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DRESDEN UNITS 2 & 3
TOP RING PLATE AND STAR TRUSS STRESS ANALYSIS

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EXECUTIVE SUMMARY

The installation of the proposed shroud modification in Dresden 2 & 3 will result in an increase in the seismic force transmitted to the reactor pressure vessel (RPV) and support structure. The members of the support structure, specifically the RPV stabilizer, top ring plate and star truss, are analyzed to determine if the design is sufficient to withstand the increased load. This report presents the detailed stress analysis performed for the top ring plate, RPV stabilizer and star truss.

The results of the stress analysis show that the RPV stabilizer, top ring plate and star truss are capable of withstanding the increased loads resulting from the installation of the shroud modification hardware.

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1.0 INTRODUCTION

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2.0 TOP RING PLATE STRESS ANALYSIS AND RESULTS

Stress analysis of the Dresden 2 & 3 reactor pressure vessel (RPV) support structure was performed to evaluate the effects of the increased seismic loads on the RPV stabilizer, top ring plate and star truss. The details and results of the stress analysis for the top ring plate are presented in this section.

2.1 Assumptions

In the top ring plate stress analysis it was assumed that the RPV stabilizers behave like truss members. This assumption is conservative because the stablizers actually behave like beams. A beam structure increases the stiffness and resistance of the structure more than a truss.

2.2 Finite Element Model

The purpose of this model was to perform a stress analysis of the top ring plate when subjected to increased seismic loads due to the addition of the shroud modification hardware. Dimensions for the model were obtained from the drawings specified in Ref. [1]. The complete finite element model is shown in Fig. 2-1.

The finite element model of the Dresden 2 & 3 top ring plate structure was developed using the COSMOS/M, version 1.70 finite element program [2]. COSMOS/M is verified for accuracy by using sample problems and comparing the results with alternate calculations. The sample problems included static analysis problems with similar elements.

A finite element analysis was performed on the top ring plate to evaluate the local effects of the axial and bending loads induced by the RPV stabilizer connection. The model consisted of a quarter section of the structure because of the symmetry of the geometry and loading. The top ring plate was modeled with shell elements. An equivalent moment was distributed among nodes representing the stabilizer bracket. Forces representing the axial load were also applied. The long edges of the plate were fixed and vertical motion was constrained at the locations where the biological shield concrete would act to inhibit the downward vertical motion.

The maximum SSE global forces in the RPV stabilizers were determined in Ref. [3]. These SSE loads were used to produce the maximum, and therefore most conservative, stress results for the top ring plate. The jet force from a main steam line break (MSLB) was shown to yield a greater resultant force than a reactor recirculation line break (RRLB) at the location of the support structure [7]. Thus, the appropriate MSLB jet force was applied to the support structure to yield the most conservative results. The axial load in the RPV stabilizer was taken as half of the faulted condition global force given for the RPV stabilizer, 1120 kips, in addition to half of the main steam line break (MSLB) jet force of 184 kips [7], resulting in a load of 652 kips. The stabilizer pretension load of 260 kips was subtracted as this load is taken by the sleeve. To determine the effects of the stabilizer eccentric loading, the maximum stabilizer load acting on each stabilizer bracket, 392 kips [6], was converted into an equivalent moment by using the appropriate lever length, 7 inches. The equivalent moment was effectively represented by distributing vertical forces among nodes representing the stabilizer bracket.

Constant material properties evaluated at an operating temperature of 150°F, as shown in Table 2-1, [5], were utilized in the stress analysis.

Table 2-1 Material Properties

Symbol	Description	-Top Ring Plate -SA 36
ρ	Density	0.283 lb/in^3
E	Modulus of Elasticity	29.65 $x10^6$ psi
ν	Poisson's Ratio	0.326
α	Mean Coefficient of Thermal Expansion	$6.57x10^{-6}$ in/in-°F

2.3 Stress Evaluation Methodology

The loads described in Section 2.2 were applied as specified. The stress in the top ring plate was obtained by taking the maximum average stress of the elements in the area of the stabilizer bracket.

