PHILADELPHIA ELECTRIC COMPANY

CRACK GROWTH ANALYSIS

OF

PEACH BOTTOM UNIT 2

RESIDUAL HEAT REMOVAL FLAW

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General Electric

Figure 1 shows the weld residual stress and applied stress distribution used in the evaluation. The weld residual stresses are typical of large diameter piping. The applied sustained stress (pressure + weight + thermal stress) was 13 Ksi. Table 1 shows the detailed values of the stresses (sustained and Pm + P6) obtained from the Bechtel Report for the RHR piping.

Figure 2 shows the crack profiles in the pipe as well as elbow side of the weld 10-0-6. A conservative value of 0.3 in. was used for the average crack depth in the pipe. This is consistent with the limit load approach used in the analysis since the allowable crack size is based on average depth (or area) rather than the maximum depth. Because of the more extensive cracking, the crack on the pipe side was more limiting.

Figure 3 shows the crack growth rate data used in the analysis. Curve #1 represents the upper bound for weld sensitized material and Curve #2 is the upper bound for Furnace Sensitized material. Crack growth analysis was done for both cases.

Figure 4 shows the stress intensity factor vs. non-dimensional crack depth for a 360 degree circumferential crack under the influence of the combined residual stress + applied sustained stress of 13 Ksi.

Figure 5(a) shows the crack depth as a function of time assuming upper bounding crack growth rate for weld sensitized material. The final flaw size after 4000 hours ($\simeq$ 6 months) is a_f/t = 0.42. This is also shown on the failure diagram (Pm + P6 = 0.6 Sm) in Figure 5(b). It is seen that the final crack size is well within the allowable value.

To provide a conservative upper bound value for the crack, growth analysis was also performed using the crack growth rate data for furnace sensitized material in 8 ppm oxygenated water. Figure 6(a) shows the crack depth as a function of time. The final flow size after 4000 hours is a_f/t = 0.608. This is shown on the failure diagram on Figure 6(b). Even with the very conservative assumptions on crack growth rate, the final flaw size is within the allowable value specified in the new Section XI Code Appendix X.

Based on the results of the analysis presented here, Continued operation for the next 6 months without repair can be justified for Peach Bottom 2.

TABLE 1

Peach Bottom 2 RHR Suction Line
Flaw Evaluation (Weld 10-0-6)

SUSTAINED STRESSES*
(For crack growth Evaluation)

Pressure -	5.8 Ksi
Dead Weight -	1.6 Ksi
Thermal Expansion -	5.7 Ksi
Total	$\simeq$ 13 Ksi

PRIMARY STRESSES
(For allowable flaw side determination)

