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DRESDEN UNITS 2 & 3
TOP RING PLATE AND STAR TRUSS STRESS ANALYSIS
BACKUP CALCULATIONS
(GENE-771-95-0195)

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PROPRIETARY INFORMATION NOTICE

IMPORTANT NOTICE REGARDING THE CONTENTS OF THIS REPORT

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 finite element analysis and hand calculation 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 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.

1.1 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.

1.2 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. 1-1. The node numbering scheme is depicted in Fig. 1-2.

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 loads for the faulted condition 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 [6]. Thus, the 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 MSLB jet force of 184 kips [6], resulting in a load of 652 kips. The stabilizer pretension load of 260 kips was subtracted as this load is taken by the sleeve. This result, 392 kips, is detailed in Calculation 1-1. To determine the effects of the stabilizer eccentric loading, the maximum stabilizer load acting on each stabilizer bracket, 392 kips, 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. The eccentric loading calculations are presented in Calculation 1-1.

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

Table 1-1 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

1.3 Stress Evaluation Methodology

The loads described in Section 1.2 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. The stress calculation is presented in Calculation 1-2.

1.4 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 with a safety factor of 2.13. The stress distribution is seen in Figure 1-3. This result is presented in Calculation 1-2.

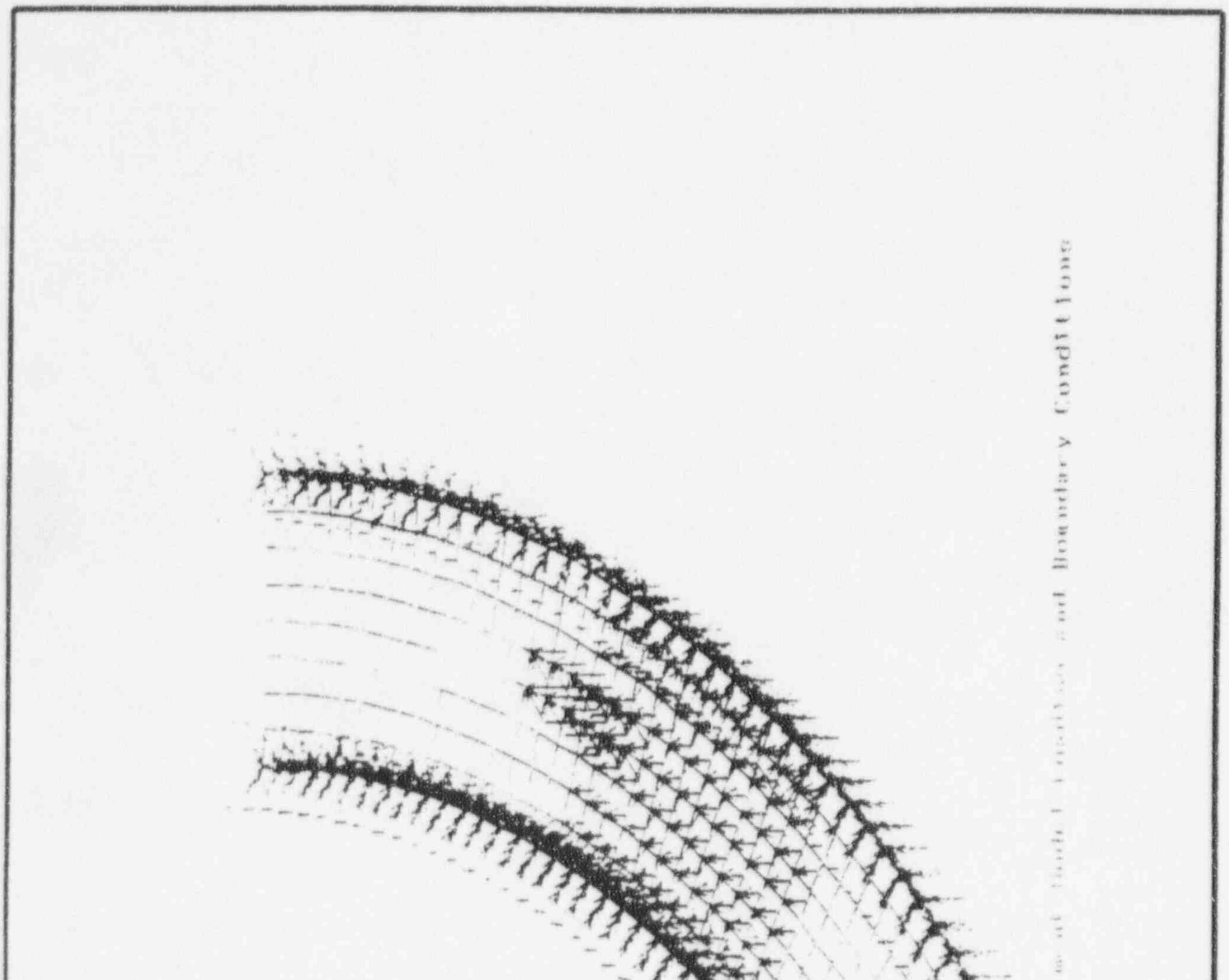

Figure 1-1 Finite Element Model Loading and Boundary Conditions

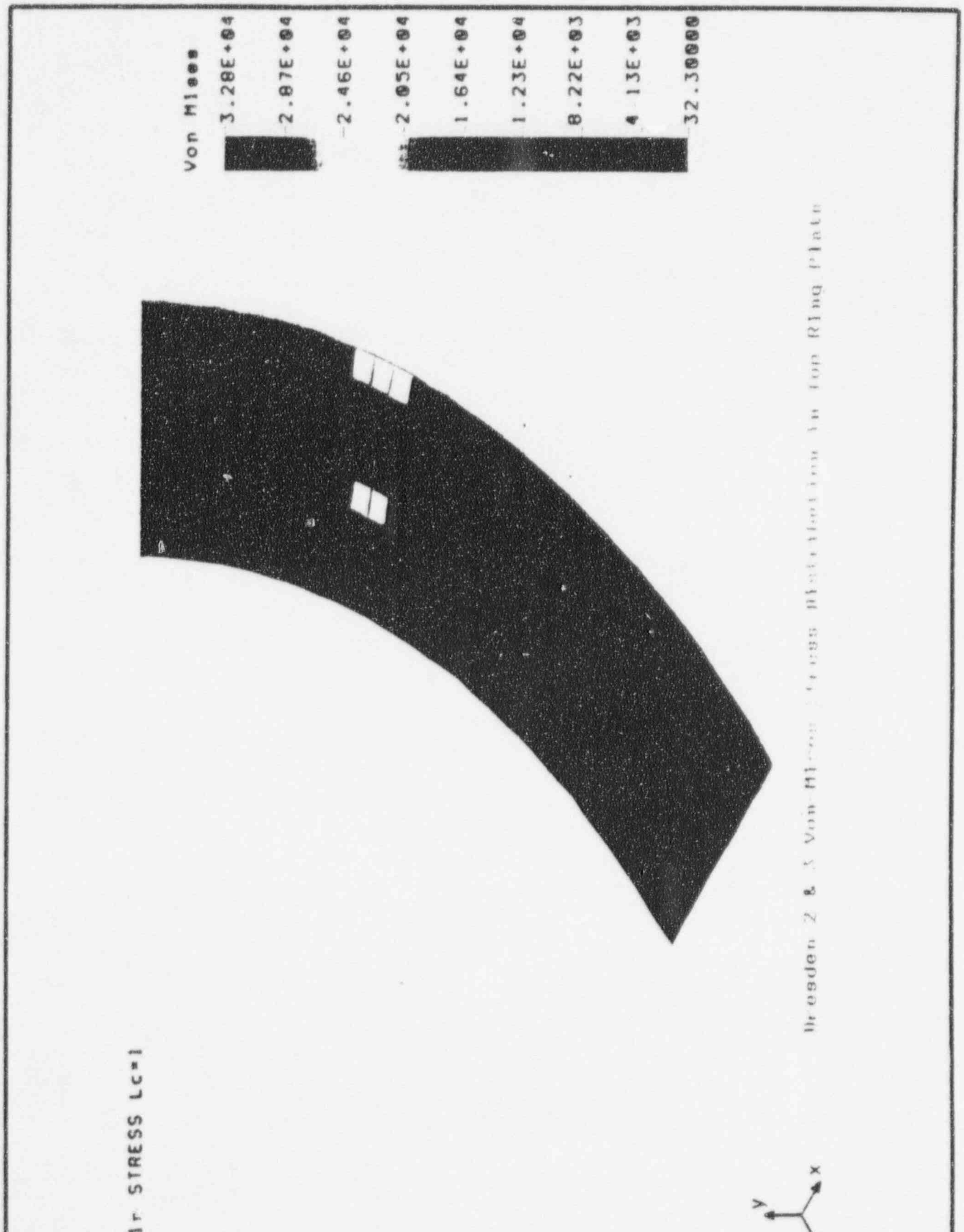

Figure 1-3 Von-Mises Stress Distribution in Top Ring Plate

2.0 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.

2.1 Assumptions

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

