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February 29, 2000

1CAN020009

U. S. Nuclear Regulatory Commission
Document Control Desk
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Subject: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
Modified Approach for Analyzing Repair of ANO-1 Hot Leg
Nozzle RC-1071/1072

Gentlemen:

In letter dated February 24, 2000 (1CAN020006), Entergy Operations requested an alternative repair in accordance with 10CFR50.55a(a)(3)(i) and (ii) for a reactor coolant system hot leg nozzle associated with root valves RC-1071/1072 for Arkansas Nuclear One, Unit 1 (ANO-1). A conference call was conducted between the NRC, Entergy Operations and Framatome Technologies, Inc. (FTI) on February 24, 2000, to discuss comments by the NRC Staff regarding our repair approach and the supporting analysis. An additional submittal was provided to the NRC on February 25, 2000 (1CAN020007), to respond to the NRC request for additional information. Upon confirmation of the information provided, the NRC Staff granted verbal acceptance of the alternate ASME Code repair requested by Entergy Operations on February 25, 2000. During preparation of the final weld package it was recognized that an additional flaw needed to be evaluated in the existing fillet weld. An additional submittal was made on February 28, 2000 (1CAN020008), which provided our revised results. The results documented in this submittal were discussed with the NRC in telephone conversations on February 28, 2000. It was determined that additional information was requested from Entergy Operations prior to receiving NRC approval.

In our February 28, 2000, submittal, a conservative stress intensity factor (K_I) was derived for the purposes of calculating a limiting crack growth rate into the new weld material. Utilizing this factor, the crack growth over a single fuel cycle was demonstrated acceptable. However, the NRC Staff questioned development of a stress intensity factor without development of an allowable material toughness value. Efforts to respond to this NRC Staff question were hampered by a lack of industry data for the specific material used in the welding process, largely because the ASME Code exempts this material from fracture toughness testing. The limited data that is

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available suggests favorable results, and shows significant margins at temperatures above 200 degrees. There is also some margin at lower temperatures, but due to the limited amount of data to support this approach, Entergy Operations has elected to show acceptability by using an alternate approach.

FTI calculation 86-5007275-01 (attached) concludes that meeting the primary stress limits of ASME Section III, NB-3221 satisfies the requirements that would be imposed by a limit load calculation of piping components allowed by ASME Section XI, IWB-3640. Per IWB-3641.2, the analytical procedures of ASME Section XI, non-mandatory Appendix C is used for limit load evaluation. This appendix was developed for piping systems where the primary loadings were either pressure stresses (for axial flaws with hoop stresses) or pressure plus global pipe bending stresses (for circumferential flaws).

For both orientations, the "flow stress" was established as three times the allowable stress intensity ($3S_m$) at temperature. For the axial flaws, a factor of safety of 3.0 was applied since this was consistent with the basic allowable stress factor of safety for ASME Section III, Class 1 components. For circumferential flaws, the factor of safety for the longitudinal stress was a composite equal to 2.77, since the allowable stress was increased by a factor of 1.5 for bending stresses. With these values of "flow stress" and factors of safety, the ASME Section XI code committee concluded that the margins were consistent with requirements from ASME Section III for piping component design conditions (Ref: Evaluation of Flaws in Austenitic Steel Piping, Journal of Pressure Vessel Technology, Volume 108, August 1986, pages 352 through 366). It is important to observe that there is no throughwall bending stress evaluation required for piping, whereas there is for vessels, where the allowable is $1.5S_m$.

Since the level tap nozzle repair weld is not for a standard pipe, it is appropriate to use $3S_m$ as the "flow stress" and apply a factor of safety of three to the resulting stress. By applying these two factors, the resulting allowable stress for the limit load analysis is S_m. Also, it is appropriate to consider only the membrane stresses through the thickness of the component since this is the basis of Appendix C. The FTI calculation shows that the conservatively calculated membrane stress in the piping (which included an equivalent bending load on the nozzle) is 16.9 ksi. This is less than the allowable membrane stress of 18.4 ksi. For piping components, the membrane plus bending stresses at the sections evaluated in the FTI calculation do not have to be evaluated.

