CONTROLLED NO. 1

EVALUATION OF

THE RPV HEAD AND INTERNALS LIFT RIGS

FOR

SALEM UNITS 1 AND 2

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1.0 INTRODUCTION

1.1 Purpose

This report, prepared for the Public Service Electric and Gas Company (PSE&G) under purchase order E-216168, charge order number 1 (reference 1.1-1), summarizes the review of the lifting devices for the reactor pressure vessel (RPV) head and the reactor internals. The review was performed to assist PSE&G in suppplementing its "Six-Month Response" to the U.S. NRC's letter of December 22, 1980 (reference 1.1-2). The initial PSE&G "Six-Month Response" to the NRC (reference 1.1-3) did not include an evaluation of the lift rigs because the details were not available.

1.2 Scope

The scope of this study was to review the compliance of the RPV head lift rig, the reactor internals lift rig, and the associated PSE&G maintenance procedures for the Salem Nuclear Station units 1 and 2, to NUREG-0612, section 5.1.1(4) (reference 1.2-3) and ANSI N14.6-1978 (reference 1.2-4).

This review is based on the Westinghouse analysis (reference 1.2-5) including PSE&G and Westinghouse comments (references 1.2-6 and 1.2-7), and the assembly drawings listed in references 1.2-1 and 1.2-2. The detail drawings and specifications of the lift rigs were not available; therefore, the material identification, dimensions, weld sizes, and weld strengths specified in the Westinghouse analysis were assumed correct. In addition, the PSE&G maintenance procedures (1.2-9 and 1.2-10) were used.

1.3 Background

The Nuclear Regulatory Commission issued NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" (reference 1.2-3), in 1980 to address the control of heavy loads to prevent and mitigate the consequences of postulated accidental load drops. NUREG-0612, section 5.1.1(4) requires special lifting devices to meet the requirements of ANSI N14.6-1978, "American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds or More for Nuclear Materials" (reference 1.2-4).

The RPV head lift rig and the reactor internals lift rig were designed and built by Westinghouse for Salem Nuclear Station units 1 and 2, before 1971, i.e., prior to the issuance of ANSI N14.6-1978. Hence, these two devices were not originally designed to comply with the requirements of ANSI N14.6-1978.

An evaluation of the Salem reactor vessel head and internal lift rigs, per NUREG-0612 requirements, was performed by Westinghouse and documented in report number WCAP-10167 (reference 1.2-5). The Westinghouse analysis consists of:

- A comparison of the ANSI N14.6 requirements to the requirements used in the design and manufacture of these devices.
- A stress report in accordance with the design criteria of ANSI N14.6.
- A list of recommendations to assist in demonstrating compliance with the intent of NUREG-0612 and ANSI N14.6.

In addition, PSE&G has responded to the ANSI N14.6-1978, section 5.1, requirements of scheduled periodic testing, procedures, load limit marking, and records. These are documented in:

- "Maintenance of the Special Lifting Devices," dated January 9, 1984 (reference 1.2-10)

- Salem maintenance procedure M2S (revision 1), "Control, Inspection, Testing, and Maintenance of Special Lifting Devices" (reference 1.2-8)
- Salem maintenance procedure M8C (revision 15), "Reactor Vessel Head and Upper Internals Removal and Installation" (reference 1.2-9)

2.0 SUMMARY OF REVIEW COMMENTS

An independent review of the following documents was performed:

- Westinghouse analysis (reference 1.2-5)
- PSE&G comments (reference 1.2-6)
- Westinghouse comments (reference 1.2-7)
- RPV head lift rig assembly drawing (reference 1.2-1)
- RPV reactor internals lift rig (reference 1.2-2)
- PSE&G maintenance procedures (references 1.2-9 and 1.2-10).

The review comments are grouped into three categories:

1. Section 3.0 - Unresolved Comments. These comments could not be resolved by us because we lack detailed drawings.

2. Section 4.0 - Comments that Provide Additional Justification. These comments are provided for your records. They may be helpful in responding to future NRC questions.

3. Section 5.0 - Minor Comments. These comments are included for completeness and to satisfy quality assurance requirements.

3.0 UNRESOLVED COMMENTS

3.1 Reactor Internals Lift Rig (Westinghouse Analysis, Reference 1.2-5, Appendix B of Attachment B)

The Westinghouse evaluation of the spreader leg assembly did not include the assembly attachment to the triangular block. For this critical part (the spreader leg assembly) to function properly in compression, it is essential that this attachment is a moment connection. Since the detail drawings are not available, we could not evaluate this connection. It should be evaluated.

