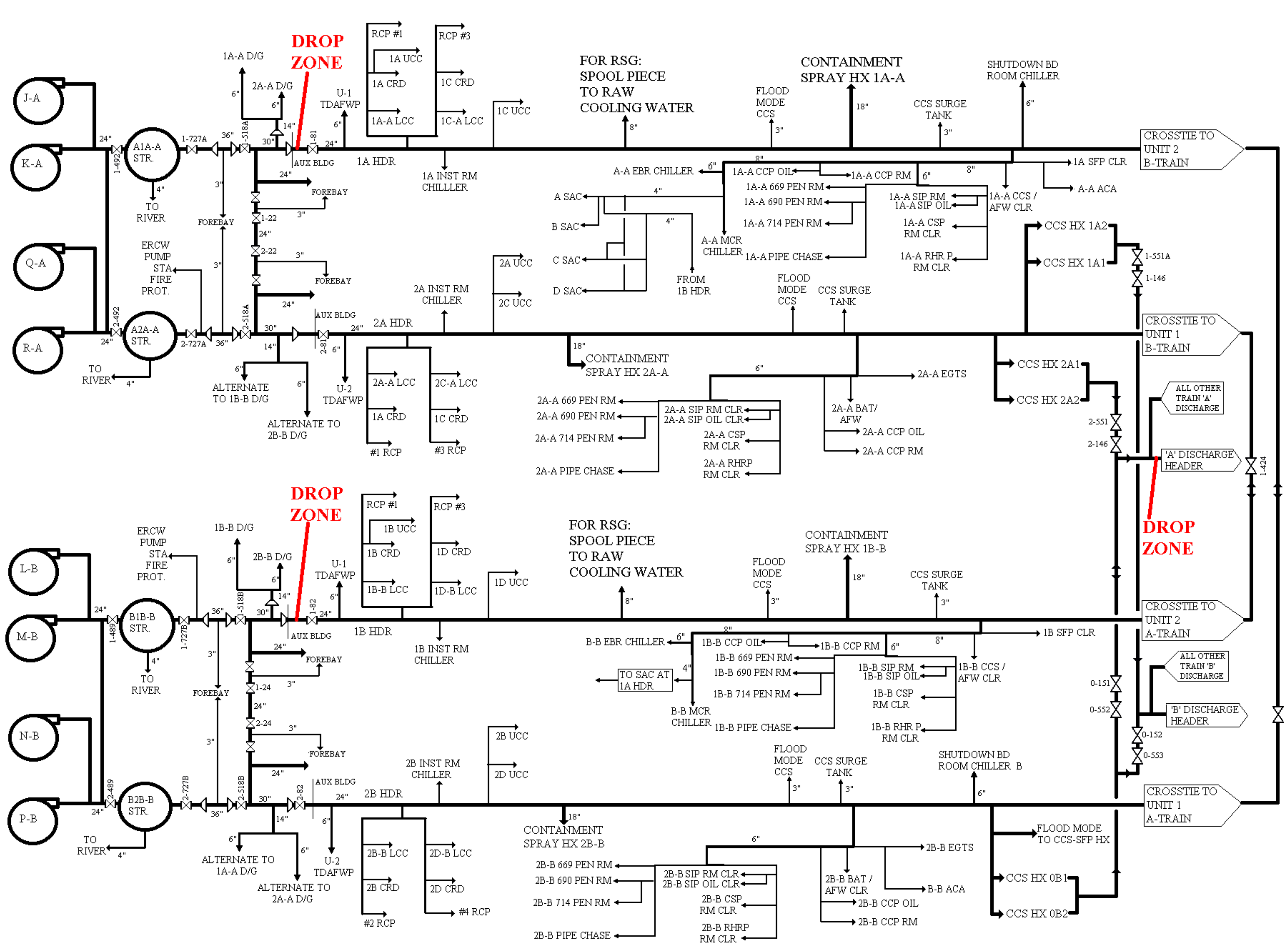

Figure 6-1 – Simplified ERCW Flow Diagram

7.0 Postulated Load Drops

Details of the design of the cranes being used (including their seismic capability), inspections and load testing performed on these cranes, restrictions on operation of the cranes, operator training, and procedural controls have been provided in the previous sections. Given these considerations, it is highly unlikely that a load will be dropped from these cranes. However, as required by NUREG-0612, load drops from each of these cranes have been postulated and the potential consequences of these postulated drops evaluated.

Rigging of the heavy loads described in Section 5 will be performed within the load paths defined on Figure 5-2. In the event of a non-mechanistic failure of a crane or rigging equipment resulting in a load handling accident, the load is assumed to impact within the evaluated load path.

As detailed in Section 5, the heaviest loads being handled are the Steam Generators. Other significant loads include Shield Building concrete sections, Containment Vessel steel sections, Steam Generator Compartment roof concrete sections, and OLS components during assembly/disassembly.

7.1 Steam Generator Load Drops

<u>SG Drop Above Containment</u>

Two SG load drop situations above the Containment have been considered; those within a radial distance from the center of Containment of about 60 ft. (remote from Containment Building ~131 ft. diameter cylindrical shell wall) and those between this region and the parapet (near the cylindrical shell wall). Since the Unit 1 Reactor will be defueled while the SGs are being moved, the primary concern with a SG drop is the SG trajectory following impact with the Shield Building dome and its subsequent impact location.

SG Drop Above Containment – Away From Shield Building Wall

The SG drop trajectory following vertical impact from an arbitrary height onto the dome is difficult to predict. Since the lift height of the SG is only limited by the capability of the OLS, a substantial clearance between the SG and the Shield Building dome will be maintained by lifting the SGs vertically through the Containment openings until a defined minimum clearance is attained. The SGs will then be translated horizontally to the outer edge of the Containment as shown on Figure 5-2. Applying an energy balance methodology to a rigid-plastic shell model, it was analytically determined (Reference 26) that a SG drop from a height of 12.75 ft. or greater will perforate the concrete Containment shield wall and SCV. A drop from this height ensures complete penetration of the SG through the dome and into the Containment Building, as opposed to a response characterized by impact with and deflection off the Containment dome. A minimum clearance from the Shield Building dome of 20 ft. will be used when lifting the SGs. This 20 ft. clearance is within the lifting limit of the OLS. Some substantial conservatisms support the conclusion that perforation and entry will occur. These conservatisms are: 1) neglect of energies associated with local deformations, 2) consideration of the "laminar" concrete dome as a contiguous or single layer, 3) neglect of the weakening effect of the openings, and 4) use of a lift height (20 ft.) that is 50% higher than that calculated for perforating the dome.