Pressure -	5.8 Ksi
Dead Weight -	1.6 Ksi
Seismic -	2.1 Ksi
Total	9.5 Ksi

$$\frac{Pm + P6}{Sm} = \frac{9.5}{16.9} = 0.56 \text{ (Assume 0.6)}$$

Sm = 16.9 Ksi at 550 degrees F

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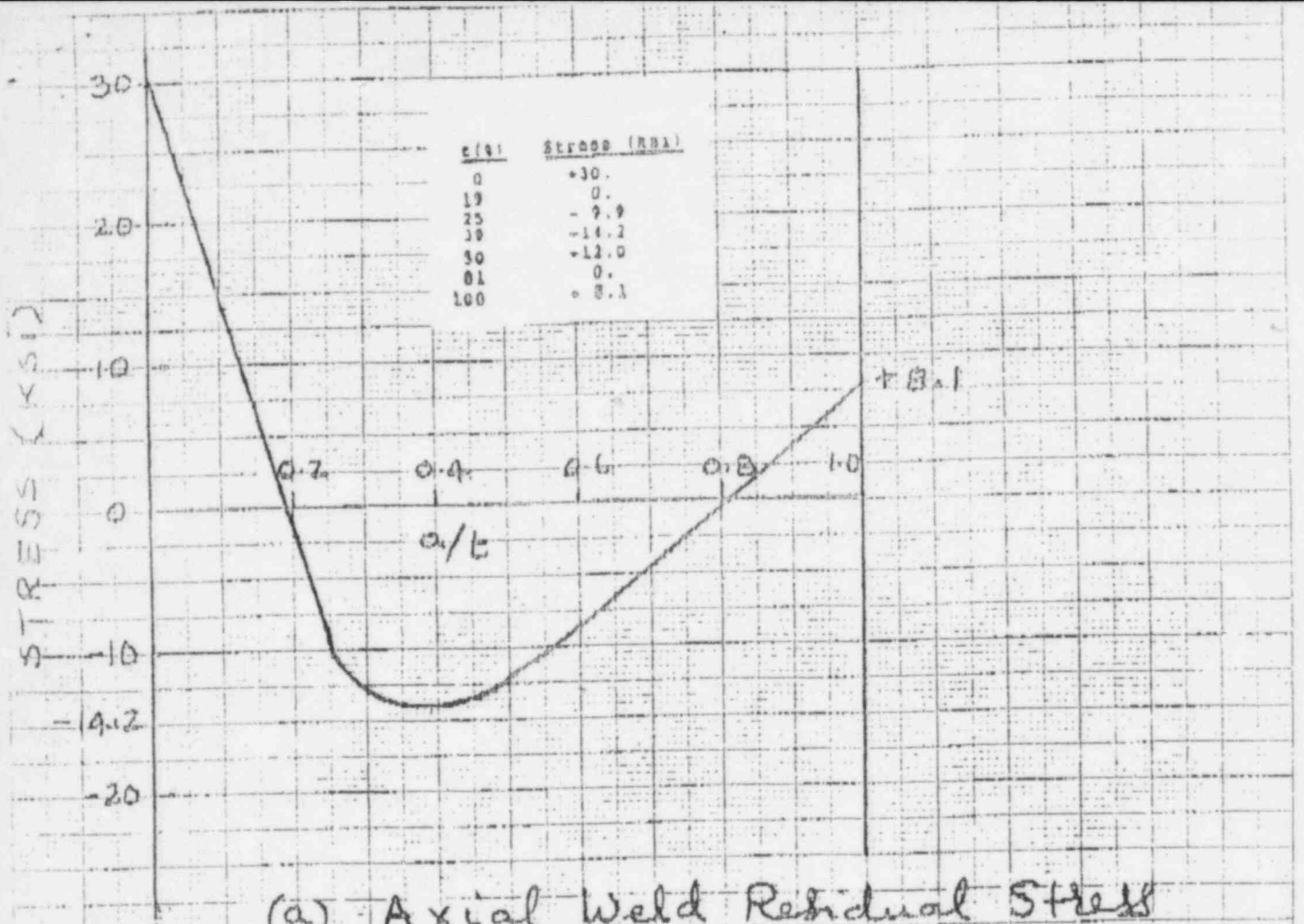
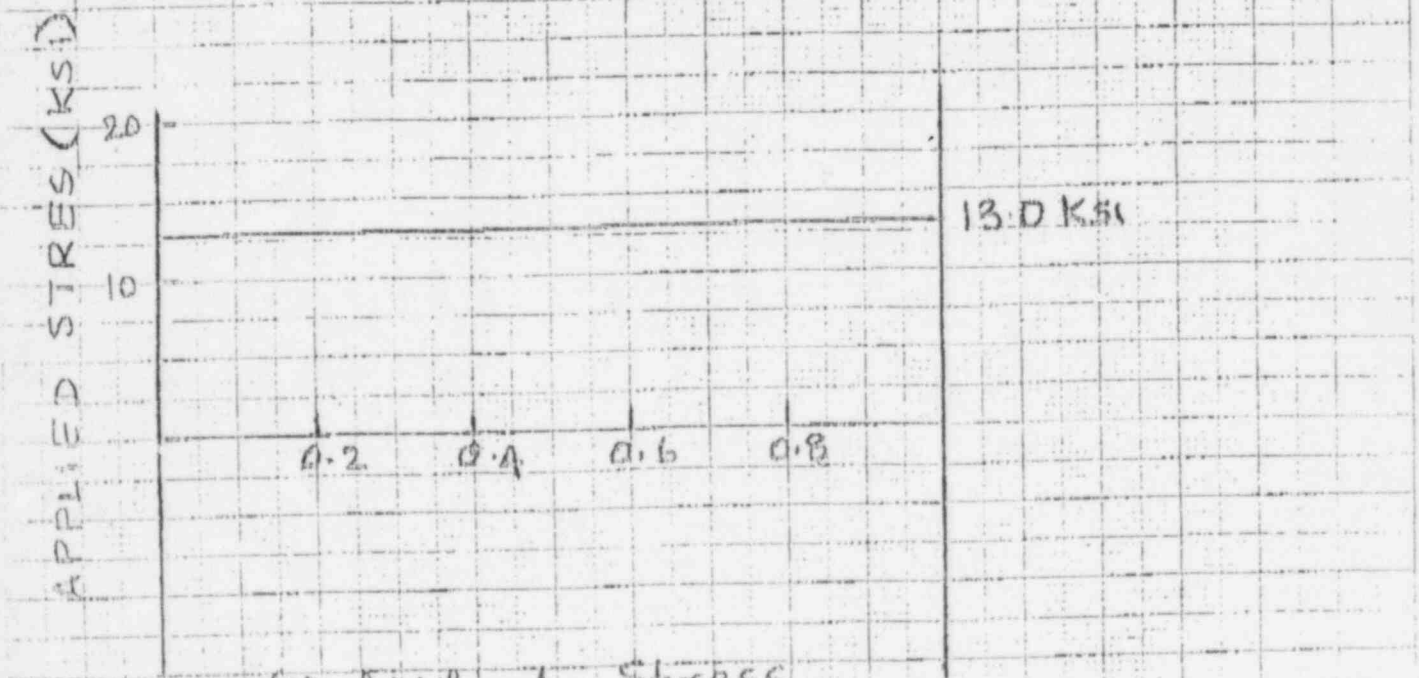
*Based on the Bechtel Stress Report. Adjusted for thickness (0.9 in. vs. 0.775 assumed in the Analysis)



(a) Axial Weld Residual Stress



(b) Applied Stress

Fig 1. Weld Residual Stress and Applied Stress Distribution Used in Evaluating Peachbottom 2 RHR Flaw Indications.

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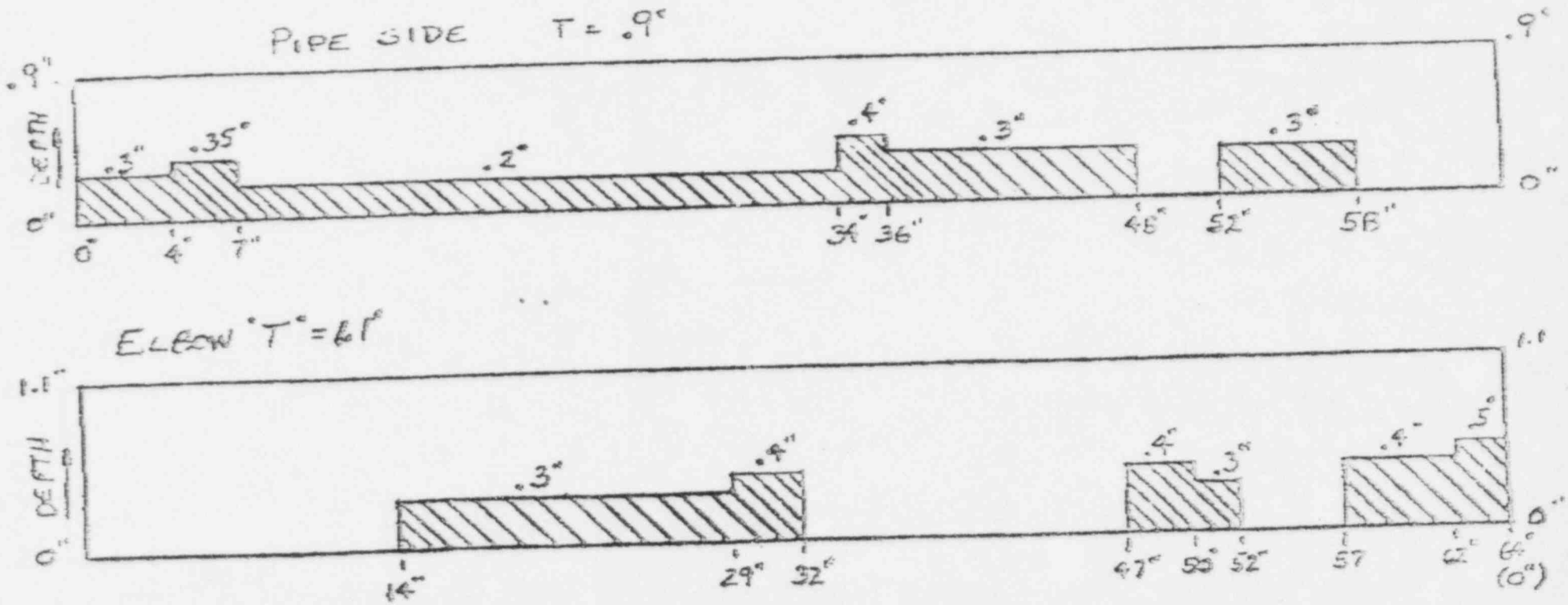
Fig 2.

