Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37384-2000

February 4, 2003

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

Gentlemen:

In the Matter of	)	Docket No. 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," ADDITIONAL INFORMATION

Reference: TVA letter to NRC dated January 15, 2002, "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

The purpose of this submittal is to provide additional information in response to NRC question 14 as contained in the reference letter. The additional information provides clarification of TVA's response to question 14 as discussed during a teleconference between TVA, NRC staff, and Bechtel on January 28, 2003.

In addition, this submittal provides information that shows equivalency between the crane described in the subject topical report and the alternate crane that TVA plans to utilize for the Sequoyah Unit 1 steam generator replacement project.

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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 on March 16, 2003.

Enclosure 1 provides the additional information that supports TVA's response to NRC Question 14. Enclosure 2 provides the equivalency information associated with cranes.

This letter is being sent in accordance with NRC Regulatory Issue Summary 2001-05. There are no commitments contained in this submittal.

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

Sincerely,

Pedro Salas
Licensing and Industry Affairs Manager

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 4 day of February, 2003

Enclosures
cc (Enclosures):
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ENCLOSURE 1
TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 1
DOCKET NO. 327
ADDITIONAL INFORMATION FOR NRC QUESTION 14
TOPICAL REPORT NO. 24370-TR-C-002,
RIGGING AND HEAVY LOAD HANDLING"

Note: TVA is providing the following response to NRC Question 14. This response supersedes TVA's response previously provided in TVA letter to NRC dated January 15, 2003.

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 outer 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 seated 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 strength and stability 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 strength and stability 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 (FEM).

Description of the Finite Element Model:

Schematic sketches of the finite element model showing the members, joints and boundary conditions (at the base) are provided as Figures 1 and 2.

The PTC Crane base ring (~21.5 m dia) is supported by 24 jack or ring cylinders with out-rigger plates at its base where it sits on the foundation. The jack cylinders are enclosed in support rings for protection. The outrigger plates ensure proper spreading of the load from the jack cylinders. These outrigger plates are permanently connected to the ring cylinders by means of two 40 mm dia shafts. The ring segments spread the load of the wheels to the jack cylinders by means of shear shafts (locked in place using a bush) and links that couple male and female segments alternately. The outrigger plates, support ring and jack cylinders are connected to the base ring segments.

The base ring and jack stands were not explicitly modeled. The wheel-system on the base ring of the crane is represented by vertical members with pinned ends at the 8 joints (Joints 139 to 146 - see Figures 1 and 2) in the model where the wheel-system is in contact with the base ring. Note that the wheel system is provided with up-stop devices to the under side of the base ring flange plates on which the wheels ride, thereby providing restraint against uplift from the ringer base. The base-ring and outrigger ringer/plate system of the crane is a rigid system. Therefore, the base-ring and outrigger ringer/plate system is represented in the model by rigid horizontal links from the 8 wheel joints to the center of the crane at the level of the base ring and thereon by a rigid vertical link to the foundation (pile cap) (Joint 150 - see Figures 1 and 2).

Soil-structure interaction effects at the foundation have been incorporated by including 6 soil springs at the foundation joint (Joint 150). The spring constants represent the horizontal (kx & kz), vertical (ky), rocking (kmx & kmz) and torsional (kmy) stiffnesses of the soil-pile foundation system. These spring constants were computed using published formulas in soil dynamics literature for circular bases (Reference: p169, Table 7.1 of Wu, T.H., *Soil Dynamics*, Allyn and Bacon Inc, Boston, 1971.). Since the piles are almost vertical (10° batter), the contribution to these spring stiffnesses from the piles were included only for the vertical and rocking springs. It is also noted that the PTC crane for the Sequoyah SGR project will operate with a total ballast (counterweight) of 1300 tonnes located at a radius of 11.83 m from the center of the crane (which is the center of the base ring). This ballast weight was accounted for in the model.

The seismic SSE response spectrum input into the model was derived as explained in the response to Question 34. The model assumes that the crane will remain firmly seated to the foundation in a seismic event without the jacks/outrigger plates sliding or lifting off from the foundation. This assumption was later verified by examining and evaluating the base reactions obtained from the finite element analysis at Joint 150 for sliding and overturning considerations.

Critical Crane Configurations Analyzed:

Three critical OLS load handling configurations (based on lift radius and load) that envelop all the configurations of the OLS for the Sequoyah Unit 1 SGRP were analyzed separately. Each of these three configurations were analyzed both with and without the lift load and the results evaluated for strength and stability. These critical crane configurations are:

Configuration 1

Lift Radius = 23.2 m. This configuration was analyzed for two lift load cases: (a) no lifted load, and (b) Lifted load (L) = maximum weight of a Steam Generator (SG) (Note that this is a hypothetical load case since minimum lift radius for an SG lift is 34 m).

This is the crane configuration where the lift radius is the smallest possible. This is the most vertical orientation the crane can physically be in.

Configuration 2

Lift radius = 55 m. This configuration was analyzed for two lift load cases: (a) no lifted load, and (b) Lifted load (L)= maximum weight of a Steam Generator.

This is the crane configuration where the lift radius is the maximum used when the lifted load is the full weight of a Steam Generator.

Configuration 3

Lift radius = 83.5 m. This configuration was analyzed for two lift load cases: (a) no lifted load and (b) Lifted load (L) = 250 tonne (550 kip) test load that will be used for the load test of the OLS after erection at the Sequoyah site.

This is the crane configuration where the lift radius is the maximum lift radius used for any SGR Project lift with a relatively significant lift load (e.g. partial load of SG during upending/down-ending from/to the transporter, shield building concrete sections, SG compartment roof concrete sections, OLS test load concrete blocks, etc.) other than the full weight of a Steam Generator. The governing load for this condition was the 250 tonne (550 kip test load).

Responses were obtained for dead (D) + lifted loads (L)± E load combinations, where ±E is the seismic SSE load, which could act in either positive or negative sign. For the case where there is no lifted load, L = 0. Based on the structural responses from the finite element analyses for the D+L±E load combination, the OLS was evaluated for strength (stress) and stability under a seismic (SSE) event.

Summary of Results:

(a) Strength: Check for Stresses

The maximum enveloped (for the three critical configurations) stresses in the structural members/connections of the OLS under the D+L±E load combination (where E is the safe shutdown earthquake) were as follows.

- The maximum stress (axial) in the chord of the superstructure lattice frame mast components (main mast, back mast, jib, stay beams) is 54.4 ksi against the yield strength of 101.4 ksi. This stress occurred in the Back Mast chord made of DIN StE 690 material with a yield strength of 700 N/mm^2 (101.4 ksi).

- The maximum stress (axial) in the diagonal bracing of the superstructure lattice frame mast components (main mast, back mast, jib, stay beams) is 26.6 ksi against the yield strength of 66.6 ksi. This stress occurred in the bracing of the Jib made of DIN StE 460 material with a yield strength of 460 N/mm^2 (66.6 ksi).

- The maximum stress (combined axial and bending) in a base component (longitudinal beams, ring segments, cross beams, winch beams) is 79.1 ksi against the yield strength of 101.4 ksi. This stress occurred in the longitudinal beams made of DIN StE 690 material with a yield strength of 700 N/mm^2 (101.4 ksi).

- The maximum stress (bearing) in a connection is 78.1 ksi against the yield strength of 101.4 ksi. This occurred at the eye of the connection between two insert sections of the back mast made of DIN StE 690 material with a yield strength of 700 N/mm^2 (101.4 ksi).

The above results demonstrate that the stress in the structural members/connections of the OLS under the D+L±E combination (where E is the safe shutdown earthquake) is less than the yield stress of the material.