SG Drop Above Containment – Near Shield Building Wall

As the SGs near the edge of the Containment, it no longer becomes possible to analytically show that the SG penetrates the Containment dome. At this point, a dropped SG is assumed to tumble over the edge of the Containment and impact the ground somewhere near the Shield Building wall along the load path. It may also impact the side of the Shield Building as it falls. Since it is difficult to predict exactly where the SG will impact, SSCs within and near the load path were assumed to be affected. The potentially affected SSCs in the vicinity of this postulated drop location are the Unit 1 Shield Building, ERCW tunnel and pipes, RWST, PWST, MS piping, FW piping, and Fire Protection System piping.

SG Drop Along Shield Building Wall

The SGs will be lowered/raised by the OLS near the Shield Building wall above the load path shown on Figure 5-2. A SG drop in this area is assumed to impact directly below where the SG is being lowered/raised. Since the impact area is bounded by the area assumed for the postulated SG drop above the Containment near the Shield Building wall, the consequences of the drop along the Shield Building wall are also bounded.

SG Drop Between Lowering/Raising Area and Downending/Upending Area

A SG drop along the load path between the lowering/raising area and the downending/upending area is assumed to impact SSCs within the flopover distance (approximately 70 ft. from the impact point on the load path) of the SG. In addition to those SSCs potentially affected by the SG drop above Containment near the Shield Building wall, this postulated drop could also affect the two ERCW ductbanks shown on Figure 5-2. These ductbanks contain ERCW cables associated with trains A and B of both units.

SG Drop Dose Consequences

Since it is more conservative from a dose standpoint to assume a failure of the OSG outside Containment, Reference 23 determined the radiological consequences of a Steam Generator drop outside Containment along the load path between the Containment and the OSGSF.

The acceptability of the offsite dose consequences associated with a postulated drop of an OSG has been evaluated and compared to the consequences of postulated design basis accidents for a gaseous release. For assessing offsite dose consequences, the drop of an OSG is considered to most closely resemble a rupture of a tank containing radioactive material. Failure of the Waste Gas Decay Tank (WGDT) (Reference UFSAR Section 15.3.5) is the limiting event currently evaluated in the UFSAR for accidental gaseous release from a tank. As indicated in UFSAR Section 15.5.2, the gamma, beta, and thyroid doses at the EAB from a WGDT failure are 2.5 Rem, 5.8 Rem, and 5.9×10^{-2} Rem, respectively. The gamma, beta, and thyroid doses at the LPZ are 0.29 Rem, 0.68 Rem, and 6.9×10^{-3} Rem, respectively.

Reference 23 conservatively assumed that 10% of the Steam Generator activity is released due to the impact of the drop and 1% of this release amount is in the form of particulates small enough to become airborne. Confirmatory NRC analyses of the early

SGRs also used this percentage of activity release. Based on an isotopic survey of the CVCS, the prime contributors to the offsite dose due to a SG drop were determined to be Ni-63, Co-60, Cs-134 and Cs-137. Using these conservative assumptions, the maximum calculated Control Room dose is 3.76×10^{-2} Rem whole body. The offsite doses from a postulated drop at the limiting location along the haul route are 4.86×10^{-2} Rem whole body (correlates to the WGDT gamma dose) and 3.02×10^{-4} Rem to the skin (correlates to the WGDT beta dose) at the EAB and 4.63×10^{-3} Rem whole body (correlates to the WGDT gamma dose) and 1.3×10^{-3} Rem to the skin (correlates to the WGDT beta dose) at the LPZ. A thyroid dose was not calculated since the SG dose is primarily due to activated corrosion products and contains no iodine.

UFSAR Section 15.5.2 presents the radiological consequences of a WGDT rupture in the context of 10CFR100. However, in NRC Standard Review Plan (SRP) Section 11.3, the WGDT radiological consequences are limited per the guidance of Branch Technical Position (BTP) ETSB 11-5. BTP ETSB 11-5 establishes an offsite dose limit of 0.5 Rem whole body which at the time of issuance was consistent with 10CFR20 limits. The Technical Specifications acknowledge this regulatory criterion by placing an activity limit on the WGDTs (Reference Technical Specification 3/4.11.2.6 and the associated bases) to ensure the whole body exposure of 0.5 Rem to an individual in an unrestricted area is not exceeded. This limit on dose is greater than the calculated dose for an OSG drop. The evaluated consequences of an OSG drop are within the applicable regulatory criteria of BTP ETSB 11-5 and are much less than the limiting licensing design basis accidents currently evaluated in Chapter 15 of the UFSAR.

Auxiliary Building Flooding

As indicated above, a postulated OLS load drop could affect the ERCW tunnel and pipes, RWST, PWST, and Fire Protection System piping. The failure of any of these tanks and pipes could result in flooding of the Auxiliary Building via the ERCW pipe tunnel. UFSAR Section 9.3.3.7 states that the Auxiliary Building has a passive sump that collects water from annulus drain sumps, and blowout panels located in the floors of the pipe chases and the Containment Spray and RHR pump rooms. Per UFSAR Section 6.3.2.11, the passive sump has a capacity of 209,000 gallons and a water level sensor in the passive sump alarms in the Main Control Room. Compensatory measures to preclude flooding of safety-related equipment in the Auxiliary Building following a postulated heavy load drop are described in Section 8.

7.2 Shield Building Concrete Section Load Drops

As indicated in Section 5.5, the Shield Building concrete sections will be approximately 20 ft. by 45 ft. and will weigh less than 132.5 tons (265 kips). These sections will follow the load paths shown on Figure 5-2. Unlike the SGs, they will only be raised a maximum of three feet above the Containment dome. This lift height and the inherent shape of the concrete sections will eliminate the potential for them to rebound from the Containment in an unanticipated direction. Given that the size and mass of these concrete sections are bounded by the SGs, the consequences of a Shield Building concrete section load drop are bounded by the SG drops described in Section 7.1.

7.3 Containment Vessel Steel Section Load Drops

As indicated in Section 5.5, the Containment Vessel steel sections will be approximately 20 ft. by 45 ft. and weigh no more than 15 tons (30 kips). These sections will follow the load paths shown on Figure 5-2. Unlike the SGs, they will only be raised a maximum of three feet above the Containment dome. This lift height and the inherent shape of the SCV sections will eliminate the potential for them to rebound from the Containment in an unanticipated direction. Given that the size and mass of these steel sections are bounded by the SGs, the consequences of a Containment Vessel steel section load drop are bounded by the SG drops described in Section 7.1.