Peach Bottom Unit #2
RHR Suction; Pipe to Elbow Weld: 19-0-6
20" diameter Access 64" circumference

Graphic Plot of the location and thru-wall depth of all ultrasonic indications, assumed to be cracks.



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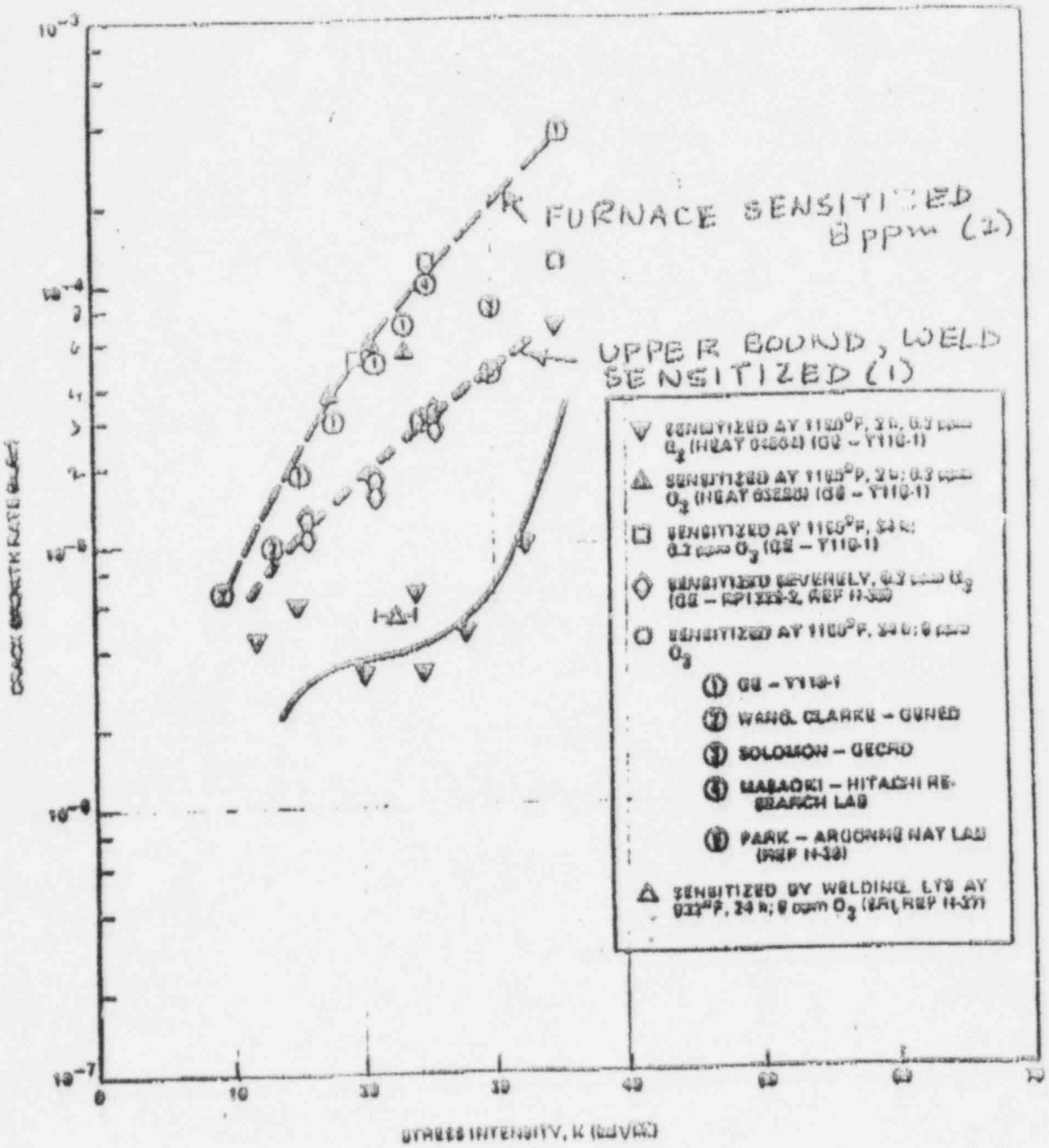


Figure 3. Summary of Constant Load Crack Growth Data (Curves are evaluation curves.) Data collected in 0.2 ppm O_2 and 8 ppm O_2 water. Different levels of sensitization examined.

