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SUPPLEMENT 1
CLASS III
DRF B13-01739

SUPPLEMENT 1 TO NINE MILE UNIT 1 SHROUD

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1. INTRODUCTION

This document is a supplement to the Nine Mile Unit 1 (NMP-1) Shroud Repair Hardware Stress Analysis. The evaluation in this supplement is in addition to the referenced stress analysis and is consistent with the results or conclusions. The tie rod loads calculated in this evaluation are bounded by the loads used in the reference analysis.

The purpose of this supplement is to further evaluate the possibility of weld crack separation during normal and upset operation. The original stress analysis show there was no weld crack separation in the lower shroud welds (H6B & H7) during normal and upset operating conditions, but the spring constants of two structural components (top guide ring and conical support) were determined to be non conservative. This evaluation supplements the original stress report with an independent ANSYS analysis of the top guide support ring for two 360° through wall crack conditions (H2 & H3). This evaluation also includes the stiffnesses of the shroud conical support and the tie rod lower support assembly. The stiffnesses in the original stress report remain valid since they yield the most conservative results for stress evaluation.

2. STIFFNESS CALCULATIONS

2.1 Shroud Stiffness

This section presents the evaluation of the NMP-1 core shroud stiffness calculation. The core shroud stiffness, including the conical support, was determined for various conditions. The conditions considered include through-wall 360° cracking simultaneously at H2 and H3. The analysis presented here does not postulate cracking at H8, but covers cracking at all other welds (H1 - H7). If H8 is assumed to be cracked the load path will be through the H8 brackets whose stiffness is very high and do not affect the overall shroud stiffness. The shroud conditions considered in this evaluation are summarized in Table 2-1. Since welds H2 and H3 affect the shroud stiffness, they are specifically cited in Table 2-1. Welds H2 and H3 include included the 0.6" fillet welds. The detail shroud drawings show a full penetration weld between the shroud cylinders and ring with a 0.63 fillet on the ring side. Fillet welds with a 0.6 inch legs are used for conservatism. Case 1 postulates a crack in through the weld at the ring and assumes the ring pivots about the weld material

attached to the shell. Case 2 postulates the crack in the shroud cylinders above the weld and takes credit for the weld material attached to the ring. In Case 3 is a conservative bounding case that assumes there are no fillet welds. All three cases take no credit for the 8 top guide alignment brackets, the 4 top guide support pads or the 4 core spray line support brackets. All of these items are welded to the top guide support ring and to the shroud shell sections which adds to the stiffness of the ring section.

Case 3 is evaluated for information only as a bounding condition and is not considered a realistic condition. The existence of Case 3 means the shroud was fabricated in severe violation of the design requirements and there is no evidence to support such a condition.

A fourth case is included for comparison with cases 1 through 3. Case 4 is the as built condition. There are no cracks and the fillet welds are included in the model.

Table 2-1 Core Shroud Conditions Evaluated

Case	Details
1	Cracks at H2 and H3 on ring side
2	Cracks at H2 and H3 on shell side
3	H2, H3 Failed, No welds considered
4	No failed welds, with fillets

Analysis

The analysis of the core shroud axial stiffness was comprised of i) developing a finite element mode, ii) applying loading to the top of the core shroud, iii) Determining the stiffness using the resulting vertical displacement and applied loads.

Finite Element Analysis

A finite element model was developed using the ANSYS computer program (Reference 2-1). The model was comprised of two-dimensional axisymmetric quadrilateral elements (STIF 42). The core shroud flange and top guide support ring were included in the model along with the shroud cylinders and the support cone.

The cracks were modeled at the H2 and H3 locations by including two sets of coincident nodes. One set of nodes corresponded to the lower row of elements, and the second set corresponded to the upper row of elements. The assumed contact point between the upper and lower portion of the shroud at each crack location was modeled by giving two elements a common node. This modeling is illustrated in Figure 2-1.