7.4 Steam Generator Compartment Roof Plug Load Drops

As indicated in Section 5.5, the Steam Generator Compartment roof concrete sections will be 18-20 ft. in diameter and will weigh less than 65 tons (130 kips). These sections will follow the load paths shown on Figure 5-2. Unlike the SGs, they will only be raised a maximum of three feet above the Containment dome. This lift height and the inherent shape of the concrete sections will eliminate the potential for them to rebound from the Containment in an unanticipated direction. Given that the size and mass of these concrete sections are bounded by the SGs, the consequences of a Steam Generator Compartment roof plug concrete section load drop are bounded by the SG drops described in Section 7.1.

7.5 Outside Lift System Component Load Drops

As indicated in Section 5.3, the OLS components vary in size and weight. These components will be handled in the OLS assembly/disassembly area shown on Figure 5-2. The crane components will be off-loaded from the tractor-trailers using lattice boom and/or truck cranes and forklifts. During the offload process, the components will be lifted slightly higher than the trailer bed and lowered to the ground. Offloading locations used will minimize the potential for impacting the RWST and ERCW piping. When it is not possible to eliminate a potential impact with the ERCW piping, timber mats (as shown on Figure 5-2) will be used to distribute the impact from a load drop. The consequences of OLS component load drops have been evaluated to be acceptable based on provision of this protection.

8.0 Heavy Load Drop Protection Plans/Compensatory Measures

Section 4 details the regulatory requirements/criteria that are relevant to the handling of heavy loads over safety-related equipment and summarizes conformance with these requirements/criteria. As discussed in Section 4.2, Section 5.1.5 of NUREG-0612 indicates that the effects of load drops should be analyzed (in accordance with the guidelines of Appendix A to NUREG-0612) and the results should indicate that damage to safe shutdown equipment is not sufficient to preclude safe shutdown.

Each of the potentially affected SSCs identified in Section 6 has been analyzed in accordance with the NUREG-0612 guidance to determine the effects of a load drop. Summarized below is the protection required to preclude an adverse effect and/or the actions or compensatory measures required to mitigate these effects should a load drop occur. Provision of the identified protection and taking the specified actions and compensatory measures assures that safe shutdown can be achieved following a load drop. In addition, it will be confirmed that the assumptions made within this Topical Report regarding the status of the station are valid prior to load handling activities.

8.1 Containment

The heavy loads of concern that will be handled above the Containment will only be moved while the Unit 1 reactor is defueled. With fuel removed from the Containment, the only other safety issue is whether a load drop into the Unit 1 Containment will affect systems common to both units that pass through the Unit 1 Containment. To preclude a SG drop inside the Unit 1 Containment from affecting Unit 2, the ERCW system and Component Cooling System (CCS) shall either be isolated or be capable of being isolated with valves located outside of Containment. In addition, the Spent Fuel Pool (SFP) shall be isolated from the Unit 1 containment.

8.2 Auxiliary Building

Heavy loads will not be handled over the Auxiliary Building and, as discussed in Sections 7.1, 7.2, 7.3, and 7.4, will not roll off the Containment roof onto the Auxiliary Building. Therefore, no additional protection of the Auxiliary Building roof is required.

To preclude flooding of the Auxiliary Building due to a heavy load drop a wall (see Figure 8-1) will be installed in the ERCW tunnel near the Auxiliary Building interface. A door will be provided as part of the wall to allow access to the tunnel, if required. The wall has been designed for the hydrostatic head generated if the tunnel was completely filled with water and an impact load associated with the rushing water just after a pipe break. Installation of this wall will be completed prior to movement of heavy loads that could cause a failure of the piping and tanks that penetrate the ERCW pipe tunnel.

8.3 Essential Raw Cooling Water System

<u>Unit 1 ERCW Supply Piping and Train A Discharge Piping</u>

As noted in Section 6.3, Section 9.2.2 of the UFSAR indicates that the ERCW system design function is to supply cooling water to various heat loads in both the primary and secondary portions of each unit. The Unit 1 ERCW supply piping between the ERCW pumps and the various heat exchangers, as well as the Train A discharge piping from the various heat exchangers returning to the Ultimate Heat Sink, located near the Unit 1 Containment might fail (i.e., crimp or rupture, or both) as a result of the postulated load drops detailed in Sections 7.1, 7.2, 7.3, and 7.4.

Following pipe damage from a postulated heavy load drop from the OLS, all of the ERCW loads that are direct Unit 2 safe shutdown components will continue to receive their design flow rates without the need for any actions. Certain components that receive flow from the 1A and 1B ERCW supply headers are indirect Unit 2 safe shutdown components, and may not receive their design flow rates. The following listing is the indirect Unit 2 safe shutdown components that might not receive their design flow rates following a postulated heavy load drop:

- Emergency Diesel Generators
- Train A auxiliary air compressor
- Main control room chillers
- Electrical board room chillers
- Component cooling system pump space coolers
- Train A 6.9 kV shutdown board room chiller

- Cooling to auxiliary building gas treatment system

All of the components in the above listing can have their function restored.

- Diesel Generators - The Diesel Generator cooling function may be restored by opening the alternate supply valves. These valves supply cooling water to the Diesel Generators from the opposite train, i.e., the Train A Diesel Generators receive their alternate supply from the B train ERCW.

- All of the remaining components can have their function restored by closing the valve downstream of the pipe damage area, and opening the valves that intertie the A and B ERCW supply headers in the Auxiliary Building. The required action consists of closing one valve and opening one valve. These valves are motor operated valves that can be operated remotely or locally. Alternatively, one train of these components can be restored by connection of a spool piece to allow the non-safety related Raw Cooling Water system to supply one of the ERCW supply headers.

An analysis has been performed that demonstrates that all Unit 2 safe shutdown components receive their design flow assuming no isolation of the failed 1A and 1B ERCW supply headers from the upstream side, and with total flow blockage of the 'A' ERCW return header, including the use of the alternate supply lines detailed above.

Mitigation of this assumed ERCW piping failure following a postulated heavy load drop from the OLS requires that compensatory measures be implemented to ensure that certain prerequisite actions are performed in order to support the analysis assumptions. These actions, as well as the actions required to restore equipment functionality, will be proceduralized prior to use of the OLS for load handling. Personnel will be trained to implement the compensatory measures.

Due to the potential to adversely affect both trains of ERCW, an operability issue has been identified that requires an amendment to the Unit 2 Operating License. A one-time condition for conduct of heavy load lifts associated with the Unit 1 steam generator replacement has been requested based on performance of heavy load lifts in accordance with NRC Bulletin 96-02 and adherence to the compensatory measures contained in this topical report.