Further, ASME Section XI IWB-3642 provides alternate criteria for evaluation based on applied stress. The flaws are acceptable if the evaluation procedures provide a safety factor of 3 for normal operating conditions and a factor of 1.5 for emergency and faulted conditions. Since FTI used ASME Section III allowable stresses (which already include a safety factor of 3.0), their analysis shows that IWB-3642 is met.

The analysis conducted by FTI reported results for allowable membrane stress at the worst location in the deposited weld material and adjacent piping (see Section 1 in Figure 3 included in the attachment). The FTI calculation used an allowable stress of S_m = 18.4 ksi (associated with the adjacent pipe material at Section 1). The allowable stresses for Alloy 690 (SB-166/167/168, UNS N06690) from Code Case N-525 (Approved December 9, 1993) is S_m = 20.0 ksi, at all temperatures up to 800°F. Thus, the flow stress could be taken as 60.0 ksi at all temperatures. Therefore, additional margin exists in the austenitic weld overlay material adjacent to the flaws remaining in the underlying weld material. Code Case N-525 has not received NRC approval, however the allowable stress values are more conservative than those contained in previously approved Code editions for similar UNS N06690 materials.

The NRC Staff also requested that Entergy Operations provide additional information related to the welding procedures and qualifications, with special attention to compliance with applicable ASME Code requirements and the post weld heat treatment (PWHT) requirements and/or use of temper bead processes. As previously noted, the repair was performed using FTI welding procedures and welders certified under their program for this welding application. This letter affirms that FTI performed the welding to documented procedures which govern the methods used to qualify welding procedures and personnel, in accordance with ASME Section IX 1992 Edition with no Addenda and any additional requirements of Section XI of the ASME Code 1992 Edition with no Addenda.

Additionally, the nozzle repair consists of a 3/4" thick structural weld overlay with an unequal leg fillet weld added for nozzle reinforcement. These welds were applied over an existing F43 material (0.375" J-groove and 0.250" fillet configuration) and a carbon steel (P1) base material. The unequal fillet weld size is 1.5625" by 0.875" with the longer leg being adjacent to the Nickel-based alloy nozzle (P43).

As referenced in inquiries III-1-83-227 and III-1-83-186 the requirement for PWHT is addressed separately for each of the two weld configurations (the weld overlay and the fillet weld).

PWHT of the Structural Overlay - ASME Section III does not specifically establish PWHT requirements for weld pads or overlays. However, a conservative approach using the requirements established in NB-4622.7(b) and Table NB-4622.7(b)-1 for a groove weld has been applied, and it is determined that PWHT is not required if a 200°F preheat is performed. All welding was performed in accordance with ASME Section III and preheat was maintained during the initial 0.187 inches of deposit to prevent a negative affect on the P1 base material. Welding above this thickness did not require preheat maintenance because the heat affected zones of subsequent weld passes are entirely included within the F43 weld material. The weld pad is a repair weld applied on top of the existing weld (F43) and carbon steel (P1) materials, and there is no weld groove or weld preparation. Therefore, the nominal thickness for this repair weld is the 3/4" weld pad thickness that is compared to a weld groove depth as described in NB-4622.3.

PWHT of the Fillet Weld - In accordance with NB-4622.3, the nominal thickness governing PWHT requirements for fillet welds is the throat thickness. The throat thickness of the subject weld is 0.62" (0.875" x 0.707") which is less than the 0.750 inches that would require PWHT, and is therefore, exempt from PWHT provided a 200°F preheat is performed. Additionally, the fillet weld is actually being applied to the structural overlay and the nozzle of which both are nonferrous materials and further exempted by NB-4622.7(a) thus not requiring the 200°F preheat.

Please notify me if you require any additional information.

