NRC FORM 195 (2-76)

U.S. NUCLEAR REGULATORY COMMISSION

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DOCKET NUMBER: 50-250/251

FILE NUMBER:

TO: Mr. George Lear

FROM: Florida Power & Light Company, Miami, Florida, Mr. Robert E. Uhrig

DATE OF DOCUMENT: 2/2/77

DATE RECEIVED: 2/7/77

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DESCRIPTION

Ltr. re our 1/25/77 ltr. and their 1/21/77 ltr.... trans the following:

PLANT NAME: Turkey Point Units 3 & 4

(1-P)

ENCLOSURE

Consists of supplemental information concerning Steam Generator Tube Integrity...

(9-P)

ACKNOWLEDGED

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P. O. BOX 013100, MIAMI, FL 33101
FLORIDA POWER & LIGHT COMPANY

February 2, 1977
L-77-40

Office of Nuclear Reactor Regulation
Attention: Mr. George Lear, Chief
Operating Reactors Branch #3
Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

RECEIVED FEB 7 1977 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

Dear Mr. Lear:

Re: Turkey Point Units 3 and 4
Docket Nos. 50-250 and 50-251
Steam Generator Tube Integrity
Supplemental Information

Your letter of January 25, 1977 formally requested additional information regarding steam generator tube integrity at Turkey Point. All of the questions in your letter have been answered by our submittals L-76-432, L-76-434, L-77-3, and L-77-30.

Subsequent to your January 25 letter, we received two additional questions from your staff. The answers to the two additional questions are attached.

As stated in our letter L-77-29 of January 21, 1977, Florida Power & Light Company has submitted considerable information on the subject of steam generator tube integrity as it applies to Turkey Point Units 3 and 4. Based on the information we have submitted through today, we request that you grant approval for continued operation of Turkey Point Unit 4 beyond the time limit specified in Amendment 20 to Operating License DPR-41. Based on our operating history from December 3, 1976 to date, and assuming continued operation at 100% rated power, we will reach the limit on February 9, 1977. Because of load management and operational considerations, we would like to have your approval by 5:00 p.m. on February 8, 1977.

Very truly yours,

Robert E. Uhrig

Robert E. Uhrig
Vice President

DOCKETED USNRC 2/7/77 U.S. NUCLEAR REGULATORY COMMISSION Mail Section

1286

REU/MAS/cpc
Attachment
cc: Mr. Norman C. Moseley, Region II
Robert Lowenstein, Esquire

ATTACHMENT

Turkey Point Units 3 & 4
Steam Generator Tube Integrity
Supplemental Information

Support Plate Expansion

a.) We have correlated support plate expansion with actual months of operatic by means of a finite element model which utilizes a pseudo-thermal expansion technique. This technique has been used to simulate plate behavior up to full closure and several months beyond. The expansion has been correlated with actual months of operation. In order to do this, relationships between field data, effective months (EM's), and results of the finite element anlysis must be established. Since the denting phenomenon extends over the entire plate, there is good correlation between measured denting and expansion of a dented plate. Although our finite element model is not detailed enough to yield denting rates, it does quantify the extent of flow slot closure for a prescribed expansion rate. Since the amount of closure over an extended period of EM's is available from field data, a relationship between model closure and EM's can be established. The rate of expansion is independent of boundary effects, insertion of blocking devices, and time

The procedure for calculating the rate of expansion per EM is as follows

For a plate expansion of .014 (hot leg)/.010 (cold leg) in/in applied to the updated plate model (Figure 1)* the average flow slot closure is .675 inches.

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* The model shown in Figure 1 is for a 51 top support plate. Several comments are necessary regarding applicability of this model to a 44 bottom support plate. With regard to the differences between a 44 and 51 plate all significant parameters are approximately 5% smaller for a 44 than a 51. Thus, the two plates are virtually identical with regard to relative parameters and 5% different in overall size. The effect of this on our results would be insignificant. The bottom plate is support differently than the top plate in both units. However, the difference can be accounted for by transposing support locations about the diameter perpendicular to the tube lane. This can be accomplished simply by flipping the results of the finite element analysis. That is, if we number the flow slots in the model as 1-6 from left to right for the top plate, they become 6-1 for the bottom plate.