(b) Stability: Check for Overturning and Sliding

Check for Overturning:

The overturning moment (Mo) is the maximum base moment reaction obtained from the analysis for the D+L±E load combinations. Overturning can occur about the edge of the jack cylinders located at a radius R = 21.5 m/2 = 11.75 m from the center of the crane. The resistance moment (Mr) was computed as the minimum vertical reaction obtained at the crane base for the D+L±E load combinations times the radius R.

The worse case overturning and resistance moments and the corresponding factor of safety (FOS = Mr/Mo) obtained for the D+L±E load combination for the three critical configurations analyzed is as below:

Configuration 1

No Load: Mo = 126180 k-ft, Mr = 142586 k-ft, FOS = 1.13.

Configuration 2

No Load: Mo = 92273 k-ft, Mr = 143820 k-ft, FOS = 1.56.
With Load: Mo = 105391 k-ft, Mr = 170046 k-ft, FOS = 1.61.

Configuration 3

With Load: Mo = 138840 k-ft, Mr = 160952 k-ft, FOS = 1.16.

The above results demonstrate that the resistance moment is always greater than the overturning moment for all three configurations. This verifies the assumption made in the model with regard to overturning. It is, thus, concluded that the OLS crane will not overturn during a SSE.

Check for Sliding:

The sliding force (Fs) is the maximum lateral reaction at the base obtained from the analysis for the D+L±E load combinations. Sliding can occur at the interface of the jack stand steel outrigger plates and the top surface of the concrete pile cap. The force resisting sliding (Fr) is provided by the frictional resistance between the steel outrigger plates and the concrete pile cap. The coefficient of friction, μ, between steel and concrete considered in the evaluation is 0.57 (Reference: Rabbat, B.G, and Russel, H.G., Friction Coefficient of Steel on Concrete or Grout, ASCE Journal of Structural Engineering, Volume 111, No. 3, March 1985, pp 505-515). Fr is computed as the minimum vertical reaction obtained at the crane base for the D+L±E load combinations times m.

The worse case sliding force (Fs) and sliding resistance (Fr) and the corresponding factor of safety (FOS = Fr/Fs) obtained for the D+L±E load combination for the three critical configurations analyzed is as below:

Configuration 1

No Load: Fs = 1483 k, Fr = 2306 k-ft, FOS = 1.55.

Configuration 2

No Load: Fs = 1395 k, Fr = 2326 k, FOS = 1.67.
With Load: Fs = 1371 k, Fr = 2750 k, FOS = 2.01.

Configuration 3

No Load: Fs = 1408 k, Fr = 2332 k-ft, FOS = 1.66.

The above results demonstrate that the resistance force is always greater than the sliding force for all three configurations. This verifies the assumption made in the model with regard to sliding. It is thus, concluded that the OLS crane will not slide during a SSE.

The results of the evaluation show that the critical failure mode of the OLS in a seismic event is overturning (tipping).

The maximum lifted load of the generators during the SGRP is approximately 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 a 55 m lift radius is 408 mt. The worse case lifted load is therefore 94.3% of chart capacity. It is noted that this 94.3% chart capacity happens only for one of the Replacement Steam Generators (RSGs). For the other RSGs and the OSGs, the percentage of chart capacity at their maximum lift radii are around 91% or less. Further, the OLS is seated on a firm engineered pile foundation that is adequately designed for the design loads including seismic SSE loads obtained from the finite element analysis, ensuring that there will not be a collapse of the OLS 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.