<u>Unit 2 ERCW Supply Piping</u>

The Unit 2 30" ERCW pipes running parallel to the west side of the Solar Building and east of the Unit 1 Containment (see Figure 5-2) do not directly lie on the load path and are located approximately 128 ft. from the load path. They were evaluated in Reference 24 for the effects of impact energy due to a postulated drop of the SG at a distance away and transmitted to it by wave propagation through the soil. The worse case postulated impact location was determined to be located at least 63 ft. away from the nearest Unit 2 ERCW pipe. The peak particle velocity (PPV) of the shock wave at the ERCW piping from a load drop was determined using the scaled-distance wave propagation equation proposed by Wiss in Reference 14. The computed PPV was then used to estimate the free field soil pressure on the buried piping, which was then used to evaluate the adequacy of the ERCW pipe as a flexible pipe. Reference 24 concluded that the Unit 2 ERCW piping will not fail and will remain functional under the impact effects of the postulated SG drop at a distance away from the piping.

<u>ERCW Ductbanks</u>

As noted in Section 7.1, the load path for the SGs crosses over two buried ERCW ductbanks (one between manhole MH12 and handhole HH3 and the other between manhole MH12 and handhole HH29). The ductbanks contain cables associated with ERCW trains A and B for both units. Therefore, it is vital that a SG drop does not affect the functioning of these cables. These ductbanks have been evaluated in Reference 24 for impact loading from a direct vertical drop of the SG as well as from the subsequent flopover fall of the SG. In order to minimize the impact energy from a vertical drop of the SG, the bottom of the SGs will be carried at an elevation not to exceed 3 ft. above grade while traversing the load path at and near these ductbanks. The impact energy from the flopover fall was determined to be more critical than from a direct vertical drop of 3 ft.

In evaluating the ductbanks, the depth of penetration of the dropped SG into the soil and the resulting contact-pressure time history were estimated considering the bearing resistance of the soil stratum overlaying the ductbank using Meyerhoff's Bearing Capacity equations (Reference 25). Suitable attenuation of the surface pressures were considered based on Boussinesq's equation (Reference 25). The ductbanks were analyzed dynamically as beams on elastic foundation subjected to the attenuated pressure time-history. The ductbank loading and boundary conditions are appropriately specified. The total response of the ductbank was calculated using modal superposition in terms of deflection, shear and bending moment based on which the adequacy of the ductbank is assessed.

The evaluation in Reference 24 concluded that the ERCW ductbanks will remain adequate in the event of an SG drop if sufficient soil cover is available over the ductbanks. Therefore, as shown on Figure 5-2, additional earth fill and/or crane mat protection will be provided in the potentially affected areas above the ductbanks where the grade elevation is lower so as to bring the grade to a sufficient height to protect the ductbanks.

8.4 Refueling Water Storage Tank

As noted in Section 6.4, the RWST is a Seismic Category I structure, but is not tornado missile protected. Pipes from the RWST to the Auxiliary Building are housed in reinforced concrete tunnels. A storage basin is provided around the tank to retain a quantity of borated water in the event the tank is ruptured by a tornado missile or other initiating event.

As shown on Figure 5-2, no heavy loads will be carried over the RWST by the OLS. Since a potential load drop from the OLS could only occur when Unit 1 is defueled, loss of the RWST function has no safety impact. However, a failure of the RWST piping in the pipe tunnel between the RWST and the Auxiliary Building could result in flooding in the Auxiliary Building. The passive sump in the Auxiliary Building has been sized to account for flooding from the RWST, but not concurrent with an ERCW piping failure in the pipe tunnel. To minimize the potential for flooding of the Auxiliary Building due to a failure of the RWST, PWST, and/or ERCW piping inside the pipe tunnel, a wall will be installed near the pipe tunnel opening into the Auxiliary Building. This wall will be installed prior to movement of loads with the OLS and will be capable of withstanding the hydrostatic and velocity head of water from the postulated piping failures and loads created by the nearby drop of a steam generator. It will also meet Sequoyah Seismic I

(L) requirements, so that an earthquake would not cause a failure of nearby safety-related SSCs as a result of a seismically-induced failure of the wall.

The mobile cranes used for assembly/disassembly of the OLS will be positioned such that a load drop will not impact the RWST. Since the mobile cranes will be used while Unit 1 is in Modes 1-6, the positioning of these cranes away from the RWST assures that the RWST function will be available, if required.

8.5 Primary Water Storage Tank

As noted in Section 6.5 and shown on Figure 5-2, heavy loads will be carried over the PWST by the OLS. Since a potential load drop from the OLS could only occur when Unit 1 is defueled, loss of the PWST function has no safety impact. However, a failure of the PWST piping in the pipe tunnel between the PWST and the Auxiliary Building could result in flooding in the Auxiliary Building. To minimize the potential for flooding of the Auxiliary Building due to a failure of the RWST, PWST, and/or ERCW piping inside the pipe tunnel, a wall will be installed near the pipe tunnel opening into the Auxiliary Building. This wall will be installed prior to movement of loads with the OLS and will be capable of withstanding the hydrostatic and velocity head of water from the postulated piping failures and loads created by the nearby drop of a steam generator. It will also meet Sequoyah Seismic I (L) requirements, so that an earthquake would not cause a failure of nearby safety-related SSCs as a result of a seismically-induced failure of the wall.

8.6 Main Steam Piping

As noted in Section 6.6, the MS piping outside the Shield Building is a potentially affected SSC for the postulated load drops described in Section 7. Since a heavy load drop induced failure of the MS piping will be isolated by closure of the MSIVs, no protective measures are required.

8.7 Feedwater Piping

As noted in Section 6.7, the FW piping outside the Shield Building is a potentially affected SSC for the postulated load drops described in Section 7. Since a heavy load drop induced failure of the FW piping will be isolated by closure of the FW isolation valves, no protective measures are required.

8.8 Fire Protection System Piping

As noted in Section 6.8, the high-pressure fire pump and flood mode pump piping in the pipe tunnel is a potentially affected SSC for the postulated load drops described in Section 7. To minimize the impact of a rupture of this piping on flooding of the pipe tunnel, valves 1-26-575 and 1-26-653 will be closed prior to movement of heavy loads with the OLS. Closure of these valves minimizes the actions that need to be taken to isolate a break. Closing these valves will not affect plant operation.