3.2 ANSI N14.6-1978, Section 5.1, Record of Required Testing, Maintenance, and Repair

Maintenance procedures should require keeping a detailed history of each rig, including instances of damage, distortion, replacement, and repairs. PSE&G should evaluate their maintenance procedure and update it to include the above requirement.

3.3 ANSI N14.6-1978, Section 5.4, Maintenance and Repair

This section requires that the repairs and alterations, if needed, be done in accordance with the original requirements and that the defective bolts, studs, and nuts be replaced rather than repaired. The maintenance procedures should be updated to incorporate the above requirement.

It should be noted that Westinghouse has the detail drawings and specifications; therefore, Westinghouse has the original requirements.

3.4 ANSI N14.6-1978, Section 5.5, Nondestructive Testing Procedures, Personnel Qualifications, and Acceptance Criteria

This section requires that nondestructive testing and inspection be performed in accordance with the applicable sections of ASME Boiler and

Pressure Vessel Code, section V (articles 1, 6, 7, 24, and 25) and section III, division 1 (paragraphs NF-5340 and NF-5350).

Liquid penetrant, magnetic particle, ultrasonic and radiograph inspections should be performed on critical welds as noted in the maintenance procedure. Should repair of any load-bearing weld become necessary, the maintenance procedure should specify that the repaired weld be tested in accordance with the original or equivalent requirements.

3.5 ANSI N14.6-1978, Section 5.5, Critical Welds Specified in the Maintenance Procedure

The nondestructive examination (NDE) that is specified in the maintenance procedure (reference 1.2-10), for every 10 years should include only the critical areas. Tables A-1 through A-3 are adequate for the visual examination program, however, we feel they are too extensive for the NDE program. Our recommendations are included in the following two tables. If cracks are found after the NDE program, then a more extensive program should be required.

TABLE 3-1
REACTOR VESSELL HEAD LIFT RIG
LIST FOR NDE

Item[1]	Description	Non-destructive Testing
5.4	Link Lugs to Link (full penetration weld)	Magnetic Particle
11,12	Ring Girder to Support Lug (fillet weld)	Magnetic Particle
13,14	Clevis Plate to leg (fillet weld)	Magnetic Particle
15	Pin	Magnetic Particle

[1] See figure A-1 of reference 1.2-5.

TABLE 3-2

REACTOR VESSELL INTERNALS LIFT RIG
LOAD CELL AND LOAD CELL LINKAGE
LIST FOR NDE

Item[1]	Description	Non-destructive Testing
8,9	Sling Block Top Lugs to Support Plate (full penetration weld)	Magnetic Particle
11,10	Side Lugs to Support Pipe (full penetration weld)	Magnetic Particle
20,21	Spacer to Leg Channel Weld (Top and Bottom) (full penetration weld)	Magnetic Particle
24a[2],25a	Torque Tube Adapter to Outer Tube (full penetration weld)	Liquid Penetrant
22,23A	Brace Plate and Leg Support Block to Leg Channel Weld (fillet weld)	Magnetic Particle
2	Load Cell Linkage Side Plates	Magnetic Particle
3	6" diameter adaptor pin	Magnetic Particle
34	Rotolock Stud	Liquid Penetrant

[1] See figures A-2 and A-3 of reference 1.2-5.
[2] Subscript (a) refers only to unit 1.

4.0 COMMENTS THAT PROVIDE ADDITIONAL JUSTIFICATION

4.1 NUREG-0612, Section 5.1.1(4), Dynamic Load Factor

Section 5.1.1(4) of NUREG-0612 requires that the lifting devices be designed to meet the stress design factors (SDF) specified in ANSI N14.6-1978. In addition, the NUREG requires that the computation of SDF be based on the combined maximum static and dynamic loads rather than on only the static load as required by ANSI.

The dynamic load on the lifting rigs results from the sudden stopping of the crane hook while lowering the load. The dynamic load depends on the hoisting speed; combined stiffness of the crane, wire ropes, and lifting devices; and the weight of the load. Because of the flexibility of the wire ropes, and the low hoisting speed (4.25 feet per minute), the actual dynamic load factor (DLF) is slightly larger than 1.0. Based on CMAA 70 criteria (reference 1.4-1), the dynamic load factor increase should be 1/2 percent of the hoisting speed in feed per minute, but not less than 15 percent. Accordingly, a DLF of 1.15 has been used in our review. This is in accordance with code requirements and is conservative.

4.2 ANSI N14.6-1978, Section 3.2, Stress Design Factor

This section of ANSI N14.6 requires a stress design margin of 3 when compared to yield strength, and 5 when compared to ultimate strength. The detailed Westinghouse stress analysis of the RPV head lift rig and the internals lift rig (reference 1.2-5) was performed to evaluate the compliance of these two rigs to ANSI N14.6 and NUREG-0612, section 5.1.1(4). The computed stresses (for static loads), multiplied by 3 and 5, and the yield and ultimate stress allowables for the RPV head lift rig and internals lift rig are presented in tables 5-1 and 5-2, respectively of reference 1.2-5.