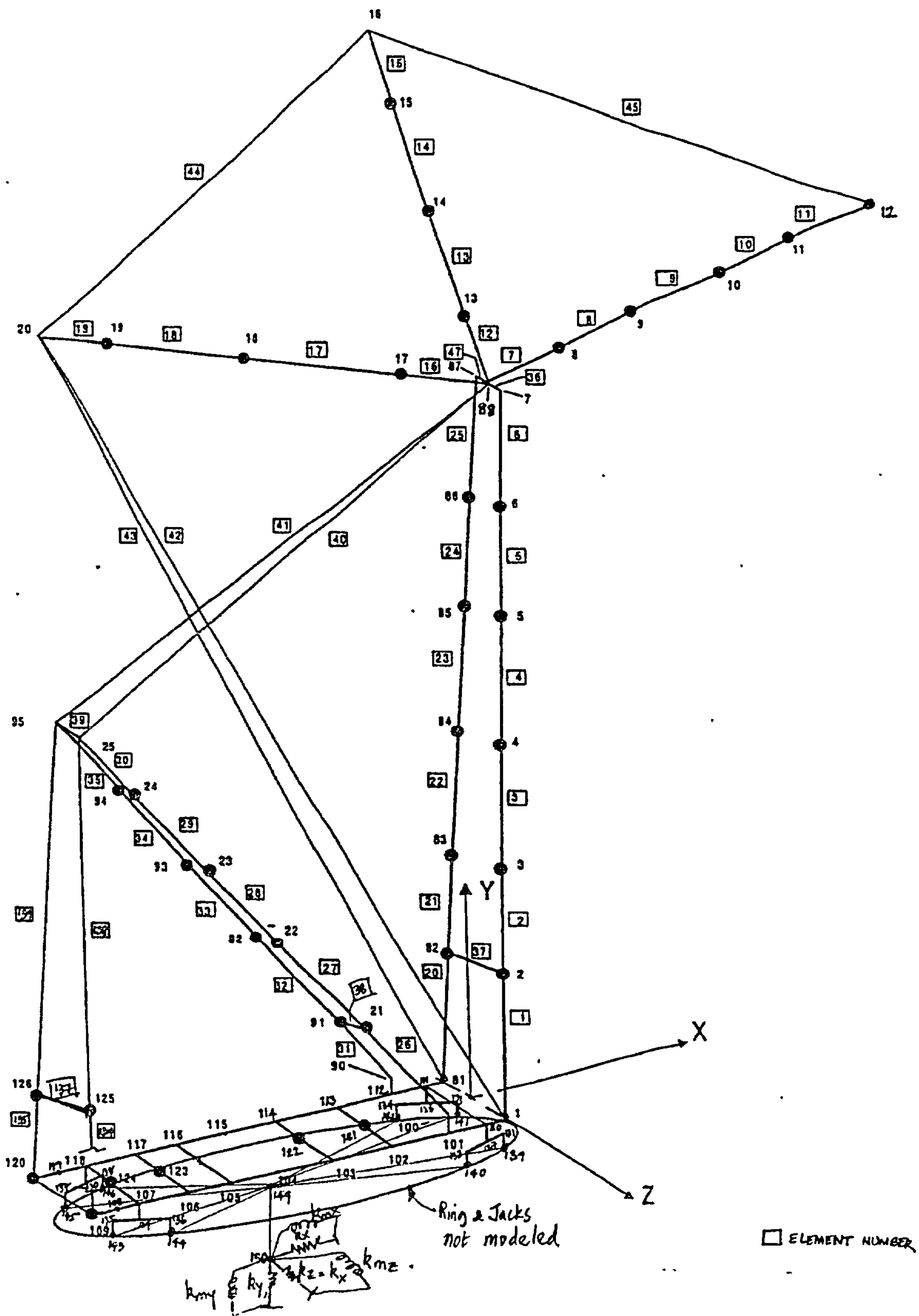

Figure 1 - GT Strudl Model of PTC Crane

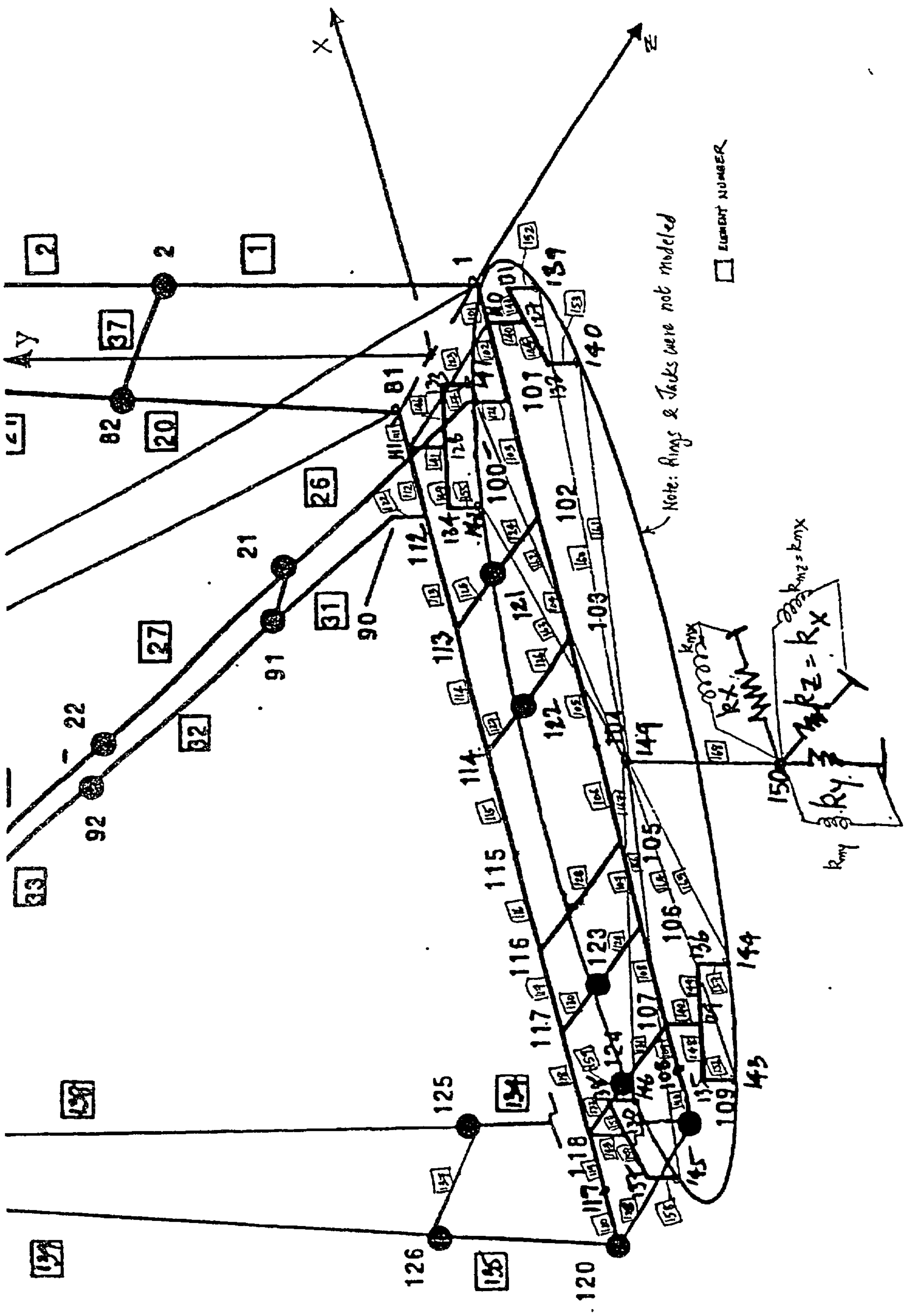

Figure 2 - GT Strudl Model of PTC Crane - Enlargement of Crane Base

ENCLOSURE 2
TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNIT 1
DOCKET NO. 327
COMPARISON OF CRANES

PTC Crane versus PRHD Crane Comparison

General Discussion

Topical Report 24370-TR-C-002, Section 5.1, describes the Outside Lift System (OLS) crane to be used for handling heavy loads during the steam generator replacement at Sequoyah Unit 1. Responses to NRC requests for additional information (RAIs) provided further details of the OLS. The crane to be used as the OLS will be one of two that are owned by the crane supplier. They are the Platform Twin-Ring Containerized (PTC) Heavy Lift Crane (see Figure 1) upon which the Topical Report was based, and the Platform Ring Heavy Duty (PRHD) Crane (see Figure 2). Recent developments in the usage schedule for the PTC may require the use of the PRHD crane instead of the PTC crane. The PRHD crane is a similarly configured crane and is the predecessor to the PTC crane. Therefore, its features are generally the same.

The standout feature of the PTC crane is that it is containerized. This means that it is easily transportable as standard containers of 20 or 40 ft length weighing no more than 35 tons. If used, the PTC crane would arrive in approximately 90 standard container-sized pieces. The PRHD crane is not as easy to transport as the PTC. The PRHD crane would arrive in approximately 140 pieces, not all of which are standard container-sized. The containerized feature of the PTC crane facilitates easy transport without any special requirements and is the most significant difference from the PRHD crane. However, this difference has no impact on the crane's ability to perform heavy load handling operations for the Sequoyah Unit 1 Steam Generator Replacement Project.

To evaluate and document the acceptability of the PRHD crane, a comparison of PTC crane attributes (detailed in Topical Report 24370-TR-C-002 and RAI responses) to the corresponding PRHD crane attributes is provided in the following table. Elevation views of the PTC and PHRD cranes are also provided as Figures 1 and 2, respectively. Two comparison bases are used to demonstrate similarity of the cranes: (1) direct comparison of the physical attributes; and (2) evaluation of the PRHD dynamic response characteristics under SSE for one of the critical configurations. Based on the comparison of the two cranes, it is shown that the conclusions of Topical Report 24370-TR-C-002 remain unchanged in that the attributes of the PRHD crane meet or exceed those of the PTC crane.