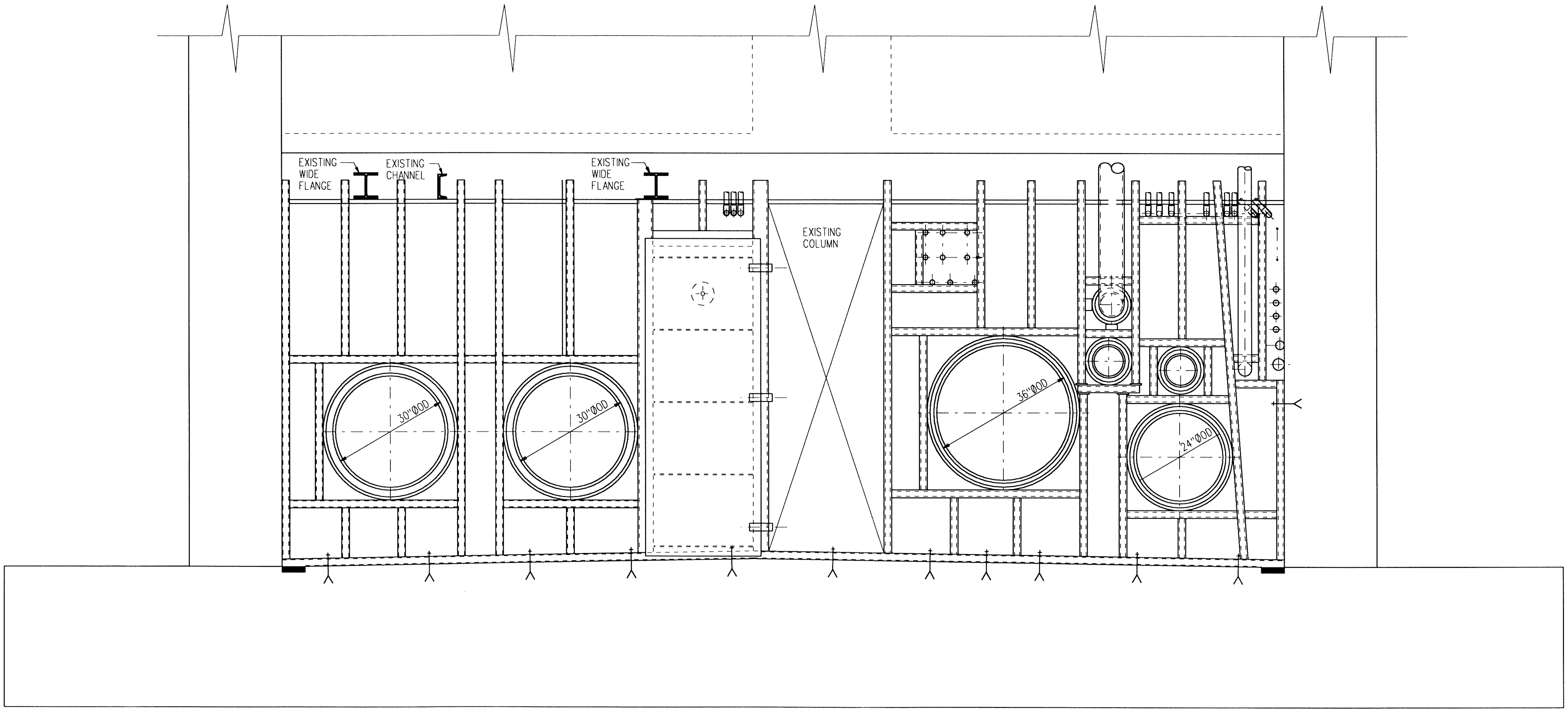

Figure 8-1 – ERCW Tunnel Wall

9.0 Summary and Conclusions

The Steam Generator Replacement at Sequoyah Unit 1 will involve the handling of heavy loads that are larger and must travel along load paths different from those evaluated during the original licensing of the plant. Paralleling the guidelines of NUREG-0612, a safe load path has been selected which generally moves the loads away from the plant and away from sensitive SSCs supporting the continued safe operation of the station. In a few cases, handling over equipment supporting safe shutdown could not be avoided. Therefore, the continued safety of the plant will be assured by:

- Equipment selection,
- Equipment evaluation for certain external events,
- Operator training, and
- Procedural controls, including lift heights, load paths, and limitations related to weather conditions.

Due to the potential to adversely affect both trains of ERCW, an operability issue has been identified that requires an amendment to the Unit 2 Operating License. A one-time condition for conduct of heavy load lifts associated with the Unit 1 steam generator replacement has been requested.

Based upon these considerations and the relatively short periods of time that loads will be suspended over safe shutdown equipment, the risk associated with the drop of a heavy load as discussed in this Topical Report is considered to be small. However, as further protection from the postulated load drop: 1) protection will be provided from secondary flooding effects that could occur as a result of the postulated load drop, and 2) compensatory measures that will be implemented in the event of a load drop have been developed and will be proceduralized for use during the SGRO. These measures provide assurance that the operating unit can be safely shut down in the event of a heavy load drop. Further, as concluded in Appendix B, these compensatory measures and proposed Operating License change do not involve a significant hazards consideration.

10.0 References

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8. Maintenance Instruction 0-MI-MXX-000-026.0, "Control of Heavy Loads in Critical Lifting Zones, NUREG-0612, C.1", Rev. 8.
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22. Calculation 24370-C-039, “Foundation for Upending/Downending Device”, Revision 0.
23. Calculation 24370-M-002, “Old Steam Generator Drop Dose Analysis”, Revision 0.
24. Calculation 24370-C-025, “Evaluation of Safety-Related Buried Commodities in the Vicinity of Heavy Lift Load Path for Postulated Load Drop from OLS”, Revision 1.
25. Bowles, J.E., Foundation Analysis and Design, Fourth Edition, McGraw Hill, Inc., 1988.
26. Calculation 24370-C-022, “Evaluation of SG Drop on Containment Shell”, Revision 0.
27. Calculation CSG-87-018, “5% Damped Free Field Top of Soil Response Spectra, SQN Units 1 & 2”, Revision 0.

Appendix A
NRC Commitments

There are a number of actions required to support the conclusions of Topical Report 24370-TR-C-002. The below listed actions ensure prerequisite actions to heavy load movement, active monitoring during heavy load movement, and protective actions in response to the unlikely event of a heavy load drop are in place. These actions are NRC commitments as listed below:

Prerequisite Actions to Heavy Load Movement

1. Install temporary pressure and flow gauges in selected locations of the Unit 1 ERCW piping.

2. Install a wall in the Unit 1 pipe tunnel to seal the tunnel from the Auxiliary Building. Develop criteria to quantify the amount of water behind the temporary pipe tunnel wall.