2.2 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 maximum SSE global force in the star truss was determined in Ref. [3]. This SSE load was distributed according to Ref. [6] 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[6] resulting in a load of 1839 kips. This load was then distributed in accordance with Ref. [6] to obtain the maximum star truss member axial load of 382.6 kips as shown in Calculation 2-1.

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 [6], 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. This result is detailed in Calculation 2-2.

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. 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. These loads are calculated in Calculation 2-3.

2.3 Stress Evaluation Methodology

The loads described in Section 2.2 were applied as specified. The stress in the star truss was evaluated by dividing the maximum axial load by the area of the member as seen in Calculation 2-1.

The stress in the stabilizer was conservatively calculated by dividing the maximum force in the stabilizer by the area of the tension rod. This is demonstrated in Calculation 2-2.

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 Calculation 2-3.

2.4 Stress Evaluation Results

The stress analysis indicated the maximum stress in the star truss for the SSE + JET loading condition is 12, 491 psi as demonstrated in Calculation 2-1. This stress is below the seismic allowable tensile stress of 34, 200 psi with a safety factor of 2.74. This stress is below the seismic allowable compressive stress of 33, 954 psi with a safety factor of 2.72.

The stress analysis indicated the maximum stress in the RPV stabilizer for the SSE + JET loading condition is 47.2 ksi as demonstrated in Calculation 2-2. This stress is below the AISC seismic allowable stress of 90.0 ksi with a safety factor of 1.91.

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 with a safety factor of 2.17. 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 with a safety factor of 2.08. These results are detailed in Calculation 2-3.

3.0 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.

Enclosure 15

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Primary Structure Seismic Models