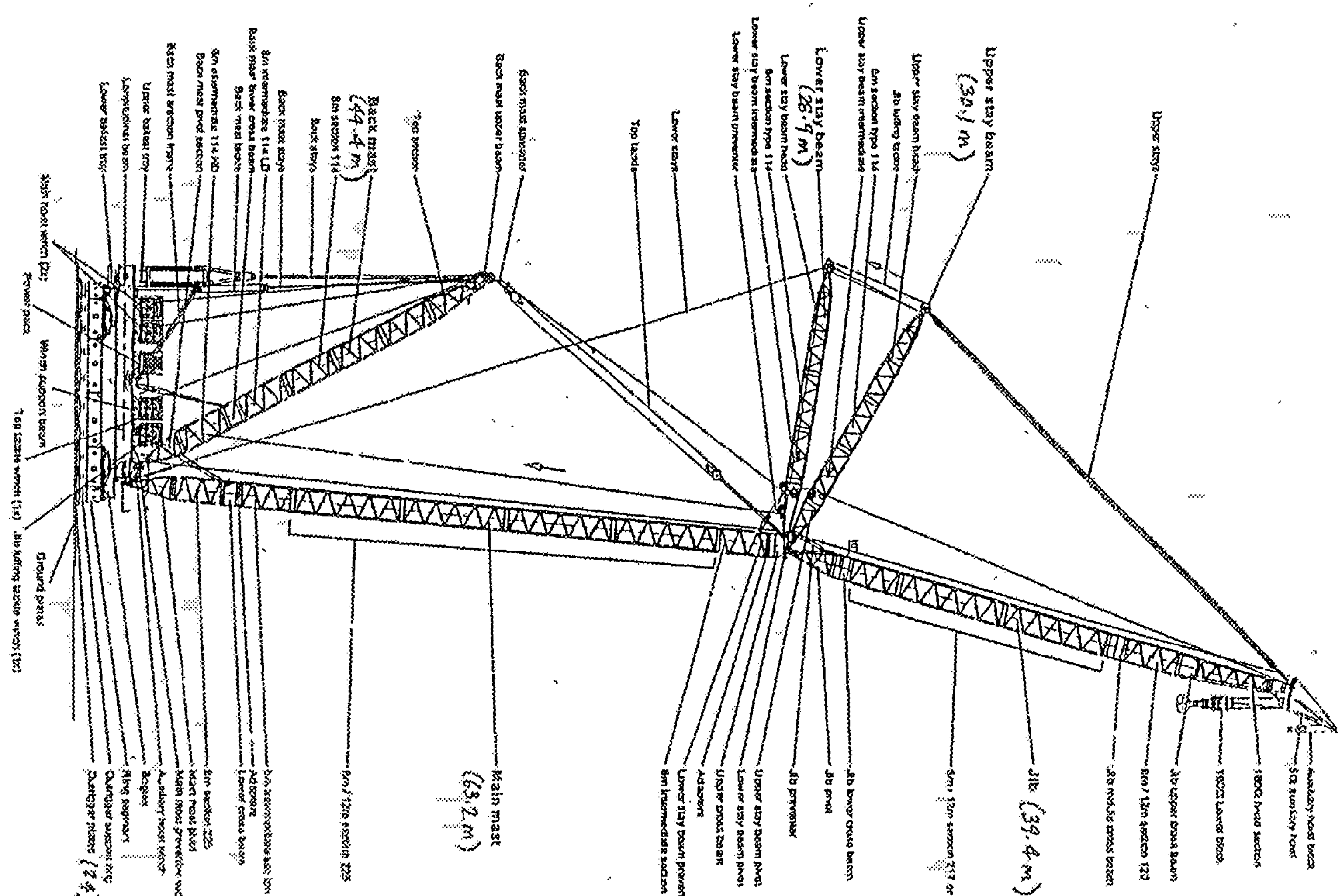

Figure 1 – PTC Crane

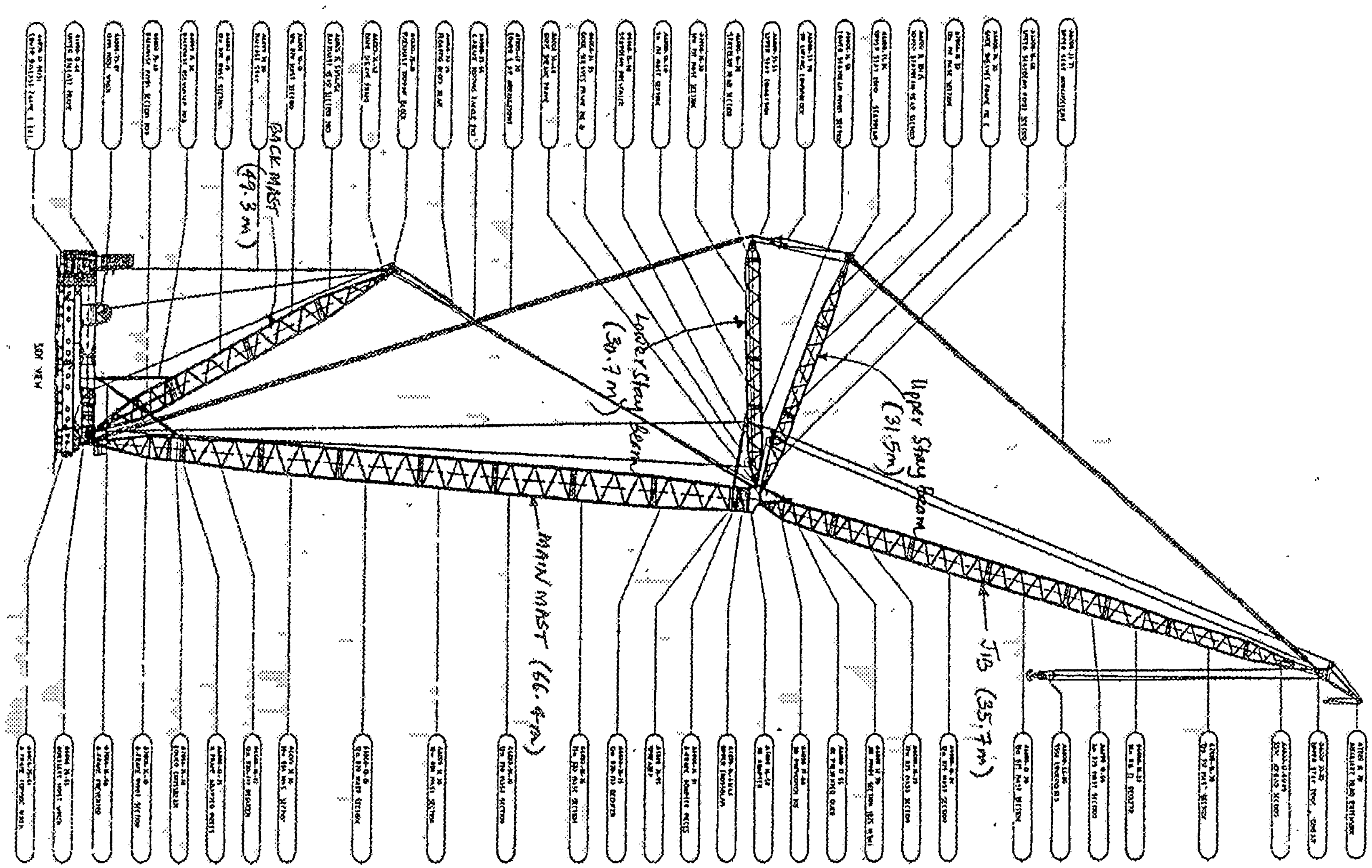

Figure 2 – PRHD Crane

Comparison Table
PTC versus PRHD Crane

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
General	• Name	Platform Twin-Ring Containerized Crane (PTC)	Platform Ring Heavy Duty Crane (PRHD) (also known as the Platform Twin-Ring HD crane)	The PTC Crane evolved from the PRHD crane with the intent to accomplish ease of transport.
	• Designed and manufactured by	Huisman-Itrec b.v. Rotterdam, The Netherlands and Van Seumeren, de Meern, The Netherlands	Huisman-Itrec b.v. Rotterdam, The Netherlands and Van Seumeren, de Meern, The Netherlands	Same Manufacturer, Designer and Supplier.
	• Owner/supplier	Mammoet b.v. (Van Seumeren Group), The Netherlands	Mammoet b.v (Van Seumeren Group), The Netherlands	
	• General construction	Ringer base mounted on jacks; longitudinal beams, ballast, main mast, luffing jib, back mast, and 2 stay beams	Ringer base mounted on jacks; longitudinal beams, ballast, main mast, luffing jib, back mast, and 2 stay beams	Very similar construction
Physical Construction Of Important Structural Components	***Main mast*** (RAI 15)			
	• Construction	A-Frame Lattice framework with the two legs of the A-Frame connected by a horizontal cross beam/frame	A-Frame Lattice framework with the two legs of the A-Frame connected by a horizontal cross beam/frame	It is seen from the physical construction of components described in this section that the stiffness properties of the major structural components (main mast, jib, back mast, stay beams, longitudinal beams etc.) are in general
	• Length	63 2 m	66 4 m	
	• Height to mast pivot	5070 mm	4620 mm	
	• Width between pivots	10080 mm	9975 mm	
	• Distance from center line of crane base to main	9210 mm	9500 mm	