3. Realign the ERCW system to minimize operator actions in the event of a heavy load drop.

4. Isolate the high-pressure fire pump and the flood mode pump piping in the pipe tunnel to the Auxiliary Building.

5. Isolate systems shared with Unit 2 or verify that they are capable of being isolated following a load drop, prior to handling a load over the Containment with the outside lift system.

6. Ensure that measures are in place to suitably handle any leakage through the temporary Unit 1 pipe tunnel wall.

Active Monitoring Actions During Heavy Load Movement

1. Monitor weather conditions, for the expected duration of the lift, to ensure conditions are acceptable for outside lift system operation.

2. Monitor outside lift system operation to ensure a minimum clearance of 20 feet exists between the Shield Building dome and the bottom of the steam generator when a steam generator is being moved over the Shield Building.

Actions in Response to the Unlikely Event of a Heavy Load Drop

1. Develop and issue plant procedure(s) to delineate specific actions required in case of a heavy load drop.

Appendix B
No Significant Hazards Consideration Determination

I. DESCRIPTION OF THE PROPOSED CHANGE

The four steam generators of the Sequoyah Nuclear Plant Unit 1 will be replaced during the spring of 2003. To support the replacement of the old steam generators (OSGs) with the replacement steam generators (RSGs), several heavy loads will be moved over safety-related plant structures, systems, and components (SSCs). While many of these SSCs could be called upon to perform a safety function during the subject lifts, only the ERCW system is a safety-related system that is common to both units. During the Unit 1 Steam Generator Replacement Outage (SGRO), the ERCW system will be supporting continuous operation and safe-shutdown capability for Unit 2.

Mitigation of the assumed ERCW piping failures following a postulated heavy load drop requires that compensatory measures be implemented to isolate the affected ERCW piping and restore ERCW flow to required equipment, as necessary. Due to the potential to adversely affect both trains of ERCW as a result of a postulated load drop, an operability issue has been identified that requires an amendment to the Unit 2 Operating License. A one-time condition for conduct of heavy load lifts associated with the Unit 1 steam generator replacement has been requested based on performance of heavy load lifts in accordance with NRC Bulletin 96-02 and adherence to the compensatory measures contained in Topical Report 24370-TR-C-002.

II. REASON FOR THE PROPOSED CHANGE

As defined in NRC Bulletin 96-02, licensees planning to perform activities involving the handling of heavy loads over safety-related equipment while the reactor is at power and involving a potential load drop accident that has not previously been addressed in the FSAR should submit a license amendment request to the NRC. Following recent revisions to 10CFR50.59, the Bulletin's guidance was supplemented by NRC Regulatory Issue Summary 2001-03, which states, "The fact that the load is larger or is moving in a different load path than previously evaluated would enter into the risk assessment required by 10CFR50.65(a)(4) and determine under what plant conditions the load lift should occur." The Sequoyah issues of interest are, perhaps, unique with respect to that guidance, in that during the Unit 1 SGRO, Unit 1-related maintenance/heavy load activities must be considered in light of their potential to influence the operation of Unit 2.

TVA Topical Report 24370-TR-C-002 documents the provisions made to ensure that heavy load handling activities associated with the Unit 1 SGRO can be accomplished without impacting the safe operation of Unit 2. These provisions support the risk assessment required by 10CFR50.65(a)(4) and an application for a one-time Unit 2 license amendment associated with the operability of the ERCW System.

III. SAFETY ANALYSIS

The Outside Lift System (OLS) that will be used to move the OSGs and RSGs during the Sequoyah Unit 1 SGRO (i.e., Mammoet PTC Heavy Lift Crane) is a commercial design. The OLS was not specifically designed to withstand the external events addressed by 10CFR50, Appendix A, General Design Criterion (GDC) 2 that are a part of the Sequoyah design and licensing basis. However, due to the size of the OLS and because of the OLS location and proximity to the Containment, Auxiliary Building, Essential Raw Cooling Water (ERCW) piping, Refueling Water Storage Tank (RWST), Main Steam (MS) piping, and Feedwater (FW) piping, the OLS was evaluated for those external events that might cause it to collapse when these SSCs are required to be operable.

The OLS meets or exceeds ASME NQA-1 Subpart 2.15 design requirements, and its load charts and operating restrictions consider applicable dead, live, wind, impact, and out-of-plumb lift loads. The OLS, supplied with standard load charts for its various boom configurations, has a rated load capacity certified by the manufacturer and has been load tested during its production; this meets the load test requirements of ASME NQA-1, 1997 Edition, Subpart 2.15, Section 601.2. In addition, after the OLS has been erected, it will be load tested by lifting a 275 ton (550 kip) test load assembly with the OLS boomed out to a radius where the test load represents 110% of the OLS rated capacity at this radius.

The OLS attachments and rigging meet the requirements of ASME NQA-1-1997, Subpart 2.15 and the applicable ASME B30 series standards. The attachments and rigging used to attach the OLS to the SGs have been previously load tested in accordance ASME NQA-1, Subpart 2.15 or have a previous load history that exceeds the loads to be lifted. Rigging will be inspected prior to use in accordance with approved procedures and rigging operations will be controlled and conducted by highly trained and qualified personnel in accordance with approved procedures.

Personnel involved in operating the OLS will receive the following instruction:

- Operators will receive the applicable Sequoyah site-specific training specified in Appendix C of MMDP-2, “Safe Practices for Overhead Handling Equipment” (Reference 9).
- Personnel will undergo hands on training with the equipment before a load is attached to the equipment.
- Prior to a lift, detailed pre-lift meetings will be conducted.
- Direction to the operators during each OLS lift will be given by technical representatives of the equipment owner and the SGR contractor’s rigging specialist.

During the lifting operation, the exact location of boom tip and load block will be monitored by two independent methods. Instrumentation internal to the crane provides continuous readout of crane and boom orientation and the location of the boom tip and load block. In addition, the boom tip will be continuously monitored from a remote survey station independent from the crane instrumentation. This survey station will have the necessary data input to monitor and calculate the boom tip location relative to the interfacing structures and components. The individual directing the rigging operations will be in constant communication with both the crane operator and the surveyor manning the remote survey station. These controls will be utilized to ensure that the exact location of the load is known and compliance with design requirements are maintained.