For the head lift rig it is observed from table 5-1 that:

- For the weld portions of items 12 and 14, the weld material allowables reported in the Westinghouse report (reference 1.2-5) are too conservative. The correct weld material allowable* for item 12 is 17.3 Ksi for the shear yield and 31.7 Ksi for the shear ultimate. The correct weld material allowable* for item 14 is 21.9 Ksi for the shear yield and 35.8 Ksi for the shear ultimate.
- With the W value (static weight) multiplied by the appropriate DLF value of 1.15 and the previously noted corrections, all components of the RPV head lift rig meet all requirements.

For the internals lift rigs it is observed from table 5-2 that:

- The results presented in table 5-2 are based on the design weight W of 285,000 pounds (reference 1.2-5, appendix B of attachment B, page 3 of 67) for the lower internals. This is misleading. The design weight of 147,750 pounds (reference 1.1-3, page 3-7) for the upper internals should be considered. Based on these considerations, the results presented in table 5-2 should be multiplied by $\frac{147,750}{285,000}$ x 1.15 or .596.
- The postulated drop of the lower internals is not a safety problem because the safety-related item, the fuel, has been removed.
- With the Westinghouse value (static weight) multiplied by the appropriate factor of .596, all of the components of the RPV internal lift rig meet ANSI N14.6 requirements for the safety-related lift of the upper internals.

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* These allowables are based on the Mises Criteria (reference 1.4-2) and the lowest material strength of the filler metal and base metal. In addition, since the weld filler metal is not identified we used a low weld strength of 50 Ksi for yield and 62 ksi for ultimate (reference 1.4-3).

4.3 ANSI N14.6-1978, Section 5.2, Acceptance Testing

The RPV lift rig for the upper internals has been subjected to a 192 percent load test. This is a result of lifting the lower internals that weight 285,000 pounds; the upper internals only weigh 147,750 pounds (reference 1.1-3). Hence the upper internals lift rig complies with ANSI N14.6-1978, Section 5.2.

4.4 ANSI N14.6-1978, Section 5.3, Testing to Verify Continuing Compliance

In general, this section requires that the lifting rigs be subjected annually to a load test equal to 150 percent of the maximum load or to dimensional testing, visual inspection, and nondestructive examination of major load-carrying welds and critical areas.

Neither an annual load test, nor an annual nondestructive examination, are considered practical or necessary for the RPV head and internals lift rigs. The reasons are:

- o These special lifting devices are used only during plant refueling that occurs approximately once per year. During plant operation, these special lifting devices are inaccessible inside the containment. They cannot be removed from the containment unless they are disassembled. Load testing to 150 percent of the total weight before each use would require special fixtures, and is impractical to perform.
- o Annual load testing to 150 percent load inside the containment would increase the probability of the hazard which NUREG-0612 intends to reduce, because the load test would subject the rig and the polar crane to a load higher than it would be subjected during actual load handling. Also, the ANSI-specified load test will almost double the number of lifts and the risks associated with them.
- o The ANSI requirement of annual load testing is primarily intended to reduce the probability of fatigue failure resulting from yielding

and damage during heavy usage, which is common to most devices. Since the RPV head and internals lift rigs are used only once a year, and since the actual stress levels in the critical load bearing members are low compared to their yield strength, fatigue failure is not considered realistic.

- o PSE&G is implementing an alternate program for continued testing and maintenance, which meets the intent of NUREG-0612 and ANSI N14.6-1978. At the start of each outage requiring the lifting devices, a comprehensive visual examination by qualified personnel is required. All critical load-bearing welds and components will be checked for evidence of degradation or cracking. Qualified personnel will also inspect the devices for obvious deformation or cracking before each use of the lifting devices. In addition, the major load-bearing welds and critical areas will be nondestructively examined every 10 years. This testing interval is justified by the lifting devices' low usage over the 10-year period (only 20 to 30 times).

4.5 ANSI N14.6-1978, Section 5.1, Load Limit Marking

The load limits and other limitations on the use of the RPV head and internals lift rig are specified in their procedures. These devices are obviously unique, therefore, there is no need to mark them with the weight of the few loads they can carry.

5.0 MINOR COMMENTS

5.1 RPV Head Lift Rig (Westinghouse Analysis, Reference 1.2-5, Appendix A of Attachment B

The shear force in the head lift rig due to the vertical load (Fvertical = 115,000 lb) is not combined with the total forces in the ring girder (item 12, pages 23 through 27, figure A-1). Also, the most critical weld section is at point B (page 26) not at point A.