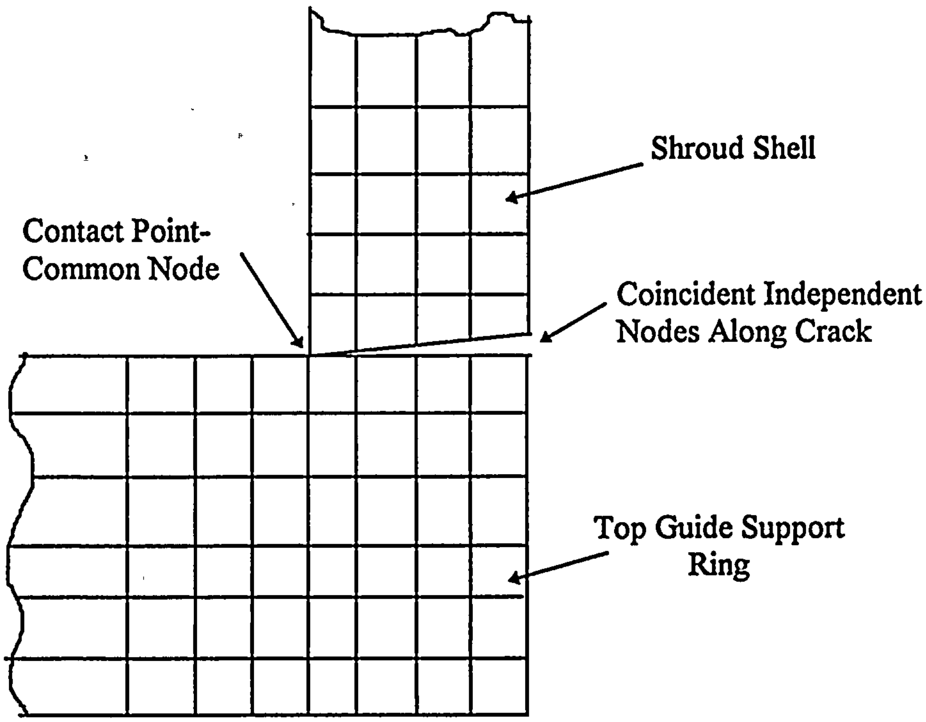

Figure 2-1 Example of Crack Simulation

Figure 2-2a shows the finite element model and Figure 2-2b shows the detail for the H2/H3 weld configuration. The actual crack assumptions are more clearly seen in Figure 2-3 (Case 1), Figure 2-4 (Case 2) and Figure 2-5 (Case 3).

Applied Load

The loading was applied as nodal forces in the downward vertical direction at the top of the shroud flange. A total of 11 nodes are on this surface and 1000 lbs (per radian) was applied at each node. Thus, the total force is $2\pi(11000) = 69{,}115$ lbs.

Stiffness Calculations

The stiffness of the shroud was calculated by dividing the total applied force by the average nodal vertical displacement at the shroud flange ($F=k\Delta$). Table 2-2 summarizes the results of the finite element cases and resulting shroud stiffness (Ks).

Figures 2-3 through 2-5 shows the exaggerated displacement which demonstrate the behavior of the cracked shroud and show more clearly the crack assumptions.

Table 2-2 - Shroud Stiffness Results

Case	Average Vertical Displacement (in.)	Ks, Stiffness (F/Δ) (lb/in)
1	0.01022	6.76×10^6
2	0.01092	6.33×10^6
3	0.02556	2.70×10^6
4	0.001006	68.7×10^6

2.2 Stabilizer Stiffness

The original stress report did not include the stiffness of tie rod lower support assembly in the calculation of the overall assembly stiffness. This supplement includes the lower support assembly stiffness. The stiffness of the lower support is analyzed as a series of springs including the toggle bolts, the lower support hook section and the lower support base section. Each component is divided into sections that are analyzed as spring elements with the K = AE/L relationship. The toggle bolts have the lowest stiffness in this series of springs controls the overall stiffness. The net lower support stiffness, including the toggle bolts (Kls) is calculated at 13 x 10^6 lb/in.

The stiffness of the upper support, tie rod and C-spring (Ktr) is calculated at 514,000 lb/in. The combined stiffness of a single stabilizer assembly including the lower support is Kst.

$$1/Kst = 1/Ktr + 1/Kls$$

$$1/Kst = 1/514{,}000 + 1/13 \times 10^6$$

$$Kst = 494{,}450 \text{ lb/in}$$

The stiffness of the four stabilizer assemblies, Kcc= 4 x 494,450 lb/in = 1.978 x 10^6 lb/in

3. LOAD CALCULATIONS

3.1 Preload

The preload is calculated for 4 different conditions of the top guide support ring resulting in four different spring constants. At normal thermal conditions, the unrestricted thermal expansion of the shroud, ΔL, exceeds the stabilizer by 0.155 in. The four different conditions of the top guide support ring are summarized below.