2.4 Stress Evaluation Results

The primary finite element analysis indicated the maximum average stress in the top ring plate for the SSE + JET loading condition is 16, 052 psi. This stress is below the seismic allowable stress, $0.95*F_y$, of 34, 200 psi. The stress distribution in the top ring plate is depicted in Fig. 2-2.

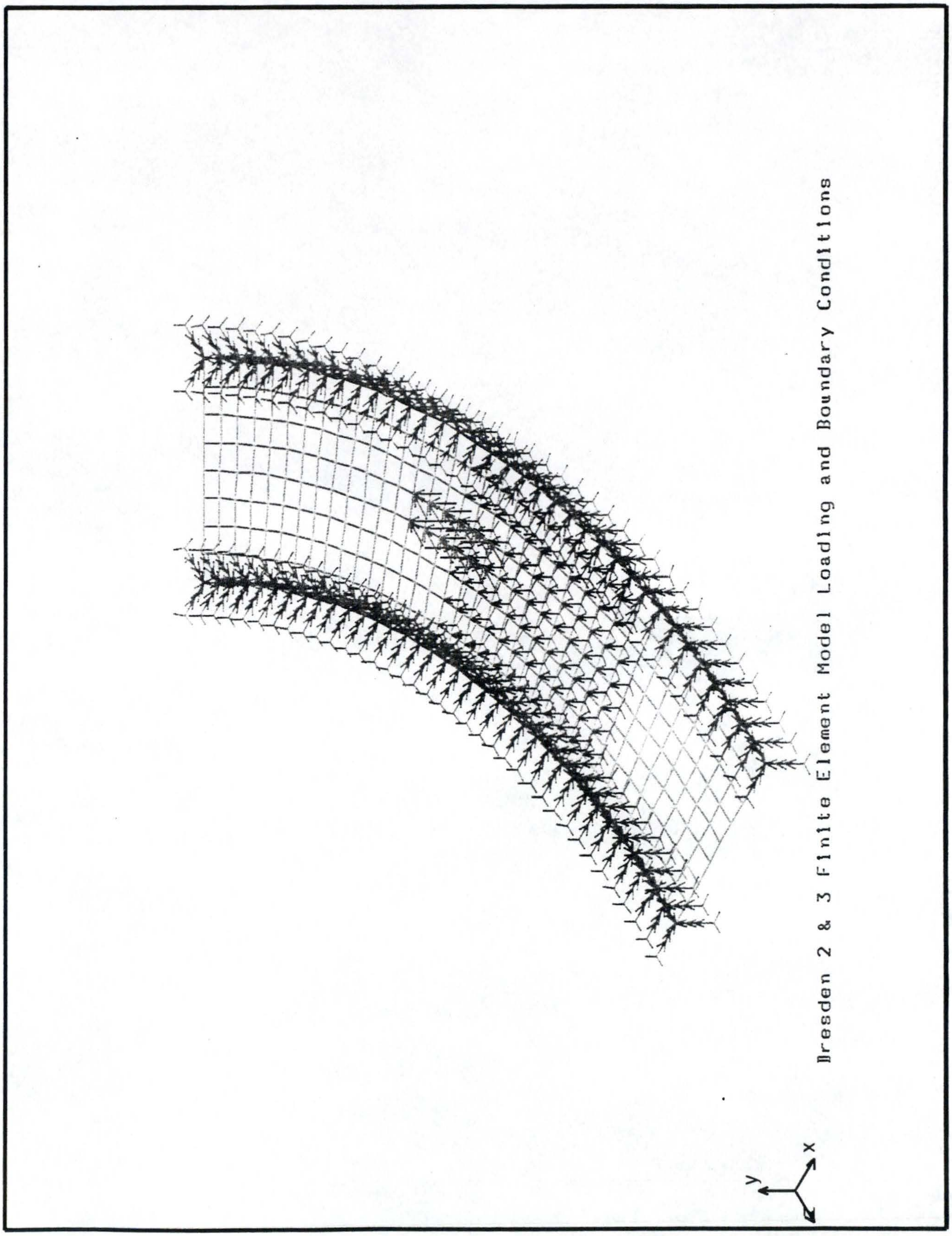

Figure 2-1 Finite Element Model for Top Ring Plate Stress Analysis

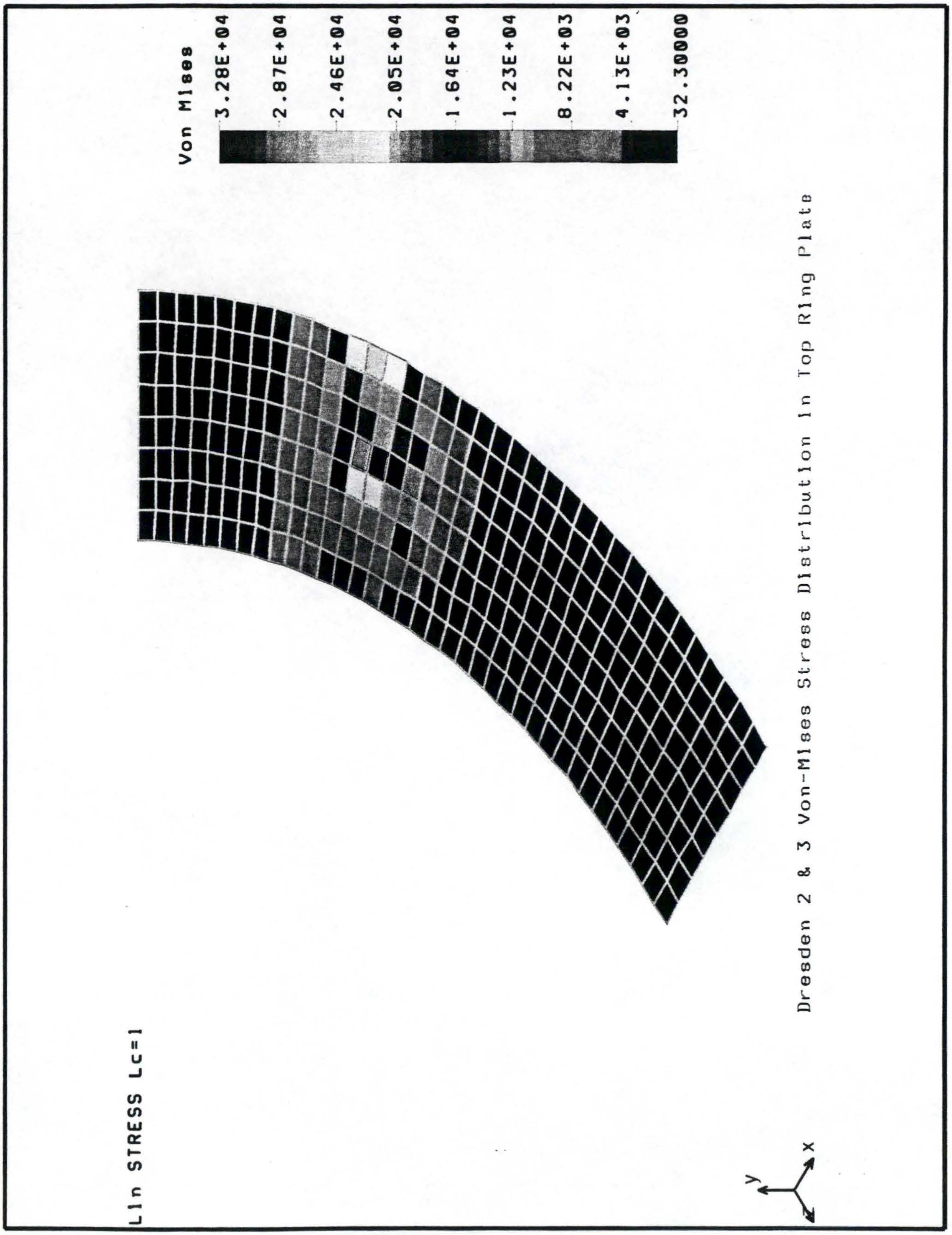

Figure 2-2 Von-Mises Stress Distribution in Top Ring Plate

3.0 STAR TRUSS AND RPV STABILIZER STRESS ANALYSIS AND RESULTS

Stress analysis of the Dresden 2 & 3 reactor pressure vessel (RPV) support structure was performed to evaluate the effects of the increased seismic loads on the RPV stabilizer, top ring plate and star truss. The details and results of the stress analysis for the star truss members, RPV stabilizer and RPV stabilizer bracket welds are presented in this section.

