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CALCULATION TITLE PAGE

Client GPU Nuclear	Page 1 of ~~15~~ 17 BRL CBS + Appendices Rev. 1
Project Shroud Vertical Weld Evaluation	Task No. 083-9601-248-0
Title Shroud Finite Element Evaluation	Calculation No. 083-248-CBS-01

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QUALITY ASSURANCE DOCUMENT

This document has been prepared, checked, and reviewed in accordance with the Quality Assurance requirements of 10CFR50 Appendix B, as specified in the MPR Quality Assurance Manual.

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RECORD OF REVISIONS

Calculation No.	Prepared By	Checked By	
083-248-CBS-01	Ben Lane	C. Sivom	Page 2

Revision	Description
0	Initial Issue
1	Revised seismic loads based on updated transient dynamic analyses. Removed results for 10 wedges because only 8 wedges will be installed.
2	Revised Summary of Results Section (pg 3) to correct a typographical error in the leakage area.

1.0 PURPOSE

The purpose of this calculation is to determine the flaw tolerance of the vertical welds in the section between circumferential welds H5 and H6A in the Oyster Creek core shroud. The vertical weld evaluation was originally performed in Reference 1. This calculation considers the effect of installing wedges between the core plate and the shroud wall. A finite element model of the shroud section is developed to evaluate the effects.

The finite element model is also used to determine the leakage path flow area through the cracked vertical weld during normal operating conditions.

2.0 SUMMARY OF RESULTS

The maximum stresses in the shroud section between circumferential welds H5 and H6A are summarized for the limiting load cases in Table 2-1. Stress contours for each load case are presented later in this calculation. As shown, these stresses meet the requirements of Subsection NB of the ASME Boiler and Pressure Vessel Code, 1989 Edition. The evaluations are performed with eight core plate wedges installed. All circumferential welds and the vertical welds in the H5/H6A shroud section are assumed to be completely failed. The evaluations show that the load through the vertical welds can be reacted by taking credit for compression across the failed circumferential welds due to tie rod preload.

For the MSLB case, if only welds H5 and H6A are failed with all other circumferential welds intact, compression could no longer be maintained across both welds H5 and H6A. Consequently, some amount of the vertical weld is required to react the hoop load from the differential pressure. Results of the evaluation performed in Appendix A show that if there is ten inches of intact vertical weld, the stresses in the H5 and H6A meet the requirements of the ASME Code.

The maximum leakage path flow area through a fully-cracked vertical weld in the H5/H6A shroud segment during normal operating conditions is 0.495 in^2. This flow area will be used elsewhere to evaluate the effect of reactor coolant flow that bypasses the core through the cracked vertical weld.

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5. Provide your basis for stating (MPR-1957, page 4-8) that the 10-wedge configuration bounds the 8-wedge configuration.

Response:

Several load cases were evaluated using different boundary conditions and wedge arrangements, as summarized below:

Load Case	Description
A	10 Wedge support configuration with conservative boundary conditions
B	10 Wedge support configuration with realistic boundary conditions
C	8 Wedge support configuration with realistic boundary conditions

A summary of the calculated reaction loads for each load case is provided below:

	Maximum Reaction Loads at Wedges		
Loading Condition	Case A	Case B	Case C
Normal Pressure (ΔP)	28 kips	0 kips	0 kips
OBE + Normal Pressure (ΔP)	43 kips	36 kips	40 kips
SSE + MSLB	107 kips	67 kips	79 kips
SSE + RLB	87 kips	64 kips	79 kips

Load Case C presents the calculated loads that are applicable for the proposed modification (with the installation of 8 wedges around the core plate). For the purpose of adding conservatism to the analysis of the core plate structure, GPU Nuclear used the reaction loads from Load Case A, which are higher than Load Case C.