Case 1. Welds H2 and H3 have a 360° through wall crack on the ring side of the fillet weld. ($Ks = 6.76 \times 10^6$ lb/in)

Case 2. Welds H2 and H3 have a 360° through wall crack on the shroud shell side of the fillet weld. ($Ks = 6.33 \times 10^6$ lb/in)

Case 3. Welds H2 and H3 have a 360° through wall cracks and there is no fillet weld. ($Ks = 2.70 \times 10^6$ lb/in)

Case 4. Welds H2 and H3 are not cracked. ($Ks = 68.7 \times 10^6$ lb/in)

The preload for each condition is calculated as shown below and Table 3.1 shows the total compressive load on welds H6B and H7. This preload calculation conservatively neglects the total mechanical preload of 12,000 lb applied by tightening the tie rod nuts.

$$P = [(Ks \times Kcc) / (Ks + Kcc)] \times \Delta L$$

The net compressive load at welds H6B and H7 is a combination of the thermal preload and the weight, less buoyancy, of the internals. The net weight of the internals acting against the reactor pressure is calculated in the referenced stress report as 174,910 lb.

TABLE 3.1
COMPRESSIVE LOAD AT WELDS H6B AND H7

CASE NUMBER	THERMAL PRELOAD, LB	NET WEIGHT, LB	TOTAL LOAD, LB
1	237,188	174,910	412,098
2	233,596	174,910	408,506
3	176,954	174,910	351,864
4	298,010	174,910	472,920

3.2 Separation Loads

The loads tending to separate the lower shroud welds are applied by the steady state pressure drop across the core plate and the shroud head. Seismic loads are not included in this crack separation analysis. The separation loads during normal operation with 105% flow and the design basis upset conditions at 100% flow are calculated below. The NMP-1 design basis is 100% core flow and 105% core flow is used to provide margin in the analysis.

The lift load is the sum of the ΔP's times the areas for each event. The applicable areas are from the referenced stress report.

Effective Core Plate Area = Acs = 12,346 in^2

Effective Shroud Head Area =Ash = 24,328 in^2

The lift load = Acs x ΔPcs + Ash x ΔPsh

3.3 Normal Conditions

During normal operation at 105% core flow, the core support pressure drop, ΔPcs, is 15.9 psi and the shroud head pressure drop, ΔPsh, is 5.9 psi. The calculated lift load is 339,836 lb.

The results show there is no crack separation for all the cases considered. The compressive thermal preload plus weight of the internals exceeds the 339,836 lb load tending to separate the welds for all load cases.

With welds H2 and H3 not cracked, the ring stiffness is calculated at 68.7×10^6 lb/in and the thermal preload is calculated to be 298,101 lb. The load on each stabilizer assembly is 74,503 lb which is less than the bounding load of 79,670 lb used for the original structural analysis.

3.4 Upset Conditions

At design bases upset pressure with 100% core flow, the core support pressure drop, ΔPcs, is 16.9 psi and the shroud head pressure drop, ΔPsh, is 8.3 psi. The calculated lift load is 410,569 lb.

There will be no separation for Case 1 since the compressive load is 412,098 lb and a separation load is 410,569 lb.

There will be no separation for Case 2 if credit is taken for the 12,000 lb mechanical preload applied by the tie rod nuts. However, if one excludes the mechanical preload, the maximum difference between the separation load and the thermal preload plus dead weight is 2063 lb. The maximum crack separation with this load is 0.001 inch. Separation is calculated be dividing the excess load by the spring constant of the four stabilizer assemblies (1.978×10^6 lb/in) This separation is acceptable and there is no need for any inspections or other operator actions following the upset pressure events.

Crack separation is predicted for the Case 3 conditions. The thermal preload plus weight of the internals result in a 351,864 lb compressive load with a 410,569 lb load tending to separate the welds. The separation load exceeds the preload by 58,705 lb, and the maximum separation is 0.03 inches. It should be emphasized that this case is overly conservative since it assumes that there are no fillet welds.

The resulting shroud stiffness is much higher and the thermal preload will be higher if credit is taken for the 8 top guide alignment brackets, the 4 top guide support pads and the 4 core spray pipe brackets. These items are welded to the top guide ring and to the shroud shell section and will increase the shroud stiffness at the top ring section.

The upset pressure drops across the core support and the shroud head are also calculated on the high side. Table 3.2 show a comparison of the design basis upset pressures and the calculated pressures for several upset events. Similar upset pressures are not available for the 105% flow conditions, but the table gives an idea of the margins involved in the pressure calculations.