3.1 Assumptions

In the star truss, RPV stabilizer and bracket weld stress analysis, it was assumed that the RPV stabilizers and star truss members behave like truss elements. This assumption is conservative.

3.2 Stress Calculations

The purpose of this calculation was to perform a stress analysis of the star truss, RPV stabilizer and RPV stabilizer bracket welds when subjected to increased seismic loads due to the addition of the shroud modification hardware. Member properties for the analysis were obtained from drawings specified in Ref. [1]. The complete calculation is given in Ref. [6].

The maximum SSE global force in the star truss was determined in Ref. [3]. This SSE load was distributed according to Ref. [7] to determine the most severely loaded member. This member was analyzed to produce the maximum, and therefore most conservative, stress results for the star truss members. The global force for the star truss was taken as the global force for the faulted condition given in Ref. [3], 1610 kips, in addition to the MSLB jet force of 229 kips [7] resulting in a load of 1839 kips. This load was then distributed in accordance with Ref. [7] to obtain the maximum star truss member axial load of 382.6 kips.

The maximum SSE global forces in the RPV stabilizer were determined in Ref. [3]. These SSE loads were used to produce the maximum, and therefore most conservative, stress results for the stabilizer. The maximum axial load in the RPV stabilizer was taken as half of the global force given for the RPV stabilizer, 1120 kips, in addition to half of the MSLB jet force of 184 kips [7], resulting in a load of 652 kips. The pretension load of 260 kips was subtracted from the seismic + jet load to yield a total stabilizer load of 392 kips [6].

The maximum SSE global forces in the RPV stabilizer brackets were determined in Ref. [3]. These SSE loads were used to produce the maximum, and therefore most conservative, stress results for the bracket welds. The maximum axial load in one RPV stabilizer bracket was 392 kips [6]. The moment induced by the eccentric axial load was calculated by using the appropriate lever length, 7 inches, resulting in a moment of 2744 kips-in.

3.3 Stress Evaluation Methodology

The loads described in Section 3.2 were applied as specified. The stress in the star truss was evaluated by dividing the maximum axial load by the area of the member.

The stress in the stabilizer was conservatively calculated by dividing the maximum force in the stabilizer by the area of the tension rod.

The stress transmitted to the bracket plate and weld was determined from the bending moment, axial load, and the section properties of the plate and weld. The maximum stress in the weld was then calculated from the resulting shear and bending stresses as detailed in Ref. [6].

3.4 Stress Evaluation Results

The stress analysis indicated the maximum stress in the star truss for the SSE + JET loading condition is 12, 491 psi. This stress is below both the seismic allowable tensile stress of 34, 200 psi and the seismic allowable compressive stress of 33, 954 psi.

The stress analysis indicated the maximum stress in the RPV stabilizer for the SSE + JET loading condition is 47.2 ksi. This stress is below the AISC seismic allowable stress of 90.0 ksi.

The stress analysis indicated the maximum stress in the stabilizer bracket plate for the SSE + JET loading condition is 15, 796 psi. This stress is below the seismic allowable stress of 34, 200 psi. The stress analysis indicated the maximum stress in the stabilizer bracket weld for the SSE + JET loading condition is 13, 816 psi. This stress is below the AISC seismic allowable stress of 28, 800 psi.

3.5 Stress Evaluation Results for Other Components[8]

The connection of the star truss members to the drywell shear lug was also evaluated in a supplementary calculation.

The results indicated that the stresses in the stiffener bolting are below the allowable stress limits for the bolting. Thus the stiffener bolts are acceptable.

The weld and base metal stresses in the stabilizer female shear lug are less than the allowable values and therefore they are acceptable.

The stresses in the stabilizer embedment reinforcement bars are less than the allowable values and thus are acceptable.

4.0 CONCLUSIONS

The results of the stress analysis show that the RPV stabilizer, top ring plate and star truss are capable of withstanding the increased loads resulting from the installation of the shroud modification hardware.