For the actual plate the maximum (most conservative) rate of closure for a bottom support plate flow slot is

.24 inches/EM

Thus .675 inches of closure represents

2.8 EM's

and the plate expansion equivalent of a single month is

$\frac{.014}{2.8}$ = ..005 in/in on the hot leg side and

$\frac{.010}{2.8}$ = .0036 in/in on the cold leg side.

The hot and cold leg expansions will be denoted as follows: .005/.0036 in/in

Based on field data taken during the last outage, the average opening was 1.5". Using a rate of closure of .24 in/month, the expected opening at the end of the current 2 month period is 1.0". This is equivalen to a 1.75" average closure. Figure 2 shows the strain intensity plots for the plate at an average closure of 1.75", and a pseudo-thermal expan sion of .041/.029 in/in.

The rate of plate expansion occurs on a very local level and will not change after complete closure of the flow slots. Thus, for each additional month of operation beyond closure, an additional plate expansion of

.0050/.0036 in/in

should be utilized.

Our results show closure occurring at

.064/.046 in/in expansion.

Thus, based on the expansion rate of

.005/.0036 in/in/month

the number of operating months between the current closure (at two montl subsequent to the December start-up) and full closure is

4.6 months.

More conservatively, we can consider the worst slot which had an openinc 7/8" at the last inspection as being representative of all slots. The expected time to full closure for that slot is

$$(.875 - 2(.24))\,1.24 = 1.6 \text{ EM's}$$

beyond the end of the current two effective month period.

Figure 3 shows the strain intensity plots for the plate with an expansion of

$$.081/.058 \text{ in/in}$$

or 3.4 EM's after closure.

The two plots indicate that while expansion continues, the continued operation to closure, then more than 3 EM's beyond that, does not alter the strain intensity patterns. That is, the areas of excessive hard spots are currently well bounded, and will remain so for more than 5 months additional operation.

NOTE: An "effective month" is defined as operation of the reactor coolant system above 350 F.

Tube Loading

In order to quantify the additional load on the tubes due to the possible tendency of the plate to buckle after full closure, it is necessary to determine the load required to prevent buckling of the support plate. We have combined two analyses from Timoshenko's "Theory of Elastic Stability" to arrive at a very conservative load, which is still quite small.

Consider the case which generates the highest in-place load before buckling occurs, and therefore would require the largest transverse load to prevent buckling. This is the case of a circular plate with clamped edges. From Timoshenko, page 390:

$$(N_r)_{cr} = \frac{14.68\ D}{a^2}$$

where

$$D = \frac{E^* h^3}{12(1-\nu^{*2})}$$

$$\nu^* = .42\nu$$

$$a = 58''$$

$$h = .75''$$

$$(N_r)_{cr} = 1215 \text{ lbs/in.}$$

Now let us consider a unit strip with clamped edges of length 2a

$$N_{cr} = \frac{\pi^2 D}{a^2} \qquad \text{(Timoshenko, page 390)}$$

$$= 817 \text{ lbs.}$$

For the case of a beam on an elastic foundation (Timoshenko, page 94):

$$N_{cr} = \frac{\pi^2 E^* I}{L^2}$$

where

$I = 1/12\ bh^3 = 1/12\ (1)\ (.75)^3 = .035\ in^4$ for a 1" strip of plate.

L = "reduced" length of the strip or beam as described on pages 96 and 97 of Timoshenko.

$$L = \sqrt{\frac{\pi^2 E^* I}{N_{cr}}} = 59.5"$$

The actual length in question is

$$\ell = 2a = 116"$$

and

$$L/\ell = .51$$

is the ratio of the "reduced" or equivalent beam length to the actual length. The reduction is due to the effect of the transverse support on the beam, in our case created by the tubes. Table 2-5 in Timoshenko relates this ratio to the force per unit length of the beam for a unit deflection β. The stiffness of the tubes is such that the most conservative evaluation of tube loads would not cause axial deformation of 1". Thus, assuming a 1" deflection in order to calculate the reactive force is conservative. From Table 2-5 for $L/\ell = .51$:

$$\beta \ell^4/16\ E^*\ I = 18.5$$

$$\beta = \frac{18.5 \times 16 \times 7.8 \times 10^6 \times .035}{116^4}$$

$$= .45 \text{ lbs per linear inch}$$

for a 1" strip or

$$.45 \text{ lb/in}^2$$

For the whole plate this translates into

4755 lbs.