Comparison Table
PTC versus PRHD Crane

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
General	• Name	Platform Twin-Ring Containerized Crane (PTC)	Platform Ring Heavy Duty Crane (PRHD) (also known as the Platform Twin-Ring HD crane)	The PTC Crane evolved from the PRHD crane with the intent to accomplish ease of transport.
	• Designed and manufactured by	Huisman-Itrec b.v. Rotterdam, The Netherlands and Van Seumeren, de Meern, The Netherlands	Huisman-Itrec b.v. Rotterdam, The Netherlands and Van Seumeren, de Meern, The Netherlands	Same Manufacturer, Designer and Supplier.
	• Owner/supplier	Mammoet b.v. (Van Seumeren Group), The Netherlands	Mammoet b.v (Van Seumeren Group), The Netherlands	
	• General construction	Ringer base mounted on jacks; longitudinal beams, ballast, main mast, luffing jib, back mast, and 2 stay beams	Ringer base mounted on jacks; longitudinal beams, ballast, main mast, luffing jib, back mast, and 2 stay beams	Very similar construction
Physical Construction Of Important Structural Components	***Main mast*** (RAI 15)			
	• Construction	A-Frame Lattice framework with the two legs of the A-Frame connected by a horizontal cross beam/frame	A-Frame Lattice framework with the two legs of the A-Frame connected by a horizontal cross beam/frame	It is seen from the physical construction of components described in this section that the stiffness properties of the major structural components (main mast, jib, back mast, stay beams, longitudinal beams etc.) are in general
	• Length	63.2 m	66.4 m	
	• Height to mast pivot	5070 mm	4620 mm	
	• Width between pivots	10080 mm	9975 mm	
	• Distance from center line of crane base to main	9210 mm	9500 mm	

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
	mast pivot			equivalent or better for the PRHD crane. Considering the large geometry and mass of the crane system, any differences are not sensitive enough to cause any significant change in the structural/ dynamic response characteristics of the crane. The similarity in dynamic response characteristics for the SSE has been demonstrated in Calculation 24370-C-026, Rev. 1.
	• Chord centerline dimensions of lattice frame sections (width x depth)	1880 mm x 2360 mm (each A-Frame leg)	2750 mm x 3650 mm (each A-Frame leg)	
	• Chords (dia x thk)	193.7 mm x 25 mm	267 mm x 20 mm	
	• Bracings (dia x thk)	121 mm x 7.1 mm	152.4 mm x 5 mm & 152.4 mm x 8 mm	
	• Equivalent structural section properties of each leg of A-Frame	A = 0.57 ft^2, Iy = 5.45 ft^4, Iz = 8 57 ft^4	A = 0.67 ft^2, Iy = 13.65 ft^4, Iz = 24 ft^4	
	Jib (RAI 15)			
	• Construction	Double-framed lattice framework with the two legs of the double frame connected by horizontal cross beam at three locations	Single-frame lattice framework	
	• Length	39 4 m	35.7 m	
	• Width between pivots	3950 mm	2960 mm	
	• Chord centerline dimensions of lattice frame sections (width x depth)	1880 mm x 2360 mm (each leg)	3650 mm x 2750 mm	
	• Chords (dia x thk)	193.7 mm x 25 mm	267 mm x 25 mm	
	• Bracings (dia x thk)	121 mm x 7.1 mm	168.6 mm x 6.3 mm	
	• Equivalent structural section properties	A = 1.14 ft^2, Iy = 58.7 ft^4, Iz = 17.4 ft^4	A = 0.82 ft^2, Iy = 29 4 ft^4, Iz = 16.7 ft^4	

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
	<u>Backmast</u> (RAI 15)			
	• Construction	A-framed lattice framework with the two legs of the A- frame connected by a horizontal cross beam	Single-frame lattice framework forked at the pivot section	
	• Length	44.4 m	49.3 m	
	• Backmast Angle (fixed)	~66°	~64°	
	• Width between pivots	10080 mm	8000 mm	
	• Chord centerline dimensions of lattice frame sections (width x depth)	1840 mm x 2360 mm (each leg)	3650 mm x 2750 mm	
	• Chords (dia x thk)	168.3 mm x 20 mm	267 mm x 20 mm	
	• Bracings (dia x thk)	114.3 mm x 4 mm	152.4 mm x 5 mm	
	• Equivalent structural section properties	A = 0.6 ft^2, Iy = 99 ft^4, Iz = 8 9 ft^4	A = 0.67 ft^2, Iy = 24 ft^4, Iz = 13.7 ft^4	
	<u>Stay Beams (Upper and Lower)</u> (TR Sect. 5.1)			
	• Length	29.3 m (upper) and 28.01 m (lower)	31.5 m (upper) and 30.66 m (lower)	
	• Chord centerline dimensions of lattice frame sections (width x depth)	2360 mm x 1840 mm	2750 mm x 2100 mm	
	• Chords (dia x thk)	168.3 mm x 20 mm	93.7 mm x 17.5 thick mm	
	• Bracings (dia x thk)	114.3 mm x 4 mm	121 mm x 4 mm	
	• Equivalent structural	A = 0.3 ft^2, Iy = 4.45 ft^4, Iz = 2.71 ft^4	A = 0 43 ft^2, Iy = 8.67 ft^4, Iz = 5.07 ft^4	

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
	section properties			
	Longitudinal Beams (2)			
	• Construction	1474 mm x 1800 mm box section built up from 20 mm flange plates and 12 mm side plates, 21 m long	1250 mm x 2000 mm box section built up from 20 mm flange plates and 15 mm side plates; 21 m long	
	• Structural section properties	A = 1.05 ft^2, Iy = 4.52 ft^4, Iz = 7.84 ft^4	A = 1.17 ft^2, Iy = 3.23 ft^4, Iz = 7.86 ft^4	
	Base			
	• Ringer and jacks (RAI 14, 15, TR Sect. 5.1)	21.5 m diameter ringer base mounted on 24 jacks, self leveling	21.5 m diameter ringer base mounted on 48 jacks, self leveling	Increased number of jacks/out-rigger plates enables better distribution and minimize foundation bearing pressures.
	• Outrigger plates under jacks (RAI 14)	24 Rectangular – 5 ft x 7.5 ft	48 Trapezoidal – 3 8 ft to 5 ft x 8.5 ft	
	• Construction of Base ring segments	920 mm x 1560 mm box section built up from 40 mm flange plates and 20 mm side plates	680 mm x 1560 mm box section built up from 50 mm flange plates and 25 mm side plates	
	• Structural section properties of base ring	A = 1.43 ft^2, Iy = 1 47ft^4, Iz = 6.18 ft^4	A = 1. 5 ft^2, Iy = 0.8 ft^4, Iz = 6 ft^4	
	• Height to top of base ring	2685 mm	2750 mm	
	• Bogie wheels	32 in front and 32 at the rear	64 in front and 32 at the rear	
	Mast Head Capacity	1600 tonnes (metric)	2000 tonnes (metric)	PRHD has better mast head capacity
	***Ballast** (Counterweight) for Sequoyah SGR Project*	1300 tonnes (metric)	1250 tonnes (metric)	Comparable
Crane Weight		2200 tonnes (approx.)	2200 tonnes (approx.)	Total crane weight is

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
and center of gravity	• Total weight including ballast • Vertical height of crane center of gravity • Percentage of crane mass located at its base	13.94 m Approximately 80% - 85%	11.14 m Approximately 80% - 85%	approximately the same. The cg of the PRHD crane is lower by about 9 ft This is favorable for stability (overturning) of the crane under seismic loads. Since the total mass of the two cranes is approximately the same, the mass of the superstructure components will also be very comparable. Since the stiffness characteristics are also similar, the dynamic response of the structure under seismic loads will also be similar.
Material of Structural Components	• Main chords of main mast, jib, backmast and stay beams • Bracings of main mast, jib, backmast and stay beams • Base Components: Longitudinal beams, cross beam, winch beams, ballast trays, base ringer	StE 690 (Fy = 101.4 ksi) StE 460 (Fy = 66.6 ksi) StE 690 (Fy = 101.4 ksi)	StE 690 (Fy = 101.4 ksi) StE 460 (Fy = 66.6 ksi) StE 690 (Fy = 101.4 ksi)	Material of all structural components is the same.