Assembly and disassembly of the OLS will be performed in accordance with the crane manufacturer’s procedures and drawings and may be performed with Unit 1 and Unit 2 in Modes 1-6 or defueled. The assembly/disassembly process will require the use of mobile cranes and other equipment. During assembly and disassembly of the OLS, the main boom will lay in an area to the north of the Unit 1 Containment. The orientation of the main boom during assembly/disassembly, along with restrictions on mobile crane usage and SSC protection provisions, ensure that Unit 1 and Unit 2 can be safely shut down and/or maintained in a safe condition in the unlikely event of a load drop during assembly/disassembly of the OLS.

The OLS has been evaluated for seismic loads while unloaded and loaded with a steam generator (SG). A SG is the heaviest load that will be handled by the OLS. This seismic evaluation determined that the OLS would not collapse or result in a drop of the load during a seismic design basis Safe Shutdown Earthquake (SSE) event for the lift configurations to be used during the Sequoyah Unit 1 SGR. Therefore, use of the crane for the Sequoyah Unit 1 SGR will not result in Seismic II/I interaction issues on the SSCs located in the vicinity of the OLS.

To further demonstrate the capability of the OLS, it was determined that a whip-lash effect resulting from a postulated drop of a load from the OLS will not cause instability of the boom masts in the reverse direction, i.e. the masts will not flip over backwards and impact SSCs (e.g., Auxiliary Building, Control Building, etc.) behind the OLS.

Rigging operations will not be performed when wind speeds exceed the maximum operating wind speed for the OLS. If wind speeds increase during a rigging operation such that the wind speed may exceed the maximum operating speed, rigging operations will be suspended and the unloaded OLS will be secured by implementing administrative controls specified by the manufacturer. These administrative controls define the allowable mainmast and jib angles, and the slew drive and load block configurations, and are dependent on the wind speed.

To eliminate the effects of wind conditions beyond the maximum operating wind speed, a lift will not commence if analysis of weather data for the expected duration of the lift indicates the potential for wind conditions in excess of the maximum operating wind speed. Further, should there be an unexpected detrimental change in weather while the OLS is loaded, the lift will be completed and the OLS will be placed in its optimum safe configuration or the load will be grounded and the crane will be placed in a safe configuration.

The acceptability of the offsite dose consequences associated with a postulated drop of an OSG has been evaluated and compared to the consequences of postulated design basis accidents for a gaseous release. The evaluated consequences of an OSG drop are within the applicable regulatory requirements and are much less than the limiting licensing design basis accidents currently evaluated in Chapter 15 of the UFSAR.

Section 5.1.5 of NUREG-0612 indicates that the effects of load drops should be analyzed (in accordance with the guidelines of Appendix A to NUREG-0612) and the results should indicate that damage to safe shutdown equipment is not sufficient to preclude safe shutdown. Each of the potentially affected SSCs has been analyzed in accordance with the NUREG-0612 guidance to determine the effects of a load drop. Summarized below is the protection required to preclude an adverse effect and/or the actions or compensatory measures required to mitigate these effects should a load drop occur. Provision of the identified protection and implementation of the specified actions and compensatory measures assures that safe shutdown can be achieved following a load drop.

- Containment

The heavy loads of concern that will be handled above the Containment will only be moved while the Unit 1 reactor is defueled. With fuel removed from the Containment, the only other safety issue is whether a load drop into the Unit 1 Containment will affect systems common to both units that pass through the Unit 1 Containment. To preclude a SG drop inside the Unit 1 Containment from affecting Unit 2, the ERCW system and Component Cooling System (CCS) shall either be isolated or be capable of being isolated with valves located outside of Containment. In addition, the Spent Fuel Pool (SFP) shall be isolated from the Unit 1 containment.

- Auxiliary Building

Heavy loads will not be handled over the Auxiliary Building and will not roll off the Containment roof onto the Auxiliary Building. Therefore, no additional load drop protection of the Auxiliary Building roof is required.

To preclude flooding of the Auxiliary Building due to a heavy load drop that causes a failure of piping (i.e., ERCW, RWST, PWST, and fire protection piping) in the ERCW pipe tunnel, a wall will be installed in the tunnel near the Auxiliary Building interface. The wall has been designed for 1) the hydrostatic head generated if the tunnel was completely filled with water and 2) an impact load associated with the rushing water just after a pipe break. It will also meet Sequoyah Seismic I (L) requirements, so that an earthquake would not cause a failure of nearby safety-related SSCs as a result of a seismically-induced failure of the wall. Installation of this wall will be completed prior to movement of heavy loads that could cause a failure of the piping and tanks that penetrate the ERCW pipe tunnel.

- Essential Raw Cooling Water System

<u>Unit 1 ERCW Supply Piping and Train A Discharge Piping</u>

Section 9.2.2 of the UFSAR indicates that the ERCW system design function is to supply cooling water to various heat loads in both the primary and secondary portions of each unit. The Unit 1 ERCW system piping near the Unit 1 Containment would likely fail (i.e., crimp or rupture) as a result of the postulated load drops.

The postulated heavy load drop from the OLS might result in the failure of the Unit 1 ERCW trains A and B supply and/or ERCW train A discharge piping for both units. Mitigation of this assumed ERCW piping failure following a postulated heavy load drop requires that compensatory measures be implemented to isolate the affected Unit 1 ERCW piping and restore ERCW flow to required equipment, as necessary. These compensatory measures will be proceduralized prior to use of the OLS for load handling. Personnel will be trained to implement the compensatory measures.

<u>Unit 2 ERCW Supply Piping</u>

The Unit 2 ERCW pipes running parallel to the west side of the Solar Building and east of the Unit 1 Containment do not directly lie on the load path and are located approximately 128 ft. from the load path. They were evaluated for the effects of impact energy due to a postulated drop of the SG at a distance away. This evaluation concluded that the Unit 2 ERCW piping will not fail and will remain functional under the impact effects of the postulated SG drop at a distance away from the piping.

ERCW Ductbanks

The load path for the SGs crosses over two buried ERCW ductbanks. The ductbanks contain cables associated with ERCW trains A and B for both units. Therefore, it is vital that a SG drop does not adversely affect the functioning of these cables. These ductbanks have been evaluated for impact loading from a direct vertical drop of the SG, as well as from the subsequent flopover fall of the SG. To minimize the impact energy from a vertical drop of the SG, the bottom of the SGs will be carried at an elevation not to exceed 3 ft. above grade while traversing the load path at and near these ductbanks.