TABLE 3.2

ESTIMATED PRESSURES FOR UPSET CONDITIONS

COMPONENT	NORMAL 100% FLOW	UPSET DESIGN BASIS	RECIRC. FLOW RUNOUT	PR. REG. FAILURE
Shroud Head	5.5	8.3	5.8	7.5
Upper Shroud	4.7	7.1	5.1	6.7
Core Plate	14.5	16.9	15.2	14.5
Shroud Support	19.2	21.6	20.3	21.2

4. VALIDITY OF SAFETY ANALYSIS

The safety evaluation (GE-NE-B13-01739-5) was reviewed for areas in which a reduction in shroud stiffness would alter the results and/or conclusions. The following is the result of this review:

1. Part B.2.1: Safety Design Basis (Conformance)

   The maximum temporary vertical displacement will increase slightly (~0.02 inch). This negligible increase will not alter the conclusion that the ECCS piping will perform its intended safety function. The design margin for this event was originally approximately 250%.

2. Part B.3.1: Flow Partition (Conformance)

   The conclusion that this design verifies acceptable leakage through the flow partition resulting from weld separation during accident and transient events that meet the normal operations is still valid. The maximum potential weld separation predicted for upset pressure conditions has no impact on the consequences of the previously analyzed NMP1 FSAR anticipated operational transients. The anticipated operational events which result in limiting safety conditions for MCPR, LHGR, and Over-Pressure do not lead to weld separation during the event. This is the result of constant or decreasing shroud pressure differences during these limiting events. The consequences of anticipated operational events which result in weld separation, and therefore, shroud leakage are less severe than when separation does not occur. This is the result of reduced core moderation, because of the reduced core flow, leading to lower core power generation. Therefore, the consequences of anticipated operational transients are unchanged by potential weld separation.

Item 1 above is the only area in which a non-conservative result is reported. All other areas of the Safety Evaluation either have no impact or use refer to pre-loads which bound the lower pre-load values calculated by a reduced shroud stiffness.

There are no changes to any of the conclusions of the safety evaluation.

5. CONCLUSIONS

5.1. Normal Operation

The results show there will be no crack separation for all cases for normal operating conditions at 105% core flow.

5.2. Upset Pressure Operations

The results show there will be no crack separation for Case 1 and crack separation is not expected for Case 2.

The results show up to 0.03 inch crack separation for the Case 3, but this condition is not a true representation of the shroud configuration.

5.3 Action Following an Upset Event

The Nine Mile Point Unit 1 Shroud Repair Hardware Stress Analysis show the stabilizer and shroud stresses remain below the elastic limit during all normal and upset events. The loads evaluated in this analysis are bounded by the loads evaluated in original stress analysis. Since there is no plastic deformations, the shroud will return to the same condition as prior to the event. Crack separation postulated to occur during an upset event is temporary and will close following the event. The tie rod assembly remain tight and there is no need for an immediate inspections of the tie rod assembly.

Reference

G.J. DeSalvo and R.W. Gorman, ANSYS Engineering Analysis System User's Manual, Swanson Analysis Systems, Inc., Houston, PA, Revision 4.4a, May 1, 1989.