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
Operating Configurations	For the crane configuration being supplied for the SGR Project	SFSL: • Jib offset fixed at 10° or 40° • Main mast angle 10° or 40° to 86° SWSL: • Main mast angle fixed at 86° or 80° • Jib offset 5° to 86° or 80°	SFSL: • Jib offset fixed at 10° or 40° • Main mast angle 10° or 40° to 86° SWSL: • Main mast angle fixed at 86° or 80° • Jib offset 10° to 86° or 80°	Operating configurations are the same.
Design	• Lift Capacity Design Codes (RAI 15, 19)	DIN 15018 Parts 1 & 3, 15019 Part 2, 15120 Part 1, 1055 Part 4, CE, ASME B30.5-1994, SAE J987 & SAE J765	DIN 15018 Parts 1 & 3, 15019 Part 2, 15120 Part 1, 1055 Part 4, CE & ASME B30.5-1994	Primary codes are the same. The additional SAE codes J987 & J765 mentioned for the PTC crane are related to testing for ASME B30.5 certification . The PHRD crane has been certified by All Test & Inspection Inc., Blaine Minnesota, to be in compliance with the intent of B30.5. Therefore, no impact
	• Structural Design Certified and Approved by	Lloyd's Register, Croydon, Great Britain	Lloyd's Register, Croydon, Great Britain	Same
	• Meets or exceeds ASME NQA-1 Subpart 2.15 requirements (TR Sect. 5.1)	Yes.	Yes.	Same

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
	• Crane design conforms to the guidelines of ANSI B30.5, which meets the intent of ANSI B30.2 and CMAA-70 (TR Sect. 4.2(7))	Yes	Yes	Same
Wind Speed Limitations	• Wind speed monitoring instruments (RAI 10)	Two anemometers – one at the jib tip and the other at the top of the backstay. The anemometers are verified to be operational prior to jib/backstay being erected.	Two anemometers – one at the jib tip and the other at the top of the backstay. The anemometers are verified to be operational prior to jib/backstay being erected	Same
	• Maximum permissible wind load contributed from the lifted load (RAI 15)	0.75% of the Safe Working Load specified in the Load Capacity Chart	0.75% of the Safe Working Load specified in the Load Capacity Chart	Same
	• Maximum operating wind speed (RAI 15, 35)	Limited to 10 m/s (22 mph) when the lifted load is outside containment and more than 3 ft from grade. Limited to 15 m/s (33 mph) when the lifted load is 3 ft or less from grade or when the lifted load is inside containment.	Limited to 10 m/s (22 mph) when the lifted load is outside containment and more than 3 ft from grade. Limited to 15 m/s (33 mph) when the lifted load is 3 ft or less from grade or when the lifted load is inside containment.	Same
	• Actions/configurations for crane placement, when wind speed exceeds or expected to exceed maximum operating wind speed and time taken to accomplish these actions (RAI 15)	See response to RAI 15	Per Section 5 of the Crane Manual. The requirements are the same as for the PTC crane (see Response to RAI Q15) except for an additional requirement for the case when wind speeds are expected to exceed 46 m/s (103 mph). As for the PTC crane, the main mast and jib must be lowered to the ground when wind speeds are expected to exceed 46 m/s. However, for the PRHD crane the lowering must be performed at wind speeds below 30	For the Sequoyah U1 SGR Project, the OLS Crane will be lowered in accordance with the procedures in the Operating Manual when wind speeds are expected to exceed 30 m/s (67 mph) based on weather forecasts.

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
			m/s (67 mph). Also, the slewing motors brake shall be on. In the event wind speeds exceed 30 m/s and the crane is not lowered prior to 30 m/s, the crane will be placed in the configuration recommended by the manufacturer for winds in the 30-46 m/s range (same as for the PTC). The time taken to accomplish these actions are approximately the same as for the PTC crane as stated in response to RAI 15.	Therefore, no impact.
Rated Chart Capacity	• Maximum rated chart capacity of the crane configuration being supplied for the SGR Project	1135 tonnes (1250 tons).	1500 tonnes (1653 tons).	PRHD has a higher maximum rated chart capacity.
	• Minimum tipping factor of safety (FOS) associated with the safe working load (SWL) specified in the crane rated load capacity charts (includes effect of permissible operating wind speed) – RAI 14, 35	1.25	1.3	PRHD has a better FOS against tipping.
	• Load charts and operating restrictions consider applicable dead, live, wind, impact, and out-of-plumb lift loads (TR Sect. 5.1)	Yes	Yes	Same
	• Rated load capacity for the range of heavy lifts for the Sequoyah SGR Project as stated in TR Sect. 5.1	440.8 tons (400 mt) to 517.9 tons (470 mt)	465.2 tons (422 mt) to 554 6 tons (493 mt)	PRHD has a higher rated load capacity than the PTC for the range of SGR lifts.

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
	(also see RAI 12)			
Lifted load Vs chart capacity (% of chart capacity) for the Critical SG lifts (RSGs)	• RSG 1 at 52 m lift radius • RSG 2 at 52 m lift radius • RSG 3 at 55m (56 m using PRHD crane) lift radius • RSG 4 at 52 m lift radius	385 mt Vs 420 mt (91.7%) 386 mt Vs 420 mt (91.9%) 385 mt Vs 408 mt (94.3%) 385 mt Vs 420 mt (91.6%)	385 mt Vs 439 mt (87.7%) 386 mt Vs 439 mt (87.9%) 385 mt Vs 422 mt (91.2%) 385 mt Vs 439 mt (87.7%)	PRHD crane has better % chart capacity for the critical lifts. Note that the OSGs weigh less than the RSGs.
Load Testing	***<u>By Manufacturer at Production</u>***			
	Load Test soon after production (TR Sect.5.1, RAI 19, 12(a))	Load tested to 125% of rated load capacity. This meets load test requirements of ASME NQA-1, 1997, Subpart 2.15 Sect. 601.2.	Load tested to 130% of rated load capacity. This meets load test requirements of ASME NQA-1, 1997, Subpart 2.15 Sect. 601.2.	Similar. The PRHD crane was load tested to a higher percentage of the rated load capacity than for the PTC.
	Side load at the load to which tested (RA 15)	2% of Safe Working Load (SWL).	Accepted by ANSI as being equivalent to being tested for side loads equal 2% of Safe Working Load (SWL). The equivalency was established by comparing calculations performed on the PRHD to the test results of the PTC crane for 2% SWL side loads.	Same
	Construction, fabrication of steel structure and testing certified and approved by	Lloyd's Register, Rotterdam, The Netherlands. Testing of the crane was further witnessed by Keboma, The Netherlands. ANSI and DIN Inspectors also witnessed the test and have certified the crane (RAI 19).	Lloyd's Register, Rotterdam, The Netherlands. Testing of the crane was further witnessed by Keboma, The Netherlands. DIN Inspectors also witnessed the test and have certified the crane.	Similar