If we add a further conservatism and assume that only 100 tubes take all of the load, the load per tube is

48 lbs/tube.

However, let us go one step further in the direction of conservatism and use a buckling load of 1215 pounds from the circular plate results, but use the strip model to obtain β.

$$L^2 = \frac{\pi^2 \times .26 \times 30 \times 10^6 \times .035}{1215}$$

$$L = 47.1"$$

$$L/\ell = .42$$

$$\beta = \frac{50}{18.5} \times .45 = 1.22 \text{ lbs/in}^2$$

and the total load on the tube bundle is 12,850 pounds.

Again, assuming that only 100 tubes interact, the load per tube is

129 lbs/tube

This translates into a stress of

$$129/\pi(.4375^2 - .3875^2)$$

or

1,000 psi

Model Characteristics

1. Hot/Cold Side Expansion Bias
2. Improved Perforated Area Material Behavior (Anisotropic)
3. Elastic Behavior of Channels at Support Locations
4. Wrapper Stiffness Incorporated at Periphery

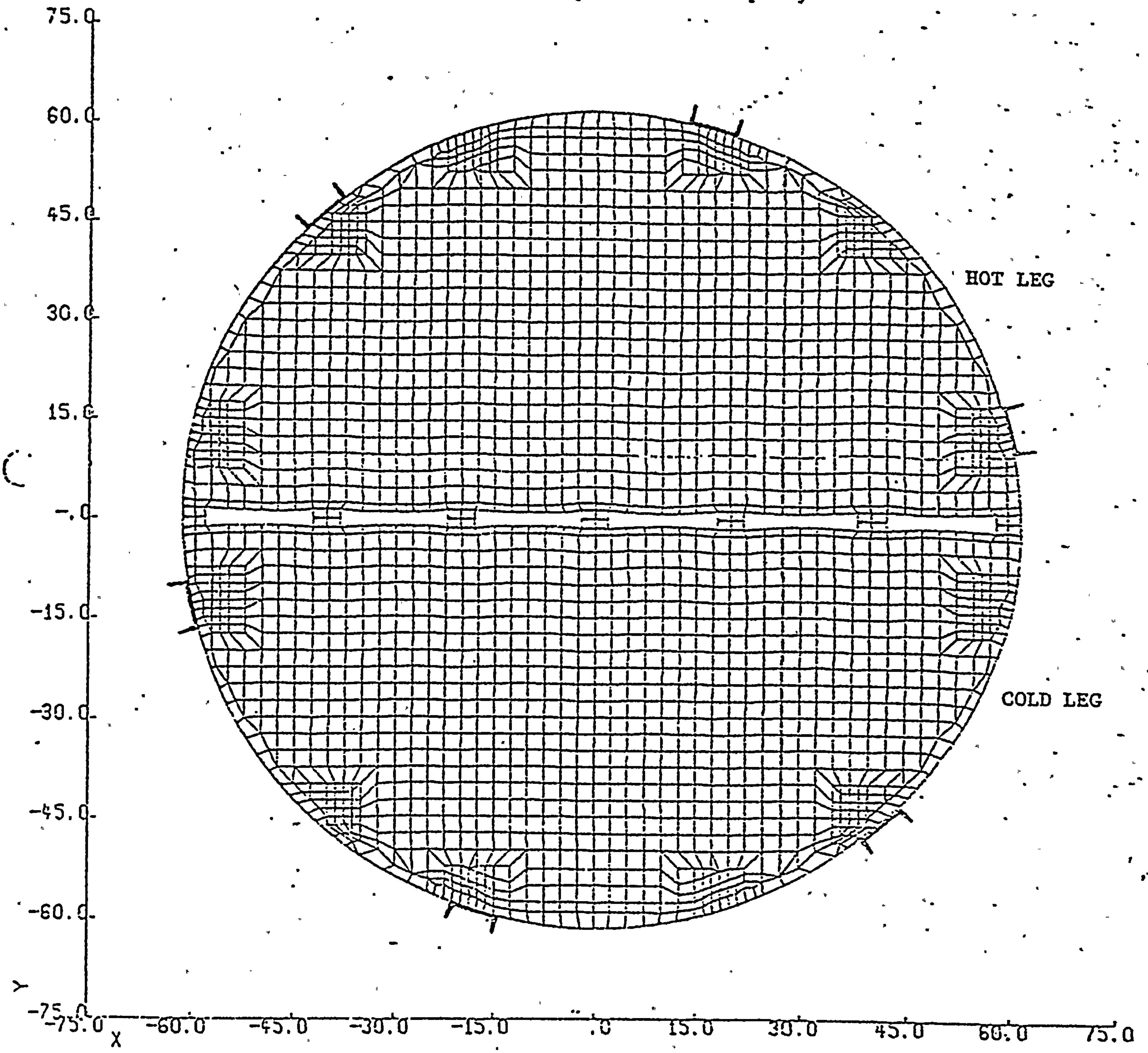

Figure 1. Finite Element Model.

CONTOURS REPRESENT % OF MAXIMUM STRAIN INTENSITY:

1-10%
2-50%
3-60%
4-70%
5-80%

:041/.029 in/in Expansion Load

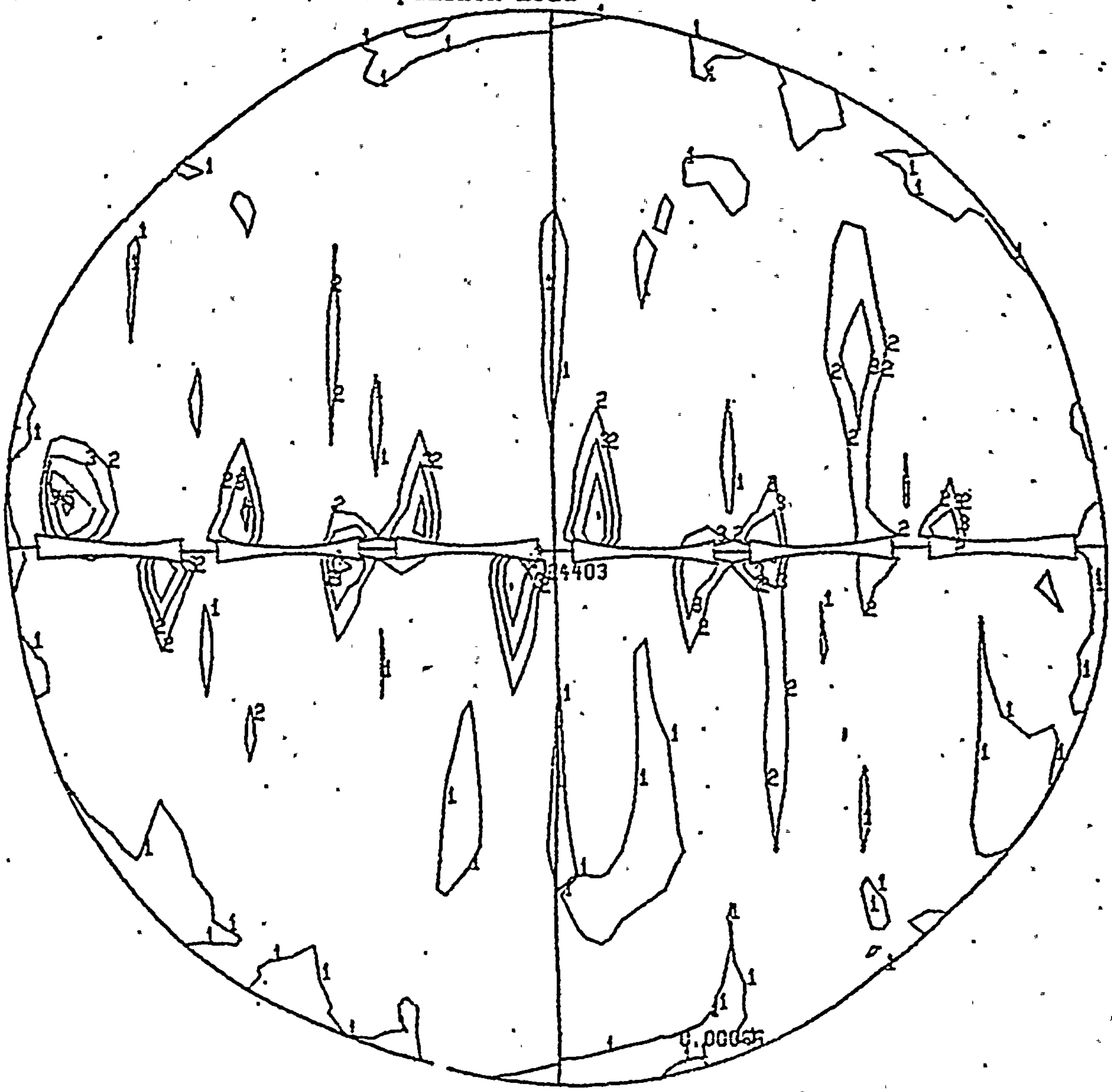

Figure 2. In-Plane Strain Intensity At 1.75" Closure.

CONTOURS REPRESENT % OF MAXIMUM STRAIN INTENSITY:

1-10%
2-50%
3-60%
4-70%
5-80%

.081/.058 in/in Expansion Load

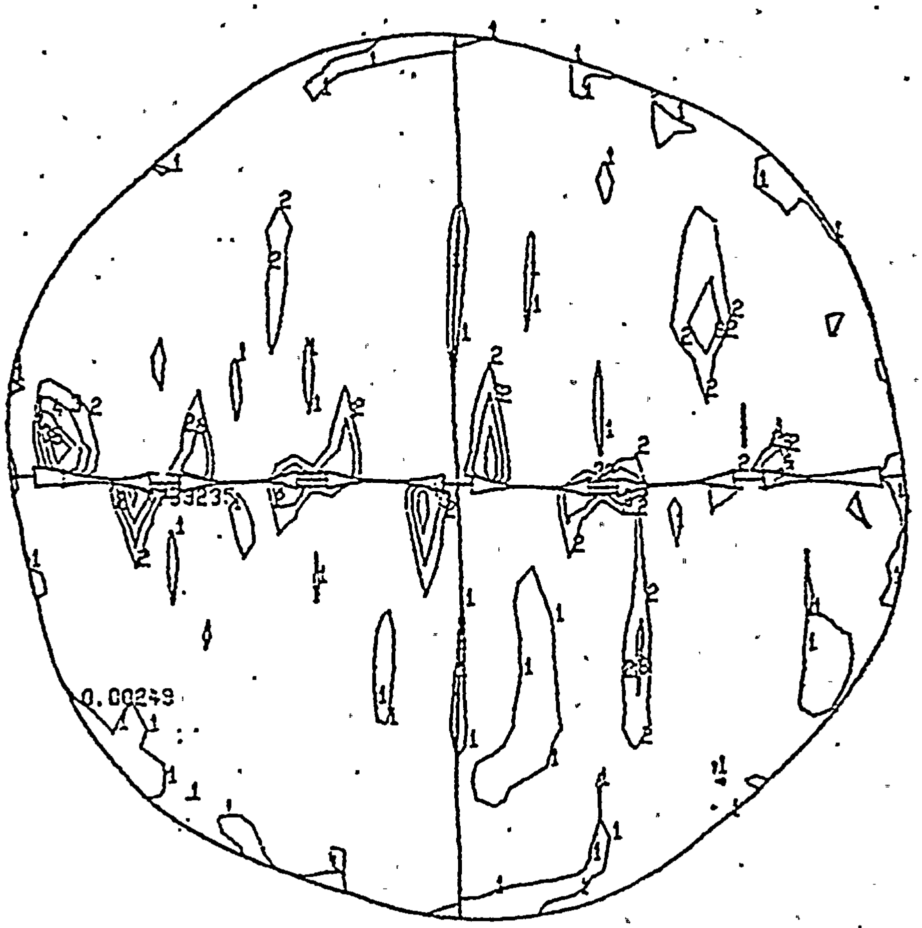

Figure 3. In-Plane Strain Intensity 3 Months After Closure.