We have corrected the analysis and found the revised stress levels. Table 5-1 of the Westinghouse report (reference 1.2-5) should be corrected as follows:

Total Shear	from 3.2 to 5.4 ksi
Maximum Bending Stress	from 4.8 to 6.9 ksi
Ring Girder to Support Weld	from 3.2 to 5.3 ksi

These are within the correct allowables. In addition, the weld allowable should be change from 18 to 17.3 ksi for shear yield and 31.7 ksi for shear ultimate (see section 4.2).

5.2 Internal Lift Rig (Westinghouse Analysis Reference 1.2-5, Appendix B of Attachment B)

The following formula:

$$f_b = (P/2)\ (a/2 + g + \frac{\ell}{4})\ \frac{32}{\pi d^3}$$

is used in the Westinghouse report to calculate the bending stress of "HOOK PIN" (item 1 in figure B-1) for RPV internals lift rig. It is not consistent with the formula used in RPV head lift rig which is:

$$f_b = (\frac{P}{2})\ (\frac{a}{3} + g + \frac{\ell}{4})\ \frac{32}{\pi d^3}.$$

However, if the RPV head lift rig stress levels are revised to reflect the more conservative approach used for RPV internals lift rig, it is found they are within allowables.

5.3 ANSI N14.5-1978, Section 3.2, Fracture Toughness

The fracture toughness of the materials is not available; therefore, we feel it would be prudent for the PSE&G maintenance procedure to specify that the lift rigs have to be at a minimum of 60°F prior to use.

5.4 ANSI N14.6-1978, Section 5.5, 10-Year NDE

In view of the defects found in other lift rigs the NRC may suggest that the NDE program be completed prior to the next use.

5.5 ANSI N14.6-1978, Section 5.1, Testing to Verify Continuing Compliance

The internals lift rig is subjected to a load test equal to 1.92 every time the lower internals are moved (see sections 4.2 and 4.3). This could be used as the basis to eliminate the 10 year NDE proposed by PSE&G.

6.0 REFERENCES

1.1-1 PSE&G purchase order E-216168 with change order no. 1, dated August 17, 1982.

1.1-2 NRC letter of December 22, 1980, to all licensees of operating plants and applicants for operating licenses and holders of construction permits. Subject: Control of Heavy Loads.

1.1-3 Quadrex Report No. QUAD-1-81-933, revision 0, "Six-Month Response for Control of Heavy Loads, Units 1 and 2, Salem Nuclear Station," dated December 17, 1981.

1.2-1 RPV head lift rig drawings and specification:

- o 210799
- o 146491

1.2-2 RPV internals lift rig drawings and specification:

- o 124836

1.2-3 U.S. Regulatory Commission, "Control of Heavy Loads of Nuclear Power Plants," U.S. NRC NUREG-0612, July 1980.

1.2-4 ANSI N14.6-1978, "Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More for Nuclear Materials," American National Standards Institute, New York, NY.

1.2-5 Westinghouse analysis (WCAP-10167), "Evaluation of the Acceptability of the Reactor Vessel Head Lift Rig, Reactor Vessel Internals Lift Rig, Load Cell, and Load Cell Linkage to the Requirements of NUREG-0612 for Public Service Electric and Gas Company Salem Generating Station Units 1 and 2," dated February 1983.

1.2-6 PSE&G comments on the Westinghouse analysis. Letter from D. J. Jayt (PSE&G) to J. A. Triggiani, Jr. (Westinghouse), dated August 1, 1983.

1.2-7 Westinghouse response to PSE&G comments. Letter from J. A. Triggiani (Westinghouse) to D. J. Jayt (PSE&G), dated October 27, 1983.

1.2-8 Salem maintenance procedure M2S (revision 1), "Control, Inspection, Testing, and Maintenance of Special Lifting Devices."

1.2-9 Salem maintenance procedure M8C (revision 15), "Reactor Vessel Head and Upper Internals Removal and Installation."

1.2-10 Preliminary PSE&G document, "Maintenance of the Special Lifting Devices, Salem Nuclear Generatin Station," dated January 9, 1984.

1.4-1 "Specifications for Electric Overhead Travelling Cranes," CMAA - 70 - 1975, (supersedes EOCI - Specification 61). Available from Crane Manufacturers Association of America, Pittsburgh, PA, copyrighted.

1.4-2 Seely, Fred B. and J. O. Smith, Advanced Mechanics of Materials, 2nd edition, John Wiley & Sons, N.Y.

1.4-3 ANSI/AWS D1.1-82, "Structural Welding Code Steel," The American Welding Society.