Figure 4: Stress Intensity Factor vs. Non-Dimensional Crack Depth (Large Pipe Residual Stress + 13 KSI Applied Stress)

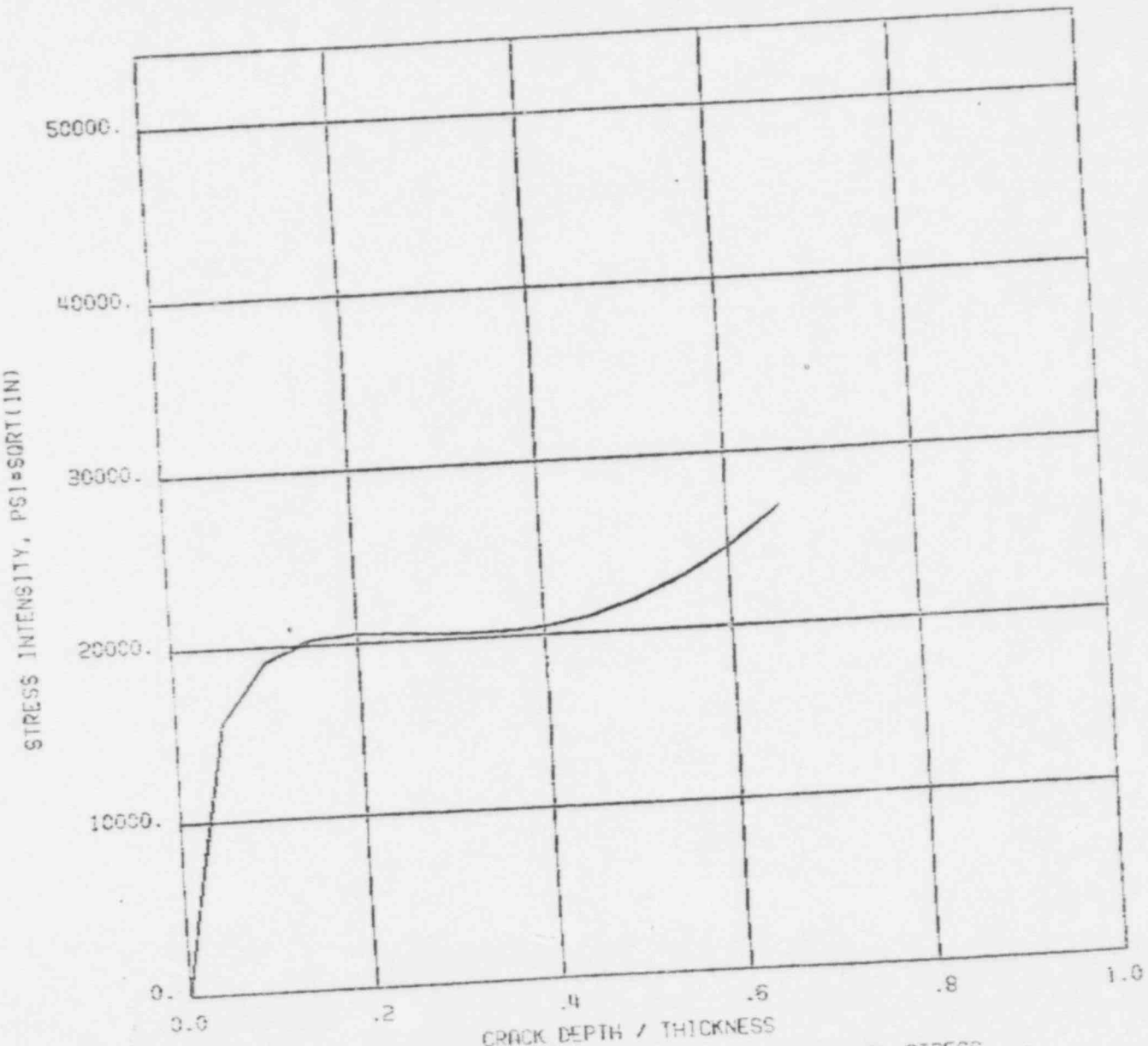


Figure 5(a) Crack Depth vs. Time; Weld Sensitized Material
Crack Growth Data (Curve 1 in Figure 3);
(Large Pipe Residual Stress + Applied Stress = 13 KSI)