5.0 REFERENCES

[1] Drawings:
a. B-709, Rev. C, "Reactor Drywell Framing Plans El. 575'-2" & 589'-2 1/2"," Sargent & Lundy Incorporated Engineers, Chicago, IL.
b. B-279, Rev. G, "Reactor Drywell Framing Plans El. 575'-2" & 589'-2 1/2"," Sargent & Lundy Incorporated Engineers, Chicago, IL.
c. B-706, Rev. D, Sargent & Lundy Incorporated Engineers, Chicago, IL.
d. B-276, Rev. G, Sargent & Lundy Incorporated Engineers, Chicago, IL.
e. 112C3568, Rev. 2, "Reactor Vessel Stabilizer," GE Nuclear Energy, San Jose, CA.
f. 153F765, Rev. 3, "Vessel Stabilizer Erection," GE Nuclear Energy, San Jose, CA.
g. 718E692, Rev. 3, "Biological Shield Wall," GE Nuclear Energy, San Jose, CA.

[2] Structural Research and Analysis Corporation, COSMOS/M Version 1.70, Santa Monica, CA, 1993.

[3] GE Report GENE-771-85-1194, "Dresden Units 2 & 3 Shroud Repair Seismic Analysis Backup Calculations", GE Nuclear Energy, San Jose, November 1994.

[4] Commonwealth Edison Company, Updated Final Safety Analysis Report, Dresden Station, Section 3.6.2.3.2, Vol. 1.

[5] "GE BWR Plant Materials Handbook," GE Nuclear Energy, San Jose, 1993.

[6] GE Report GENE-771-96-0195, "Dresden Units 2 & 3 Top Ring Plate and Star Truss Stress Analysis Backup Calculations," GE Nuclear Energy, San Jose, CA, January 1995.

[7] Commonwealth Edison Company, Updated Final Safety Analysis Report, Dresden Station, Appendix 5A, Vol. 3.

[8] GENE DRF B13-01749, "ComEd Shroud Fix for Dresden," May 1995.

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GENE Letter, M. D. Potter - GE Shroud Project Engineer to Kenneth Hutko - ComEd Shroud Project Engineer,
Performance impact of shroud repair leakage for Dresden Units 2 & 3, dated May 18, 1995 (B13-01749, MDP-9536)

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May 18, 1995

cc: R. Svarney
E. R. Mohtashemi
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MDP-9536

To: Kenneth Hutko
ComEd Shroud Project Engineer

From: M. D. Potter *M. D. Potter*
GE Shroud Project Engineer

SUBJECT: PERFORMANCE IMPACT OF SHROUD REPAIR LEAKAGE FOR DRESDEN UNITS 2 AND 3

Reference: DRF No. B13-01749.

1. Introduction

The hardware designed to repair the shroud with identified cracks for Dresden Units 2 and 3 requires the machining of eight holes through the shroud support plate. Each of these holes will have some clearance, which will allow leakage flow to bypass the steam separation system. In addition, potential leakage through the weld cracks (H1 through H8) and the replacement access hole cover is also considered. This letter reports the leakage flow for 100% rated power and core flow.

2. Evaluation

2.1 Leakage Flow Evaluation

The most restrictive flow area for leakage through the holes in the shroud support plate is based on a conservative gap between the adjacent surfaces of the shroud support plate and the lower support bracket. In addition, there are a total of eight circumferential shroud welds (H1 - H8) that are considered as potential leakage paths - two above the top guide support ring, three on the upper shroud between the core support ring and the top guide support ring, and three on the lower shroud below the core support ring. It is conservatively assumed that each of these welds develops a complete circumferential crack that opens to 0.001 inches.

The leakage flows for 100% rated power and core flow are summarized in Table 1. These leakage flows are based on applicable loss coefficients and reactor internal pressure differences (RIPD's) across the applicable shroud components. The replacement access hole cover leakage is based on information in the referenced DRF. Leakage from the weld cracks above the top guide support ring is assumed to be two-phase fluid at the core exit quality. Leakage from the remaining paths below the top guide support ring is considered single-phase liquid. All of the leakage flows bypass the steam separators and dryers. The leakage flows below the shroud support ring also bypass the core. The results show that the leakage flows from the repair holes, weld cracks and the access hole cover result in a combined leakage of about 0.23% of core flow.