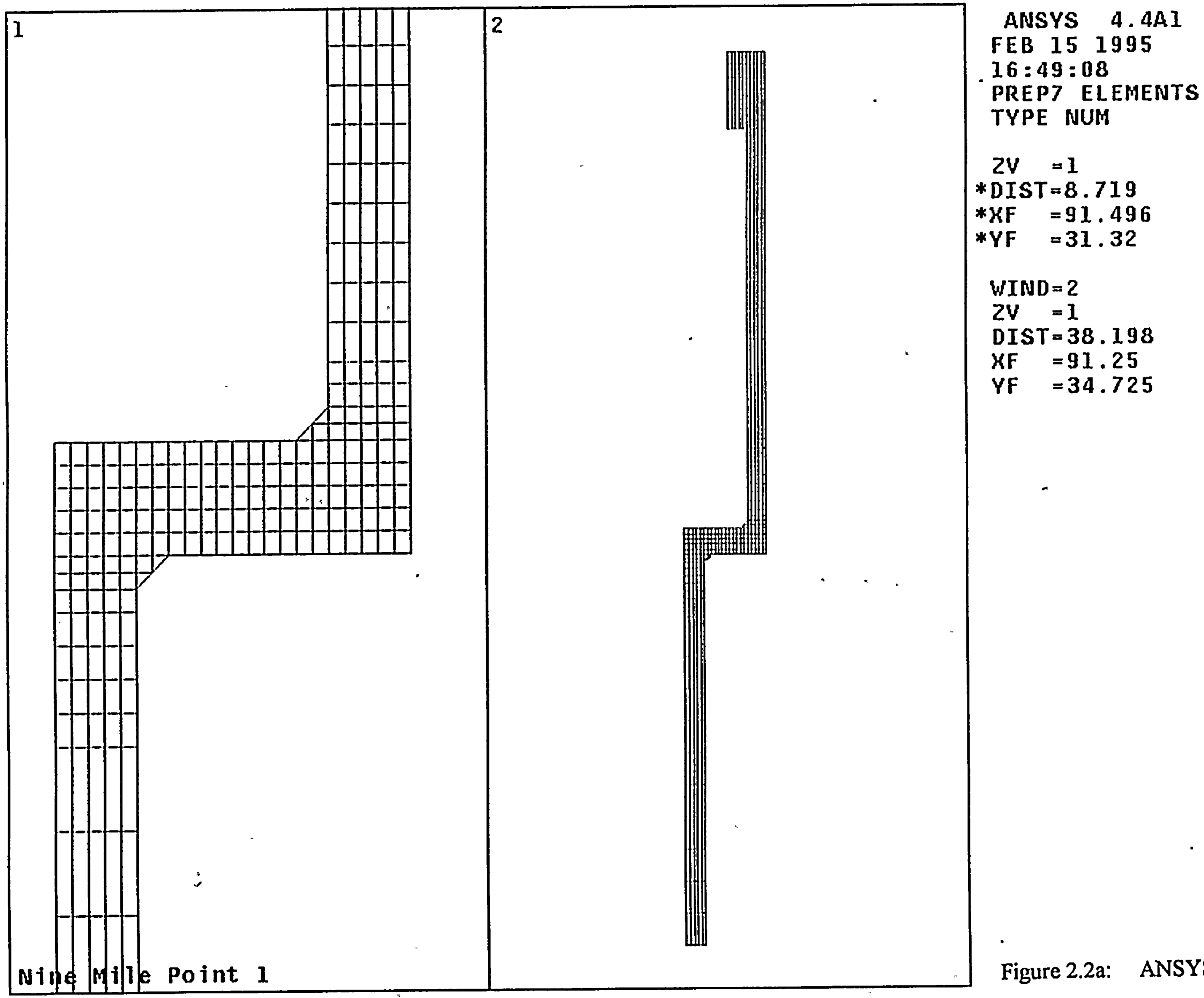

Figure 2.2a: ANSYS Mesh

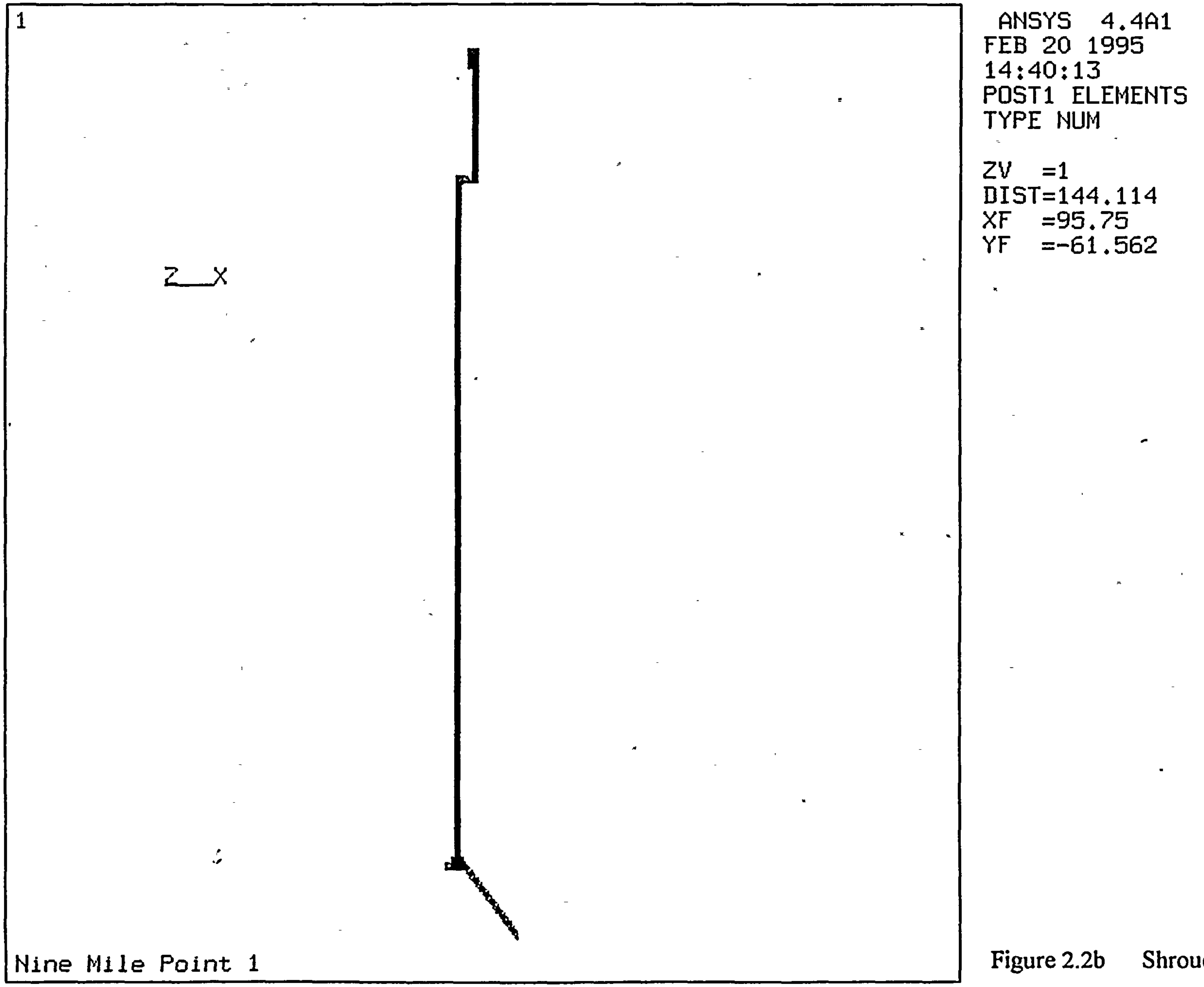

Figure 2.2b Shroud Model

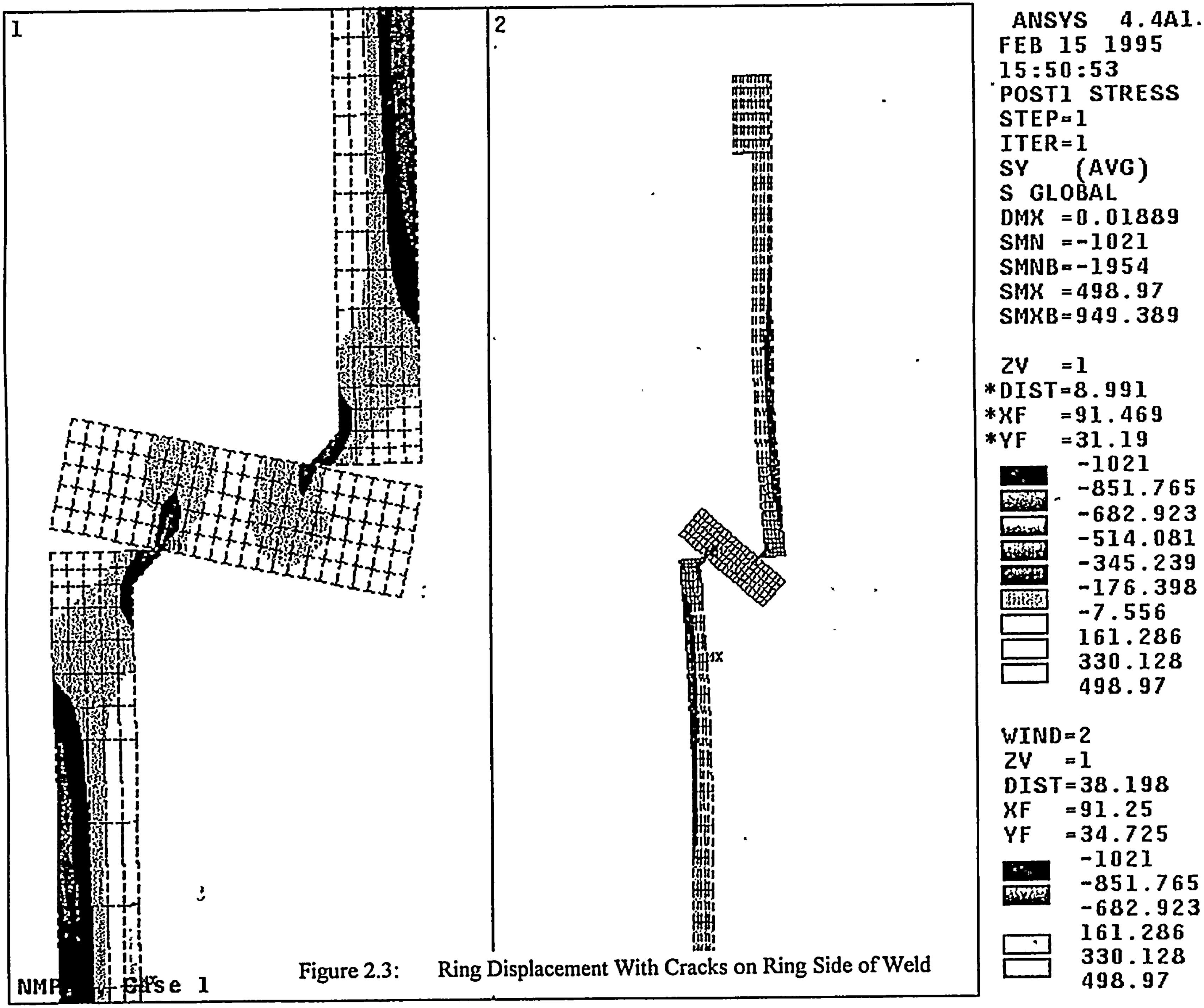