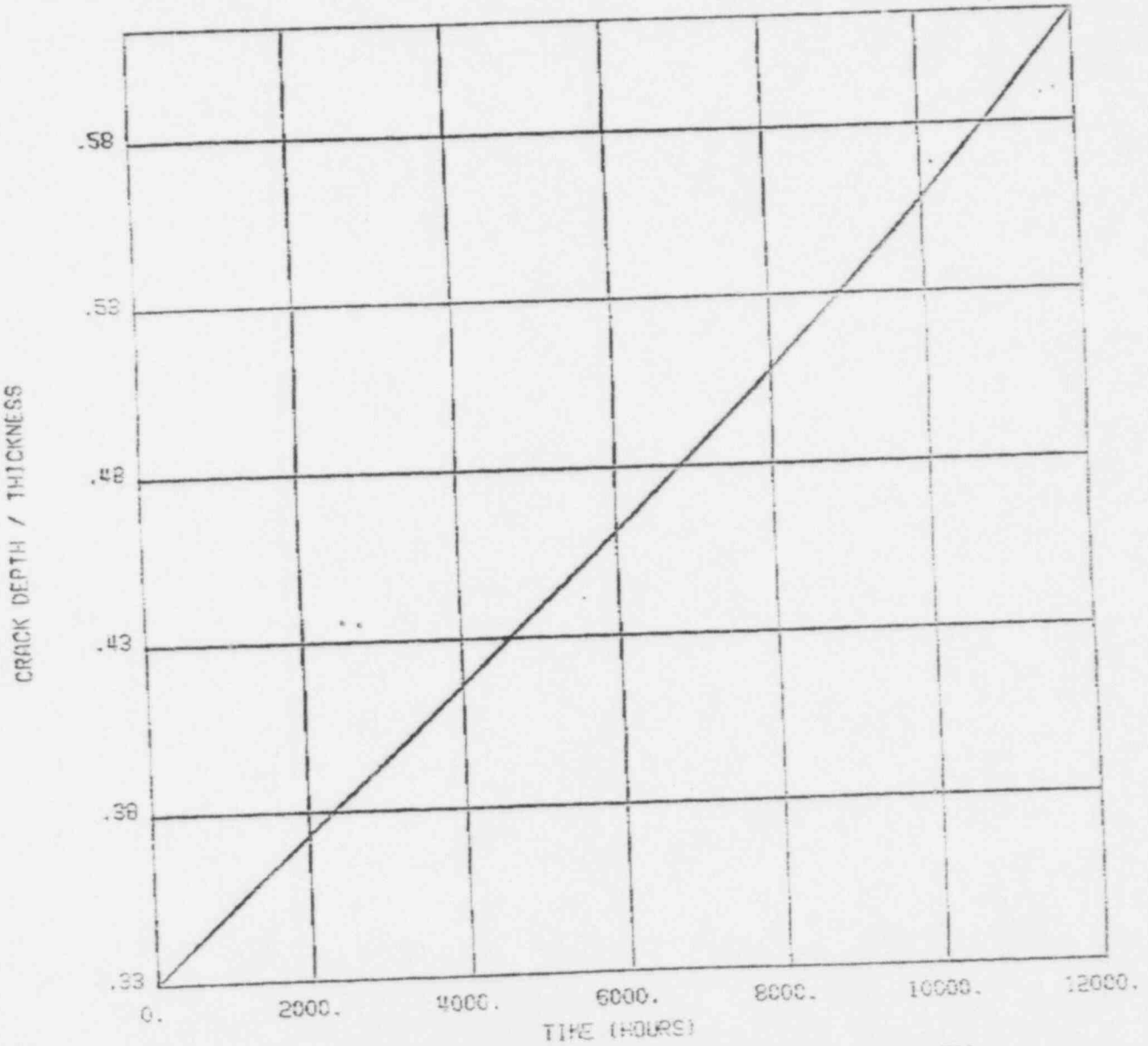


FIGURE 5a PERCH BOTTOM 2 RHR FLAW, LRG PIPE RESIDUAL STRESS
Weld Sensitized Material Growth Data

Figure 5(b): End-of-Period Flaw Size After 4000 Hours
$A_{f/t}$ = 0.42 on the Failure Diagram

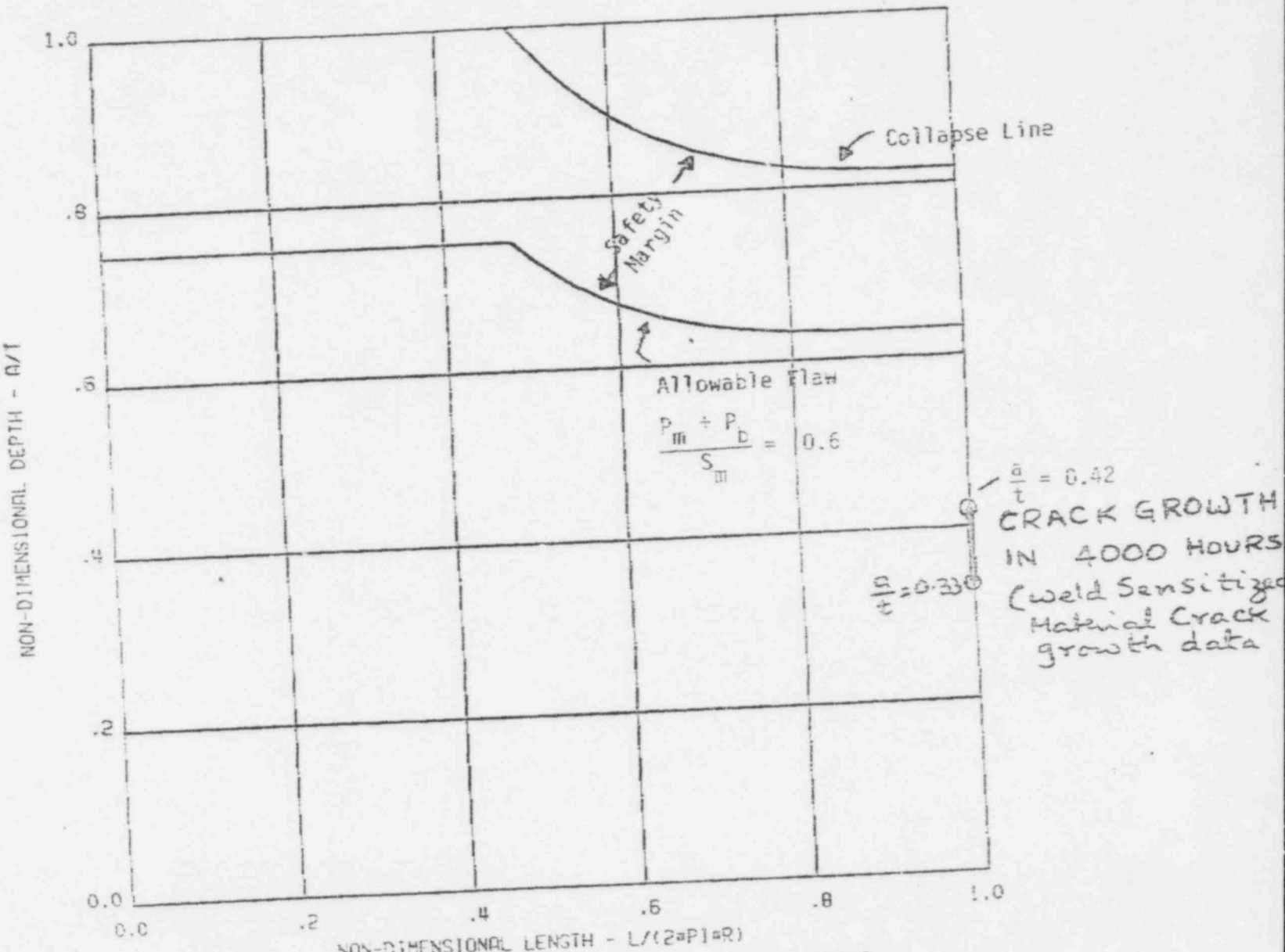


FIGURE5b PEACH BOTTOM 2 RHR FLAW. LRG PIPE RESIDUAL STRESS

Weld Sensitized Material
Growth Data

Figure 6(a): Crack Growth vs. Time Furnace Sensitized Material
Crack Growth Data (Curve 2 in Figure 3)
(Large Pipe Residual Stress + Applied Stress of 13 KSI)