Table 1. Summary of Leakage Flows at Rated Power and Flow

Leakage flow (gpm)	
Shroud head flange pockets	1600
Weld cracks	140
Repair holes in support plate	325
Access hole covers	180
Leakage-to-core Mass flow (%)	
Shroud head flange pockets	0.21
Weld cracks	0.04
Repair holes in support plate	0.12
Access hole covers	0.07

The steam portion of the leakage flows will contribute to increasing the total carryunder from the steam separators. The impacts of the total leakage on the steam separation system performance, jet pump performance, core monitoring, fuel thermal margin, emergency core cooling system (ECCS) performance and fuel cycle length are evaluated as summarized in the following subsections.

2.2 Steam Separation System

The leakage flow through weld cracks H1 and H2 occurs above the top guide support ring and includes steam flow, which effectively increases the total carryunder in the downcomer by about 0.03% at rated conditions. The carryunder from the separators is based on the applicable separator test data at the lower limit of the operating water level range. The combined effective carryunder from the separators and the shroud head leakage is about 0.18% and is bounded by the design value.

2.3 Jet Pumps

The increased total carryunder will decrease the subcooling of the flow in the downcomer. This in turn reduces the margin to jet pump cavitation. However, because the total carryunder meets the design-condition carryunder value, there is no impact on jet pump performance compared with the design condition.

2.4 Core Monitoring

The impact of the leakage results in an overprediction of core flow by about 0.21% of core flow. This overprediction is small compared with the core flow measurement uncertainty of 2.5% for jet pump plants used in the MCPR Safety Limit evaluations. Additionally, the decrease in core flow resulting from the overprediction results in only a 0.1% decrease in calculated MCPR. Therefore, it is concluded that the impact is not significant.

2.5 Anticipated Abnormal Transients

The code used to evaluate performance under anticipated abnormal transients and determine fuel thermal margin includes carryunder as one of the inputs. The effect of the increased carryunder due to leakage results in greater compressibility of the downcomer region and, hence, a reduced maximum vessel pressure. Since this is a favorable effect, the thermal limits are not impacted.

2.6 Emergency Core Cooling System

Leakage through weld cracks H1 and H2 results in slightly increased carryunder that causes the initial core inlet enthalpy to increase slightly, with a corresponding decrease in the core inlet subcooling. However, because the total downcomer carryunder still meets the design value, there is no impact on the emergency core cooling system (ECCS) performance from this effect compared with the design conditions. Another effect of the leakage flows from the repair holes and the weld cracks is to decrease the time to core uncovery slightly and, also to increase the time that the core is uncovered. The combined effect has been assessed to increase the peak cladding temperature (PCT) for the limiting LOCA event by less than 30°F. The current analysis basis yields a LOCA PCT of about 2045°F for the design basis LOCA with LPCI injection failure. The 10CFR50.46 regulatory limit PCT is 2200°F. Because the maximum potential effect on the design basis LOCA PCT is very small, there is no adverse effect on the margin of safety. This impact is sufficiently small to be judged insignificant, and hence, the licensing basis PCT for the normal condition with no shroud leakage is applicable. The sequence of events remains essentially unchanged for the LOCA events with the shroud head leakage.

2.7 Fuel Cycle Length

The increased carryunder due to leakage flow above the top guide support ring results in a slight increase in the core inlet enthalpy, compared with the no-leakage condition. The combined impact of the reduced core inlet subcooling and the reduced core flow due to the leakage results in a minor effect (~0.8 days) on fuel cycle length and is considered negligible.

3. Conclusions

The impact of the leakage flows through the shroud repair holes and the potential weld cracks in the shroud have been evaluated. The results show that at rated power and core flow, the leakage flows from the repair holes and the weld cracks are predicted equal to a combined leakage of about 0.44% of core flow (including potential replacement access hole cover leakage). These leakage flows are sufficiently small so that the steam separation system performance, jet pump performance, core monitoring, fuel thermal margin and fuel cycle length remain adequate. Also, the impact on ECCS performance is sufficiently small to be judged insignificant, and hence, the licensing basis PCT for the normal condition with no shroud leakage is applicable.

M. D. Potter

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Dresden Units 2 & 3 - Top Ring Plate and Star Truss Stress Analysis