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
	<u>Load Test to be performed at the Sequoyah Site during and after erection and prior to use</u> Load test after erection (RAI 10, 12(a), TR Sect. 5.1)	Crane will be load tested by lifting a 250 mt (550 kip) test load assembly with the crane boomed out to a radius where the test load represents 110% of the crane rated capacity at this radius	Crane will be load tested by lifting a 250 mt (550 kip) test load assembly with the crane boomed out to a radius where the test load represents 110% of the crane rated capacity at this radius.	Same
Crane Safety Systems and Verification Actions during and following erection	• Whether redundancy available for crane systems (RAI 19)	Yes. The crane has dual engines, dual hydraulic systems, and dual computers.	Yes. The crane has dual engines, dual hydraulic systems, but a single computer. However, all sensors leading to the computer are dual.	Same except that the PRHD has only a single computer system. The supplier will provide a spare computer or spare parts for the computer at site. Also, the crane can be manually controlled in the event of a computer failure.
	• Whether the load can be safely lowered using a 12-volt car battery and manual controls in the event that all power and hydraulic systems fail (RAI 19)	Yes	Yes.	Same
	• Actions to be performed for verification, during and following erection, of the proper assembly of electrical and structural	See response to RAI 12(b).	Same as for PTC as described in response to RAI 12(b) in accordance with the corresponding sections of the Crane User Manual.	Same

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
	components – Inspection, Functional test etc. (RAI 12(b))			
	• Actions to be performed for verification of the integrity of all control, operating, and safety systems following erection (RAI 12(c))	Functional tests and load tests as described in response to RAI 12(c).	Same as for PTC as described in response to RAI 12(c)	Same
	• Ability to protect against an overload situation (RAI 12(d))	Crane equipped with load measuring devices that provide indication to operator and a redundant load-moment safety system that progressively warns and then disables crane operations. See response to RAI 12(d). Also equipped with instrumentation that provide continuous read out of crane/boom orientation and location of boom tip and load bock (TR Sect. 5.1). The crane computer system is equipped with safe load indicator (SLI) software that prevents load movement outside of specified limits (RAI 38).	Same as for PTC as described in response to RAI 12(d) Also equipped with instrumentation that provide continuous read out of crane/boom orientation and location of boom tip and load block (TR Sect. 5.1). The crane computer system is equipped with safe load indicator (SLI) software as for the PTC crane.	Same
	• Crane Safe Load Indicator SLI) software (RAI 38)	Software by Pietz Automatiserings Techniek (PAT) supplied by Krüger Systemtechnik (a leading specialist/supplier in electronic control and measurement services based in Germany)	Software by Pietz Automatiserings Techniek (PAT) supplied by Krüger Systemtechnik (a leading specialist/supplier in electronic control and measurement services based in Germany)	Software from the same designer/ supplier
Calibration of Crane Instruments (RAI 11)	• Date of last performed instrument calibration	September, 2002	November, 2002	No impact.
	• Actions to ensure crane is equipped with correctly	See response to RAI 11.	Same as for PTC as described in response to RAI 11.	Same

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
	calibrated instruments (load cell, boom radius indication readouts, incline meter readings, safe load indicator, anti-two block switches, airplane warning lights and boom stops)			
Inspections and Maintenance After Erection at Sequoyah Site	• Daily Inspections (RAI 36) • Maintenance	See Response to RAI 36. Maintenance will be performed as required, based on daily inspections, in accordance with the Crane Operating Manual.	Same as for PTC. See Response to RAI 36. Maintenance will be performed as required, based on daily inspections, in accordance with the Crane Operating Manual.	Same Same
Crane Assembly (Erection)/ Disassembly	• Heaviest individual crane component of the unassembled crane (TR Sect. 5.3) • Heaviest assembled component lifted during the erection process (TR Sect 5.3) • Largest ballast blocks (TR Sect. 5.3) • Assembly and disassembly will be performed in accordance with the crane manufacturer's procedures and drawings. (RAI 12.(b),	Lower counterweight tray – 25.3 mt (55 6 kips) Main mast at 122.7 mt (270 kips) 10.9 tons (21.8 kips) Yes.	Main Boom Head (2000t capacity) - 36.5 mt (80.4 kips) Back Mast – 95 mt (209 kips) 12.5 mt (27.5 kips) Yes.	Enveloped by heaviest assembled lifted component (see below). Less than PTC. Therefore, better. Enveloped by heaviest lifted component. Same

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
	TR Sects. 4.2, 5.1) • Main boom assembly (TR Sect. 5.1)	Assembly of the main boom will be performed in an area to the north of the Unit 1 Containment as shown on Figure 5-2 of Topical Report 24370-TR-C-002.	Assembly of main boom will start to the west of the position shown on Figure 5-2 of Topical Report 24370-TR-C-002 (as shown on Figure 3), which places the boom in a northerly direction from the crane base. This will allow assembly of the main boom on the ground without interfering with the RWST structure. The main boom will be attached to the base of the crane and moved to the position shown on Figure 5-2 of Topical Report 24370-TR-C-002 for erection of the jib and stay beams.	Assembly process is the same. If initial assembly occurred as shown in the topical report, it would have to occur off the ground to clear an interference with the RWST retaining wall. Controls for erection cranes and protection of underground equipment are the same Therefore, no impact.
Seismic II/I Qualification (TR Sect. 4.1, 5.1, RAI 14)	***Methodology/Criteria used***	Dynamic Modal Analysis by the Response Spectrum method using a GT-STRUDL Finite Element model. The response spectra used is described in response to RAI 34. Three enveloping critical configurations (as described in RAI 14) in both loaded and not-loaded conditions were evaluated. The criteria used were: (a) *Strength:* limit the stresses in the crane components under seismic loads less than yield; and (b) *Stability:* Resistance moment (Mr) is always greater than the Overturning moment (Mo), and Sliding resistance (friction) force (Fr) is always greater than the sliding force (Fs).	The design, construction, lift capacity, operation and mass of the PRHD crane are very comparable to the PTC crane. The vertical height of the cg of the PRHD crane is lower than that of the PTC by ~9 ft Based on review of the PTC evaluation, the governing failure mode of the crane in a seismic SSE event is not over-stress, but stability by overturning. The most critical configuration for overturning for the PTC was with the boom in it's most vertical position (LR = 23.2 m) without load (FOS = 1.13). Therefore, the dynamic characteristics of the PRHD crane were established and compared to that of the PTC crane for this critical configuration. This was accomplished by modifying the GT-STRUDL model to	The evaluation established similarity in dynamic response characteristics between the two cranes and improvement in FOS against overturning for the PRHD crane.