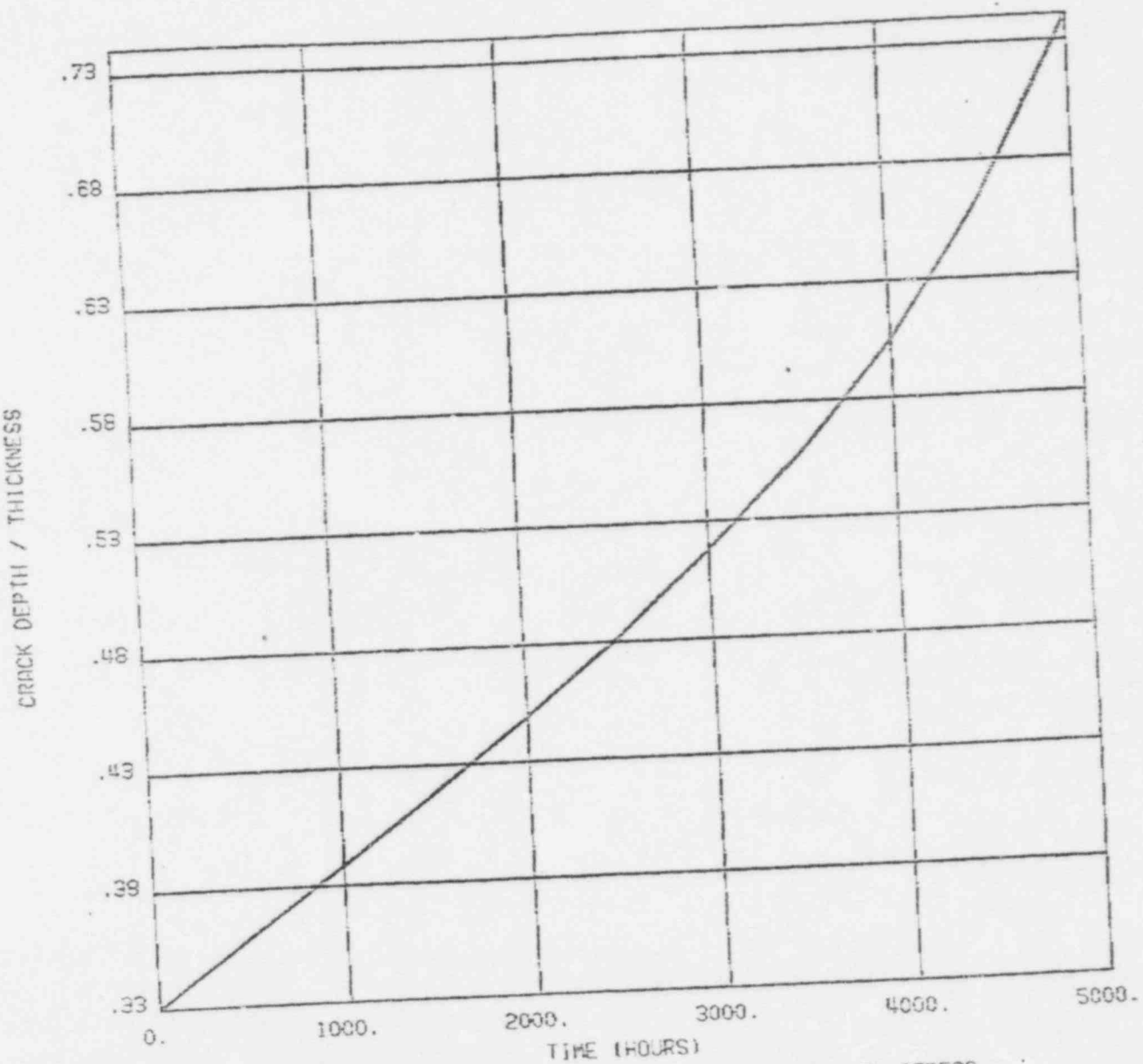
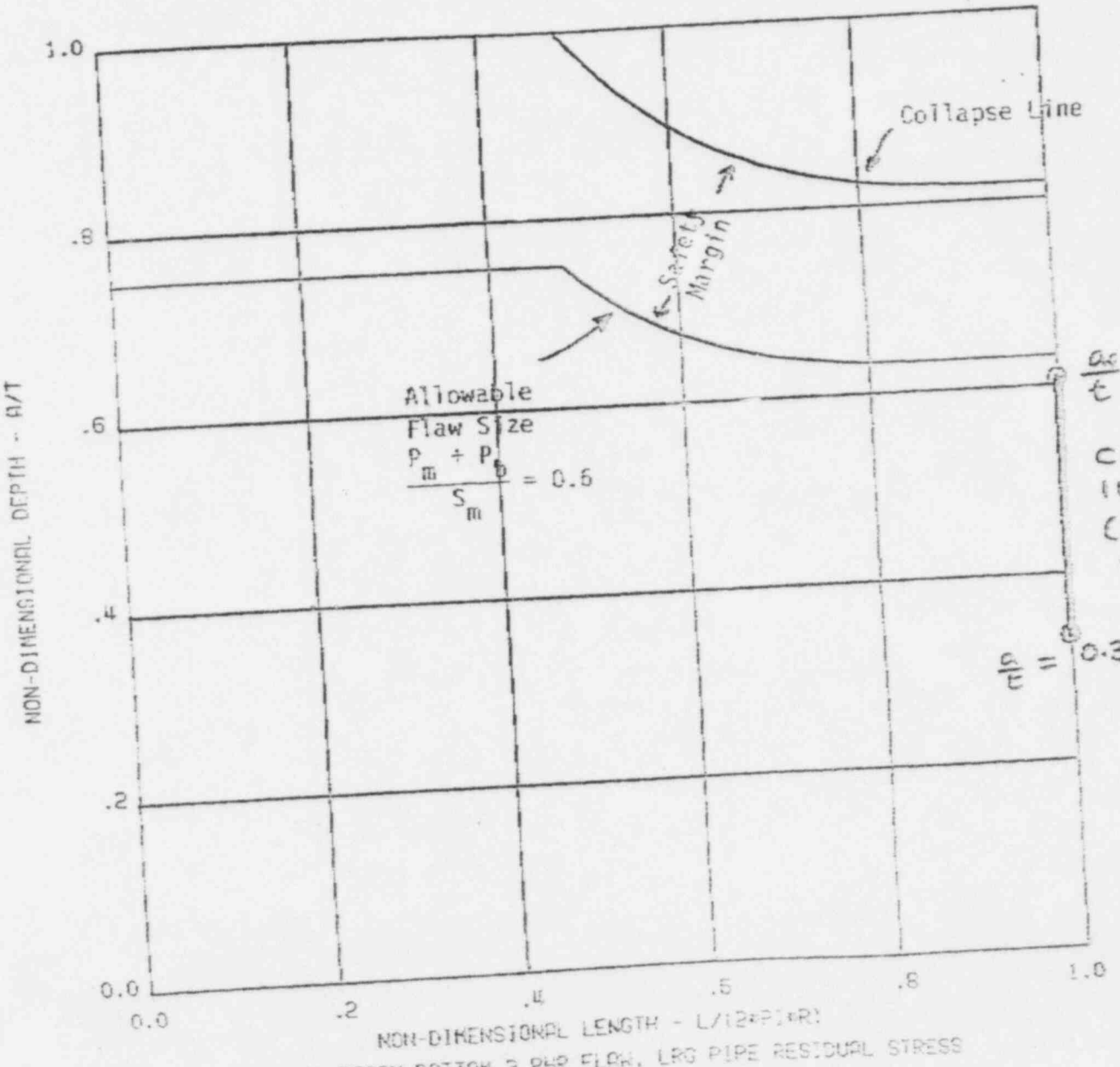