Very truly yours,

Jimmy D. Vandergrift
Director, Nuclear Safety Assurance

JDV/sab
Attachment

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Framatome Technologies

Calculation Summary Sheet

Analysis of ANO-1 Hot Leg Nozzle Weld Pad Build-up Repair

86-5007275-01

FRAMATOME TECHNOLOGIES

CALCULATION SUMMARY SHEET (CSS)

Document Identifier 86 - 5007275 - 01

Title ANALYSIS OF ANO-1 HOT LEG NOZZLE WELD PAD BUILDUP REPAIR

PREPARED BY:		REVIEWED BY:	
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SIGNATURE	H T Harrison	SIGNATURE	G. L. Weatherly
TITLE	PRINCIPAL ENGR. DATE 2-29-00	TITLE	PRINCIPAL ENGR. DATE 2/29/00
COST CENTER	41020 REF. PAGE(S) 2	TM STATEMENT: REVIEWER INDEPENDENCE	ADM

PURPOSE AND SUMMARY OF RESULTS:

Purpose:

Due to observed leakage of the Hot Leg Level Tap Nozzle connection in the Hot Leg elbow (at ANO-1; approx. elev. 368'-4 11/16"; attached to valves RC-1071 & RC-1072), a repair has been designed [see Ref. 2]. The structural adequacy of the repair configuration is demonstrated in Reference 1. Reference 1 includes the qualification of the repair for the Primary Stress criteria of sub-section NB-3200 of the ASME Code, Section III, 1989 edition w/o addendum. The document herein transmits the results of the analysis for Primary Stresses.

See following page for description of the analysis.

Conclusion:

The structural analysis of the ANO-1 Hot Leg Nozzle Weld Pad Buildup Repair (Ref. 1) demonstrates that the repair meets the Primary Stress criteria of sub-section NB-3200 of the ASME Code, Section III, 1989 edition w/o addendum.

See following page for results of the analysis.

THE FOLLOWING COMPUTER CODES HAVE BEEN USED IN THIS DOCUMENT:		THE DOCUMENT CONTAINS ASSUMPTIONS THAT MUST BE VERIFIED PRIOR TO USE ON SAFETY-RELATED WORK
CODE/VERSION/REV	CODE/VERSION/REV	☐ YES ☒ NO

ANALYSIS OF ANO-1 HOT LEG NOZZLE WELD PAD BUILDUP REPAIR

References:

1) FTI Document 32-5007262-00, "Analysis of ANO-1 Hot Leg Nozzle Weld Pad Buildup Repair"
2) FTI Drawing 02-5007223C-1, "Hot Leg Nozzle Weld Pad Buildup Repair" as modified by Special Instruction No. 39-5007319-00 & 01

Purpose:

Due to observed leakage of the Hot Leg Level Tap Nozzle connection in the Hot Leg elbow (at ANO-1; approx. elev. 368'-4 11/16"; attached to valves RC-1071 & RC-1072), a repair has been designed [see Ref. 2]. The structural adequacy of the repair configuration is demonstrated in Reference 1. Reference 1 includes the qualification of the repair for the Primary Stress criteria of sub-section NB-3200 of the ASME Code, Section III, 1989 edition w/o addendum. The document herein transmits the results of the analysis for Primary Stresses.

Analysis:

The analysis of the repair design for Primary Stresses includes the following features –

a) The structural analysis is performed using the finite element method (using the ANSYS FE program)
b) An axisymmetric analytical model is employed – including Hot Leg Pipe, cladding, nozzle, original J-groove/fillet configuration and the repair weld pad/fillet welds
c) The Hot Leg Pipe is modeled as a spherical segment with adjusted (increased) pressure to conservatively simulate the stress levels in the Hot Leg elbow
d) The pressure is applied to all internal surfaces including the perimeter of the original welds (i.e., effectively the original welds are considered as non-existent or void)
e) No structural strength is credited to the original J-groove/fillet welds
f) No structural strength is credited to the weld layer necessary to achieve 'PT clear'
g) Both the run pipe (Hot Leg elbow) moments and branch pipe (Level Tap Nozzle) loads are conservatively applied to the FE model in conjunction with the internal pressure
h) The Design Condition load combination of 'Design Pressure @Design Temperature + Deadweight + Operating Basis Earthquake' is analyzed as the limiting condition for Primary Stresses. (Consideration of the relative magnitudes of the loads associated with Emergency, Faulted and Test conditions and their respective allowable stresses verifies that they are bounded by the Design Condition.)
i) Computer generated stresses are post-processed to obtain 'membrane' and 'membrane+bending' stresses for direct comparison to ASME Code allowables (i.e., NB-3200 Primary Stress criteria)