Figure 2.3: Ring Displacement With Cracks on Ring Side of Weld

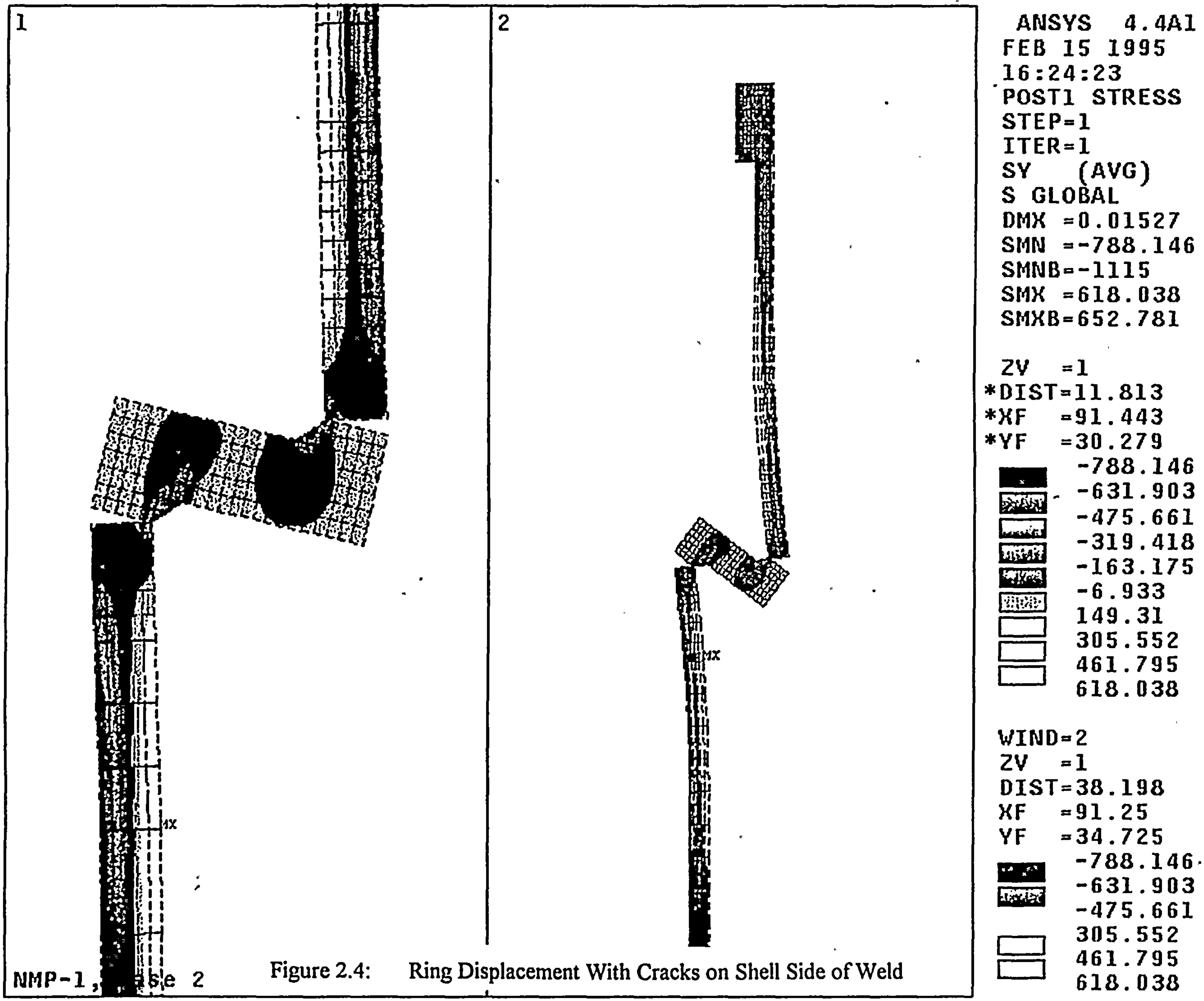

Figure 2.4: Ring Displacement With