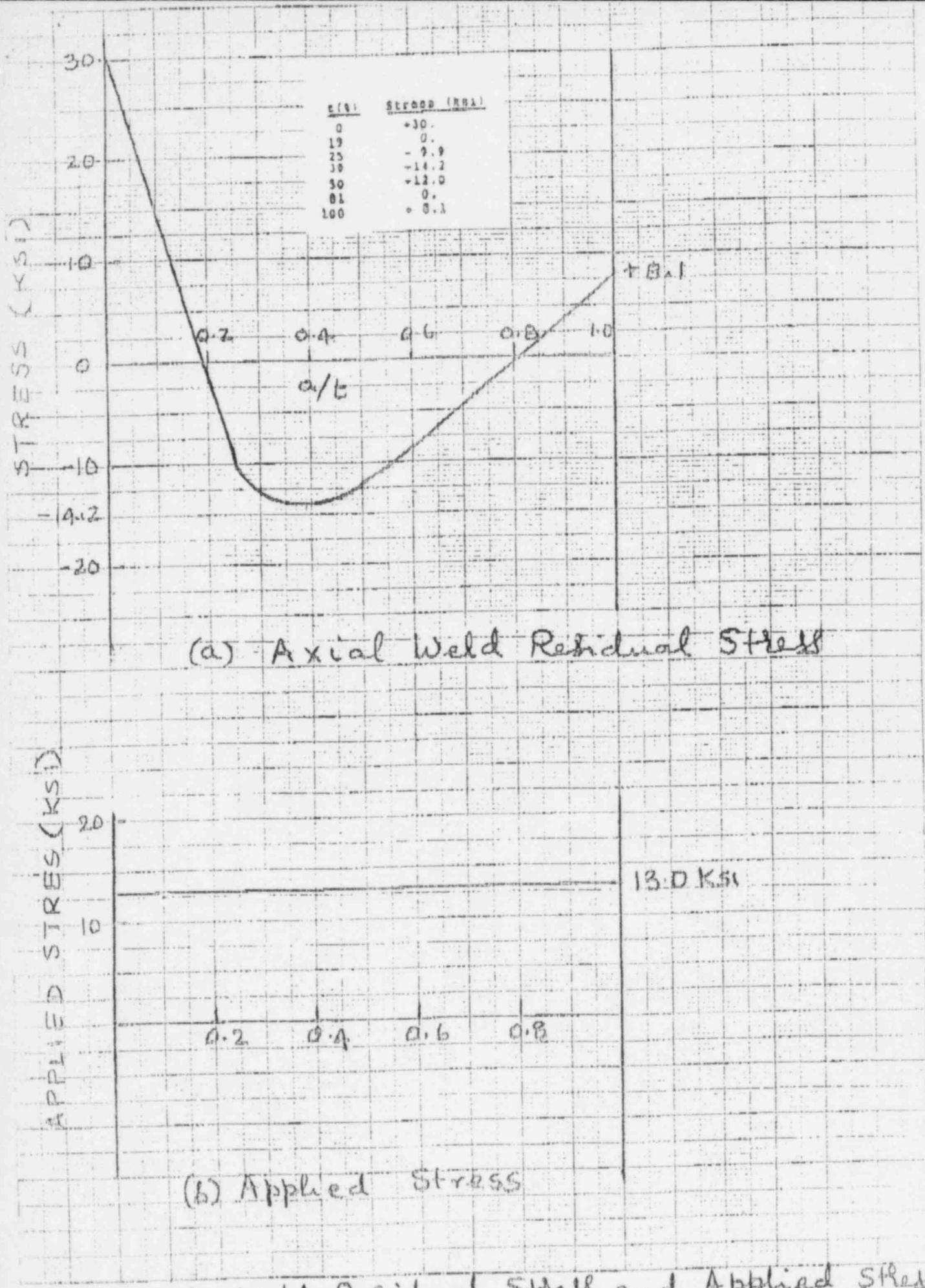
FIGURE 6aPEACH BOTTOM 2 RHR FLAW,LRG PIPE RESIDUAL STRESS

Furnace Sensitized Material
Growth Data

Figure 6(b): Crack Depth After 4000 Hours
$a_{f/t}$ = 0.5 on the Failure Diagram



Furnace Sensitized Material Growth Data