The impact energy from a flopover fall was determined to be more critical than from a direct vertical drop of 3 ft. The evaluation of a flopover fall of a SG concluded that the ERCW ductbanks will remain functional in the event of a SG drop if sufficient soil cover is available over the ductbanks. Therefore, additional soil fill protection will be provided in the potentially affected areas above the ductbanks where the grade elevation is lower so as to bring the grade to a sufficient height to protect the ductbanks.

- Refueling Water Storage Tank

No heavy loads will be carried over the RWST by the OLS. Since a potential load drop from the OLS could only occur when Unit 1 is defueled, loss of the RWST function has no safety impact.

- Primary Water Storage Tank

Heavy loads may be carried over the PWST by the OLS. Since a potential load drop from the OLS could only occur when Unit 1 is defueled, loss of the PWST function has no safety impact.

- Main Steam Piping

The MS piping outside the Shield Building is a potentially affected SSC for the postulated load drops. Since a heavy load drop-induced failure of the MS piping will be isolated by closure of the MSIVs, no protective measures are required.

- Feedwater Piping

The FW piping outside the Shield Building is a potentially affected SSC for the postulated load drops. Since a heavy load drop-induced failure of the FW piping will be isolated by closure of the FW isolation valves, no protective measures are required.

- Fire Protection System Piping

The high-pressure fire pump and flood mode pump piping in the pipe tunnel is a potentially affected SSC for the postulated load drops. To minimize the impact of a rupture of this piping on flooding of the pipe tunnel, valves will be closed prior to movement of heavy loads with the OLS. Closure of these valves minimizes the actions that need to be taken to isolate a break. Closing these valves will not affect plant operation.

IV. NO SIGNIFICANT HAZARDS CONSIDERATION DETERMINATION

TVA has concluded that operation of SQN Unit 2, in accordance with the proposed one-time change to the Operating License and implementation of compensatory measures following a load drop from the OLS during the Unit 1 steam generator replacement, does not involve a significant hazards consideration. TVA's conclusion is based on its evaluation, in accordance with 10 CFR 50.91(a)(1), of the three standards set forth in 10 CFR 50.92(c).

A. The proposed amendment does not involve a significant increase in the probability or consequences of an accident previously evaluated.

No changes in event classification as discussed in UFSAR Chapter 15 will occur due to the one-time change to the Unit 2 Operating License and implementation of compensatory measures following a load drop from the OLS during the Unit 1 steam generator replacement.

Accidents previously evaluated that are relevant to this determination are related to plant external events and load handling. The probability of an occurrence of a seismic event is determined by regional geologic conditions. Weather related events are determined by regional meteorological conditions.

The consequences of an earthquake have not changed. A seismic evaluation has determined that the OLS would not collapse or result in a drop of the load during a seismic design basis SSE event for the lift configurations to be used during the Sequoyah Unit 1 SGR. Therefore, use of the OLS for the Sequoyah Unit 1 SGR will not result in Seismic II/I interaction issues on the SSCs located in the vicinity of the OLS.

The consequences of a tornado have not changed. A lift will not commence if analysis of weather data for the expected duration of the lift indicates the potential for wind conditions in excess of the maximum operating wind speed. Rigging operations will not be performed when wind speeds exceed the maximum operating wind speed for the OLS. If wind speeds increase during a rigging operation such that the wind speed may exceed the maximum operating speed, rigging operations will be suspended and the unloaded OLS will be secured by implementing administrative controls specified by the manufacturer. Further, should there be an unexpected detrimental change in weather while the OLS is loaded, the lift will be completed and the OLS will be placed in its optimum safe configuration or the load will be grounded and the crane will be placed in a safe configuration.

An OSG drop has been postulated to occur to address the radiological consequences associated with the drop. The event is bounded by an OSG drop outside the containment (versus inside containment), since a steam generator failure outside containment results in more conservative doses. The dose analysis demonstrated that the OSG drop accident consequences remain below applicable regulatory limits and are bounded by similar, previously evaluated accidents at Sequoyah.

Therefore, the proposed one-time change to the Unit 2 Operating License and implementation of compensatory measures following a load drop from the OLS during the Unit 1 steam generator replacement will not significantly increase the probability or consequences of an accident previously evaluated.

B. <u>The proposed amendment does not create the possibility of a new or different kind of accident from any accident previously evaluated.</u>

The possibility of a new or different accident situation occurring as a result of this condition is not created.

Three postulated scenarios related to heavy load handling during the SGRO were examined for their potential to represent a new or different kind of accident from those previously evaluated: 1) a breach of an OSG, resulting in the release of contained radioactive material, 2) flooding in the Auxiliary Building caused by the failure of piping in the ERCW tunnel, and 3) loss of ERCW to support safe shutdown in the operating Unit.

Failure of an OSG that results in a breach of the primary side of the steam generator could potentially result in a release of a contained source outside containment. The consequences of this event, both offsite and in the control room, were examined and were found to be within the consequences of the failure of other contained sources outside containment at the Sequoyah site.

To preclude flooding of the Auxiliary Building due to a heavy load drop, a wall will be installed in the ERCW tunnel near the Auxiliary Building interface. Thus, the postulated flooding of the ERCW tunnel will not result in flooding of the Auxiliary Building beyond those events previously evaluated.

The potential for a heavy load drop to cause loss of ERCW supply to Unit 2 is considered an unlikely accident for the following reasons:

- The lifting equipment was specifically chosen for the subject heavy lifts,
- Operators will be specially trained in the operation of the equipment and in the Sequoyah site conditions,
- Qualifying analyses and administrative controls will be used to protect the lifts from the effects of external events,
- The areas over which a load drop could cause loss of ERCW are a small part of the total travel path of the loads.

However, as additional protection against the potential for loss of ERCW, compensatory measures will be in place during heavy lifts that could cause such a loss to isolate the breaks and redirect flow to essential equipment.

Therefore, the potential for creating a new or unanalyzed condition is not created.

C. <u>The proposed amendment does not involve a significant reduction in a margin of safety.</u>

The OLS load handling activities support the replacement of the Unit 1 steam generators. The proposed one-time change to the Unit 2 Operating License and compensatory measures support Unit 2 operation and safe shutdown following a load drop. They do not result in changes in the design basis for plant SSCs. They do not, therefore, affect the margin of safety for plant SSCs.

Therefore, a significant reduction in the margin to safety is not created by this modification.

V. ENVIRONMENTAL IMPACT CONSIDERATION

The proposed change does not involve a significant hazards consideration, a significant change in the types of or significant increase in the amounts of effluents that may be released offsite, or a significant increase in individual or cumulative occupational radiation exposure. Therefore, the proposed change meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), an environmental assessment of the proposed change is not required.