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
			incorporate the changes in the PRHD geometry, mass and stiffness from that of the PTC crane and re-running the response spectrum analysis for the above critical configuration for stability. The results obtained for stability, in comparison to the PTC, is as below.	
	Results Summary for Dead (D) + Lifted (L) ± SSE (E) :			
	• Most Critical Case for Overturning (LR = 23.2 m without a load: Config. 1 in RAI 14)	Mo = 126180 k-ft, Mr = 142586 k-ft, Mr > Mo. (FOS = Mr/Mo = 1.13)	Mo = 120574 k-ft, Mr = 150165 k-ft, Mr > Mo. (FOS = Mr/Mo = 1.25)	The difference in overturning and resistance moments between the two cranes is of the order of 5%, which is insignificant. The FOS against overturning improved for the PRHD crane.
	• Most Critical Case for Sliding (LR = 23.2 m without a load: Config. 1 in RAI 14)	Fs = 1483 k, Fr = 2306 k-ft, Fr > Fs. (FOS = Fr/Fs = 1.55)	Fs = 1562 k, Fr = 2428 k-ft, Fr > Fs. (FOS = Fr/Fs = 1.55)	The difference in sliding and resistance forces between the two cranes is of the order of 5%, which is insignificant.
	• Maximum stress in a Superstructure Mast component • Maximum Stress in base components	54.4 ksi (axial stress in back mast chord) against yield strength of 101.4 ksi. 79.1 ksi (combined axial and bending in the longitudinal beams) against yield strength of 101.4 ksi.	The analysis showed that the PHRD crane mode shapes and frequencies of the modes with significant dynamic participation under a SSE compared fairly well to that for the PTC crane, thereby establishing similarity in dynamic response of the two cranes. The FOS against overturning improved to 1.25 for the PRHD crane. Since the	The stress levels in the PRHD crane structural components will also remain below yield stress.

Crane Attribute	Description	PTC Crane	PRHD Crane	Remarks/Basis for Acceptability of PRHD Crane
			stiffness properties of the PRHD crane are in general comparable or better than that of the PTC crane in addition to margins available in the PTC results, the stress levels in the PRHD crane components will also remain below yield strength. Therefore, the results and conclusions of the PTC crane remain valid for the PRHD crane.	
	Conclusion	The evaluation demonstrated that the crane will not collapse nor drop a load in a SSE event and, therefore, will not cause a seismic II/I interaction with safety-related SSCs.	Same as for PTC crane. The PRHD crane may be used as an alternated crane	Conclusions for the PTC crane remain valid for the PRHD crane.
References	Crane manual reference (TR Sect. 10.0)	Bechtel Supplier Document 24370-SC-004-PTCManual-001, User Manual – Platform Twin-Ring Containerized Crane, Rev. 0	Bechtel Supplier Document 24370-SC-004-003-001, Rev. 2, User Manual – Platform Ring Crane, Huisman B V.-Itrec B V., Rotterdam, December 17, 1997	
	Seismic Evaluation Calculation (TR Sect. 10.0)	Calculation 24370-C-026, "Evaluation of PTC Crane for Seismic and Wind/Tornado Loads", Revision 0	Calculation 24370-C-026, "Evaluation of OLS Crane for Seismic and Wind/Tornado Loads", Revision 1	

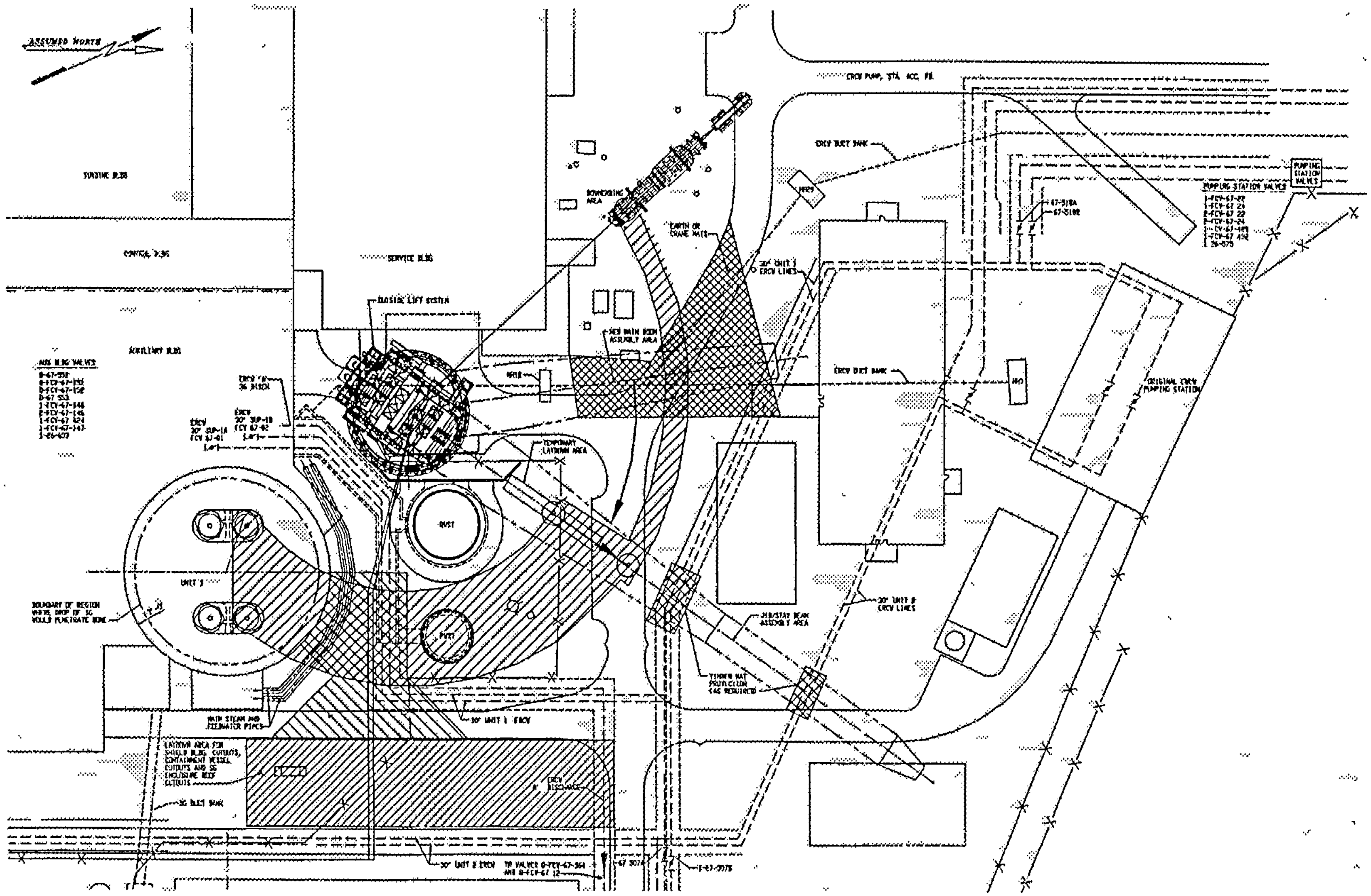

Figure 3 – PRHD Boom Assembly Location

Summary and Conclusion:

The PRHD and PTC cranes are very comparable in design, construction, lift capacity (better for the PRHD), operation and dynamic response under seismic loads. The PRHD crane base ring will be supported on 48 jacks as against 24 jacks for the PTC, providing an improved distribution of bearing pressures at the base. The seismic evaluation of the PRHD Crane established that the dynamic response characteristics of the PRHD crane are similar and further an improvement over that for the PTC crane. The margins of safety available for the structural components of the PTC crane were large enough that due to similarity in responses of the PTC and PRHD cranes, the stress levels in these elements will remain below yield stress for the PRHD crane. The evaluation determined that the factor of safety against overturning (critical failure mode) for the PRHD crane for the most critical configuration improved over that for the PTC crane. This is as expected since the two cranes have approximately the same mass (majority of which is located near the base), very similar dynamic response characteristics and the center of gravity of the PRHD is lower than that of the PTC. Therefore, the results and conclusions of the evaluation for the PTC crane remain valid for the PRHD crane. Thus, PRHD crane may be used as an alternate crane in lieu of the PTC crane for the Sequoyah Unit 1 SGRP.