Results:

The ANSYS FE analysis for the limiting Design Condition load combination yields the following key results –

Maximum Primary Membrane Stress Intensity = 16.9 ksi < 1.0 Sm = 18.4 ksi
(Hot Leg pipe/Weld Pad interface -- ASME Code allowable)

Maximum Primary Local Membrane + Primary Bending Stress Intensity = 22.5 ksi < 1.5 Sm = 27.6 ksi
(Hot Leg pipe/Weld Pad interface -- ASME Code allowable)

Conclusion:

The structural analysis of the ANO-1 Hot Leg Nozzle Weld Pad Buildup Repair (Ref. 1) demonstrates that the repair meets the Primary Stress criteria of sub-section NB-3200 of the ASME Code, Section III, 1989 edition w/o addendum.

Note:

The present analysis demonstrates compliance with the Primary Stress limits of NB-3221. Per NB-3228.1, these limits may be exceeded if a limit analysis is performed. Therefore, satisfaction of NB-3221 is more conservative than a limit analysis.

Prepared by: Date:

Reviewed by: Date:

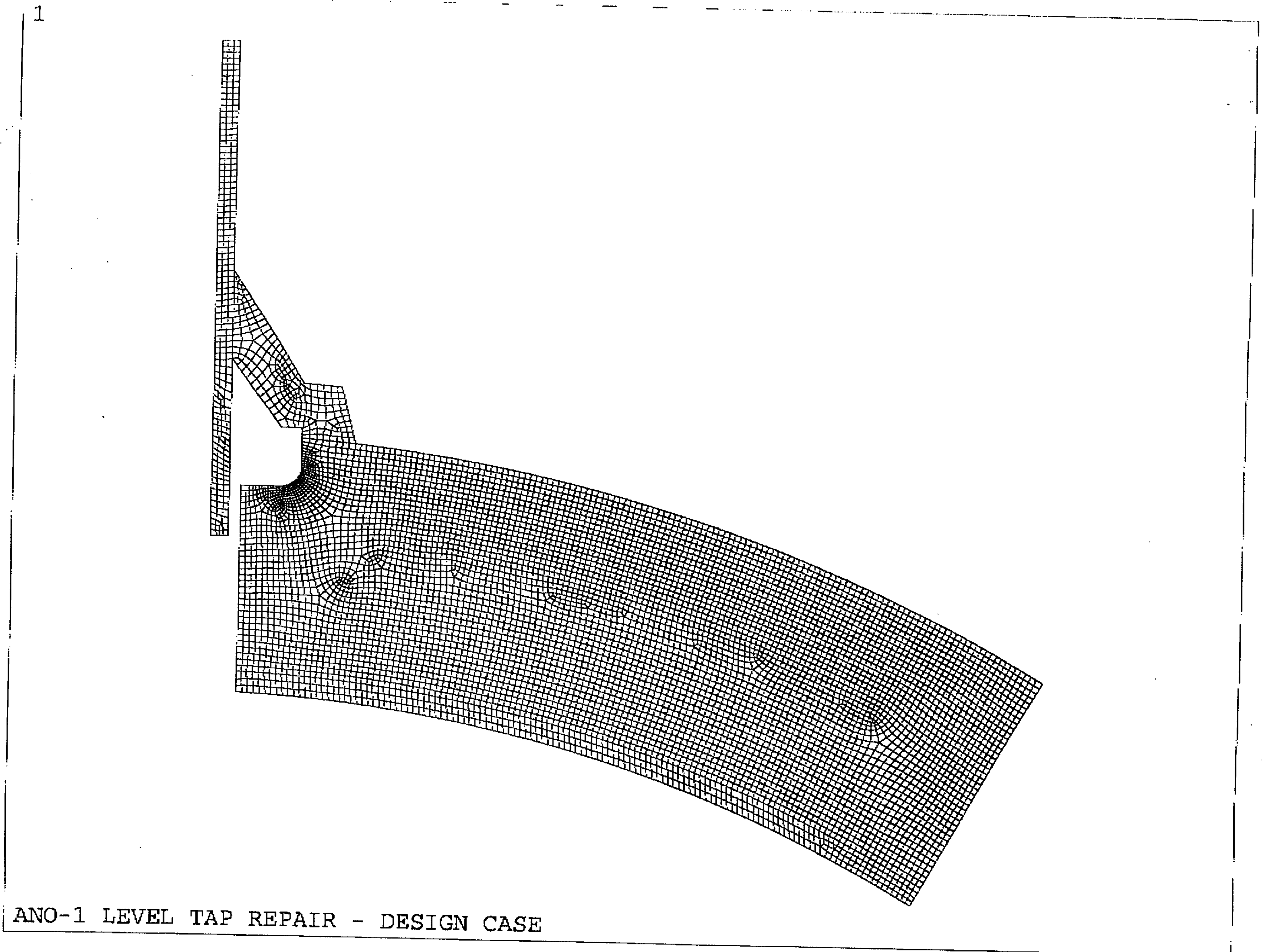

Figure 1

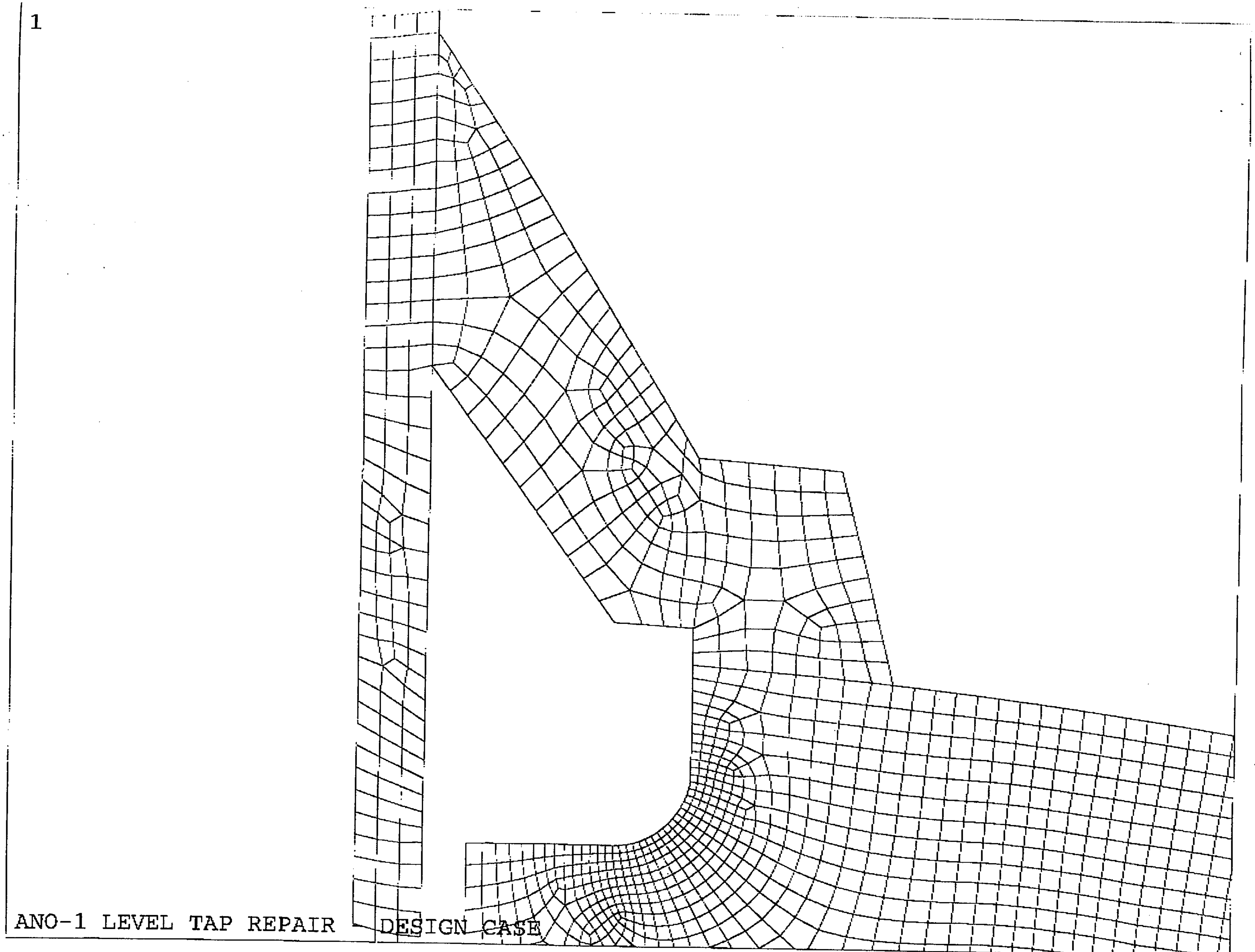

Figure 2

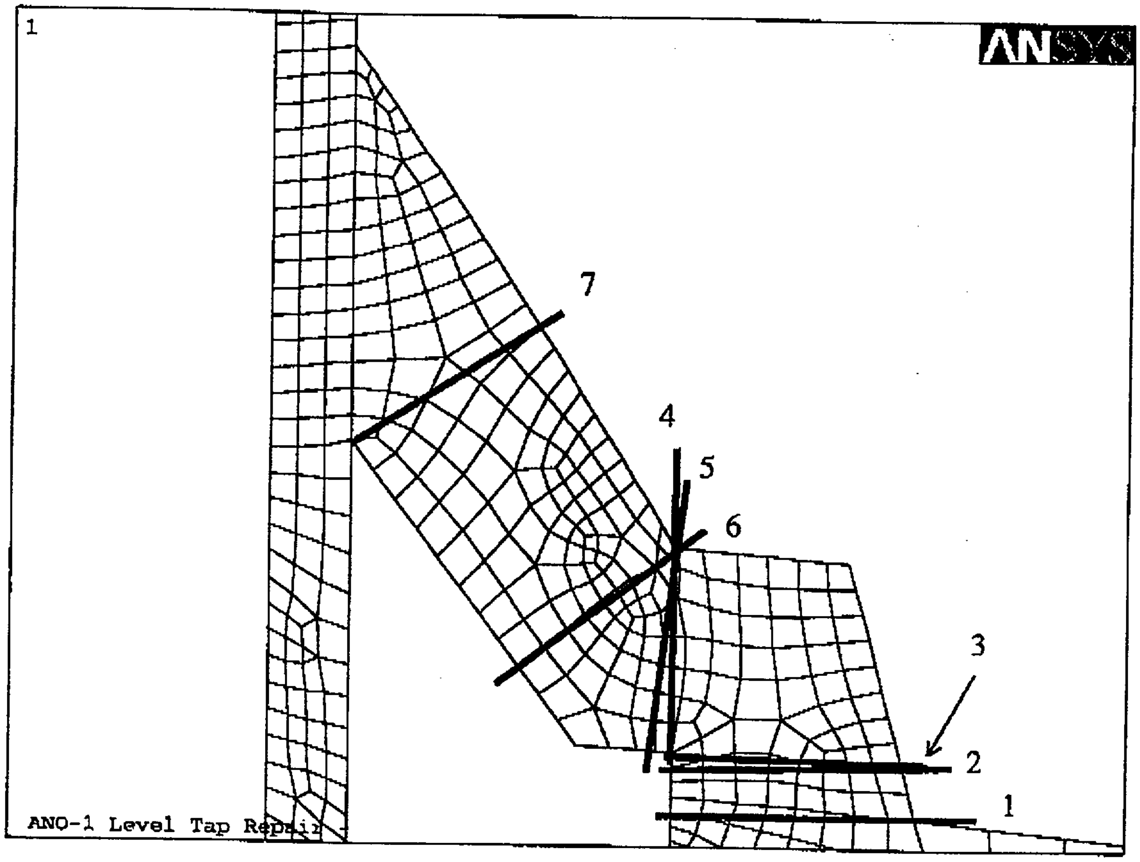

Figure 3