Cracks on Shell Side of Weld

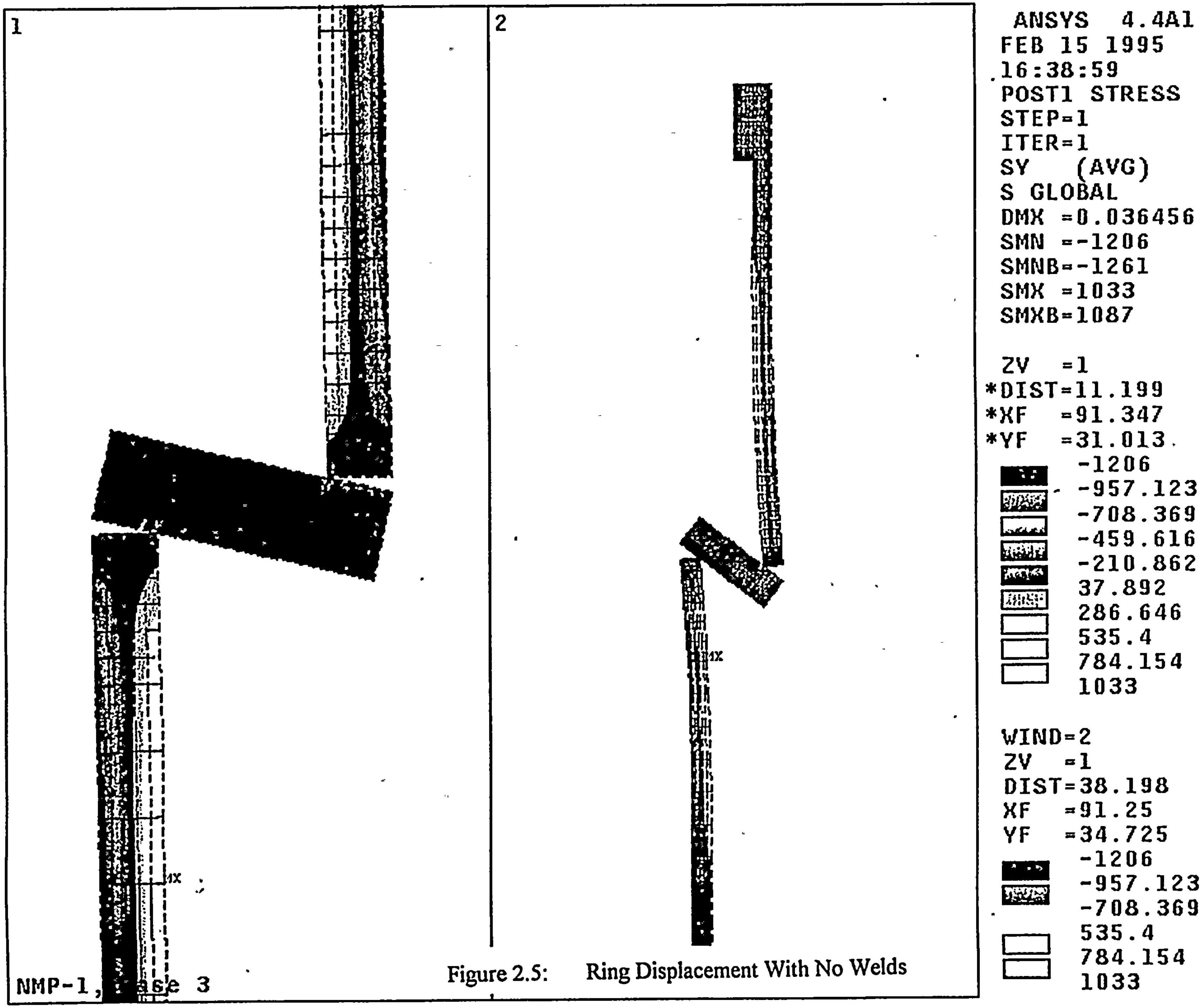

Figure 2.5: Ring Displacement With No Welds

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Legible • Reproducible • Reviewer/Verifier • Identifiable — Structure ...

Section B.

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SECTION C