Briefly, the higher reactions in Load Case A are the result of conservative boundary conditions on the core plate model, combined with the application of vertical pressure loads. For Load Case A, the wedges were modeled as being rigidly constrained in all directions (which ignores the shroud radial stiffness) and zero gaps were input between the core plate, wedges, and shroud.[1] These constraints and modeling conditions, combined with the vertical differential pressure loads, produced secondary type reactions in the core plate that are conservative, but not realistic. For example, as normal vertical pressure loads were applied to the core plate model (in the upward direction), the core plate assembly tried to elastically flex into a convex shape (i.e., the center of the core plate tried to move upward, in the out-of-plane direction). The core plate assembly is about 22 inches deep. The convex shape of the core plate caused the outer top edge of the core plate assembly to try to move radially outward (while the bottom edge tried to move radially inward).

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[1] The models for Load Cases B and C included the shroud radial stiffness and initial installation gaps between the wedges and the shroud and core plate.

Since the wedges were modeled as being completely rigid (with no flexibility or installation gaps), they restrained the core plate, which generated secondary type reaction loads at the wedge locations. An example of this effect is shown in the table above (for Load Case A); there is a 28 kip reaction load in the wedges as a result of the normal pressure differential across the core plate. Note that this reaction load is not realistic and does not appear in Load Cases B or C, since these models included the shroud radial stiffness and initial installation gaps.

With regards to Load Cases B and C, the primary difference is that Load Case B was for a 10-wedge support configuration, while Load Case C for was an 8-wedge configuration. Both of these load cases used the same boundary constraints (which included the modeling of the shroud radial stiffness and initial installation gaps between the wedges and the shroud and core plate). As expected, the reaction loads into the core plate for the eight-wedge configuration (Case C) are higher than the ten-wedge configuration (Case B). However, the bounding (highest) reaction loads are for the ten-wedged configuration (Case A), which used conservative boundary conditions.

In summary, GPU Nuclear used the reaction loads from Load Case A since they are conservative and bound Load Case C. This approach is conservative and results in the calculation of higher stresses in the core plate and wedges.

6. Provide your basis for using a 10% buoyancy effect (MPR-1957, page 4-7).

Response:

The effect of buoyancy on the core support plate weight is captured in the analysis model by reducing vertical gravitational acceleration by approximately 10%. Since an equal volume of water is displaced by the core support plate, the buoyant (upward) force on the core support plate is in proportion to the ratio of density of water to that of stainless steel. The actual value for this proportion that was used in the analysis model was 9.8%.

7. Provide the planned level(s) of visual inspection described in MPR-1957; Section 8 (VT-1, VT-3, etc.).

Response:

1. Pre-Installation Inspections

Visual exams are to be completed prior to installation of the wedges to confirm that:

- Each installation site is free of obstructions and debris, and
- The core plate (top plate) and shield angles have no signs of degradation that could affect the structural integrity or performance of the wedge installation. Inspections will be completed at each installation site, based on the use of VT-1 procedures.

The inspections of the core plate will be limited to the immediate, accessible area around each installation site (i.e., approximately a 6 to 12 inch circular area on the top plate of the core plate). The core plate will not be examined in its entirety.

Visual inspections (VT-1) of the shield angles will be performed on accessible areas where a wedge is to be installed, including the shield angle itself and the attachment weld of the shield angle to the shroud.

Shroud inspections will be done as part of other In-Vessel Visual Inspections (IVVIs) to confirm the integrity of the shroud vertical welds. No additional structurally related shroud inspections will be performed as part of the wedge installation.

2. Post-Installation Inspections

Prior to vessel re-assembly, visual inspections will be performed to verify the installation of each wedge. The inspections will be performed (VT-1) on accessible areas of the wedges in accordance with approved GPU Nuclear procedures. The inspections will confirm that:

- Each wedge is properly located, oriented, and positioned,
- The retainer springs are properly engaged on the jacking bolt,
- The fit-up with the shield support angles has been properly established, and
- All miscellaneous installation tooling and support equipment/hardware have been removed from the vessel (a foreign material exclusion program will be used to monitor materials in the vessel).

8. How does the inspections of MPR-1957, paragraph 8.2.2, compare to BWRVIP-25 (enhanced VT-1?).

Response:

Section 8.2.2 of MPR-1957 addresses inspection of the wedges during subsequent refueling outages. There are no commitments in BWRVIP-25 as regards to inspection of wedges during subsequent refueling outages after wedge installation

GPU Nuclear is taking steps beyond BWRVIP-25 to insure on-going adequacy of the wedges.