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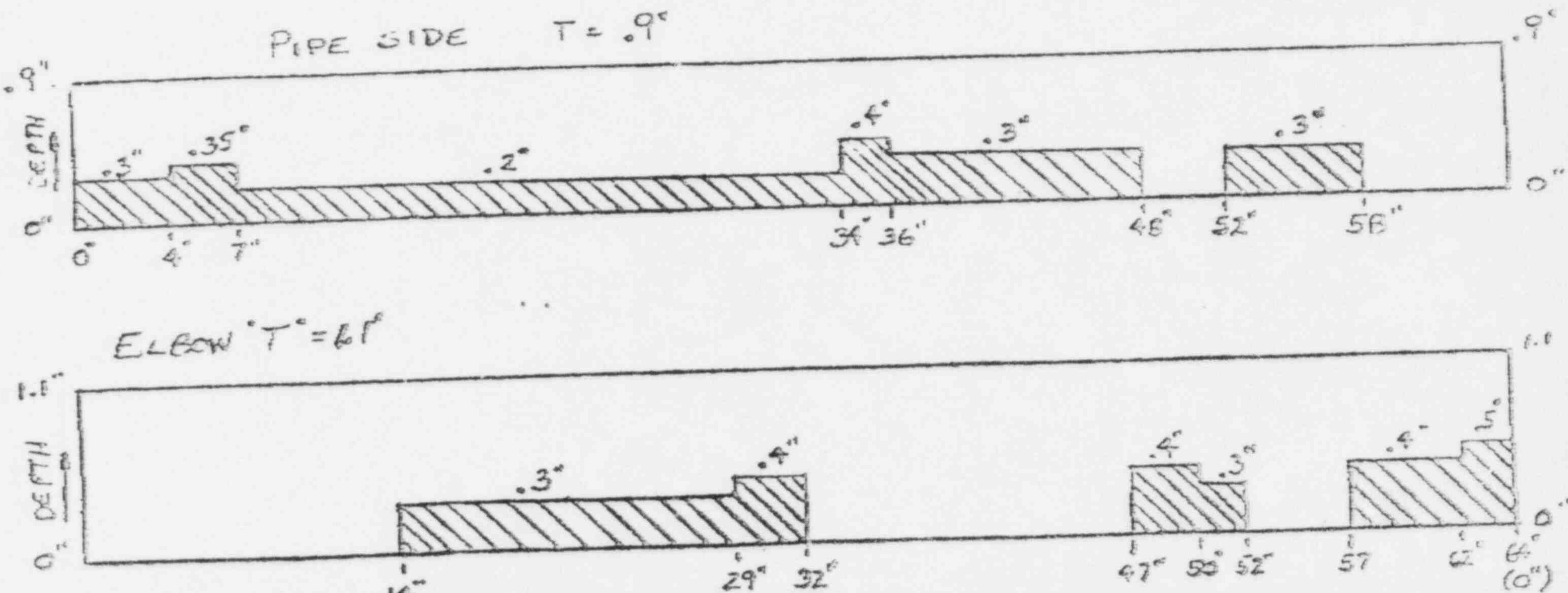

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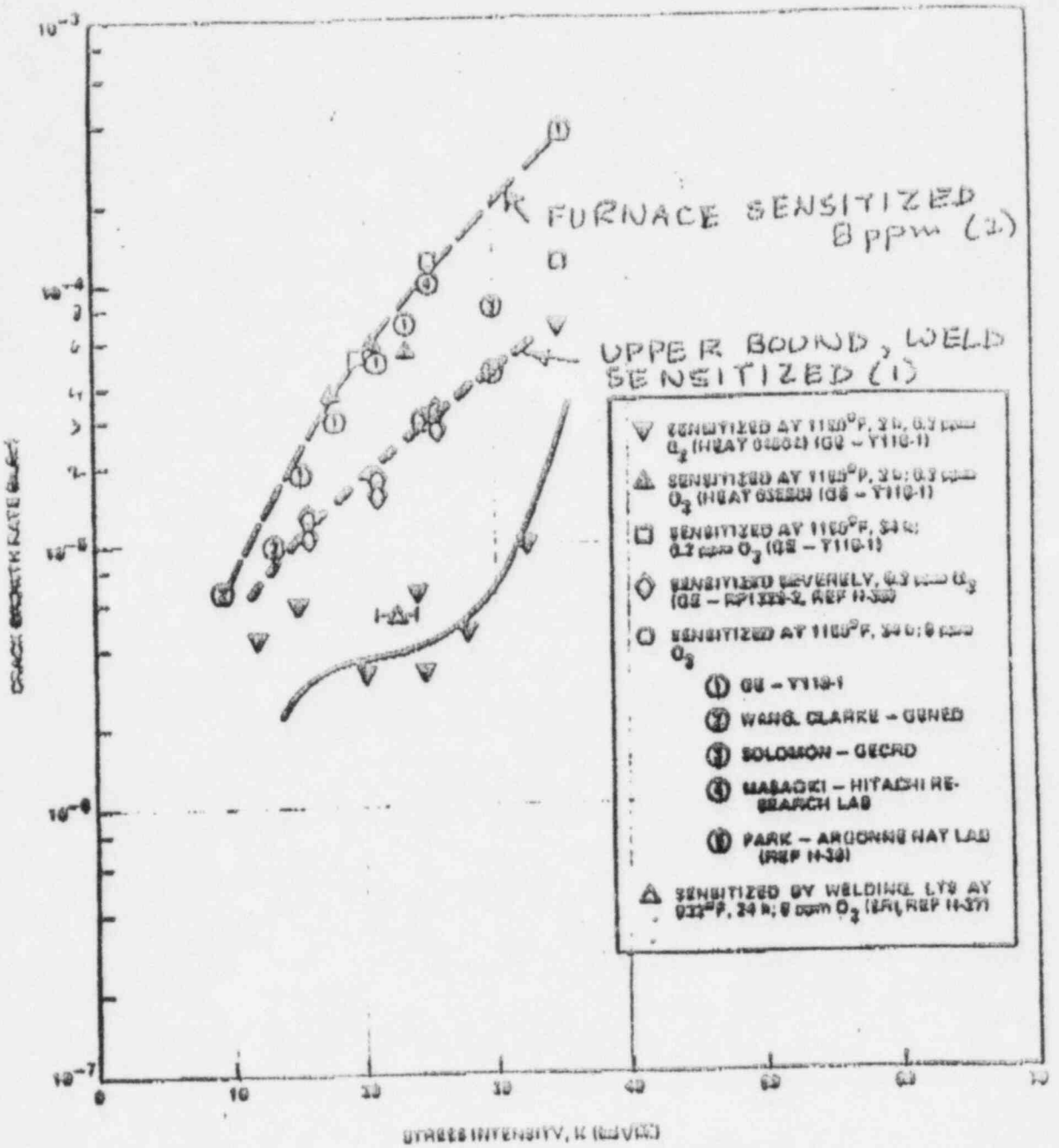

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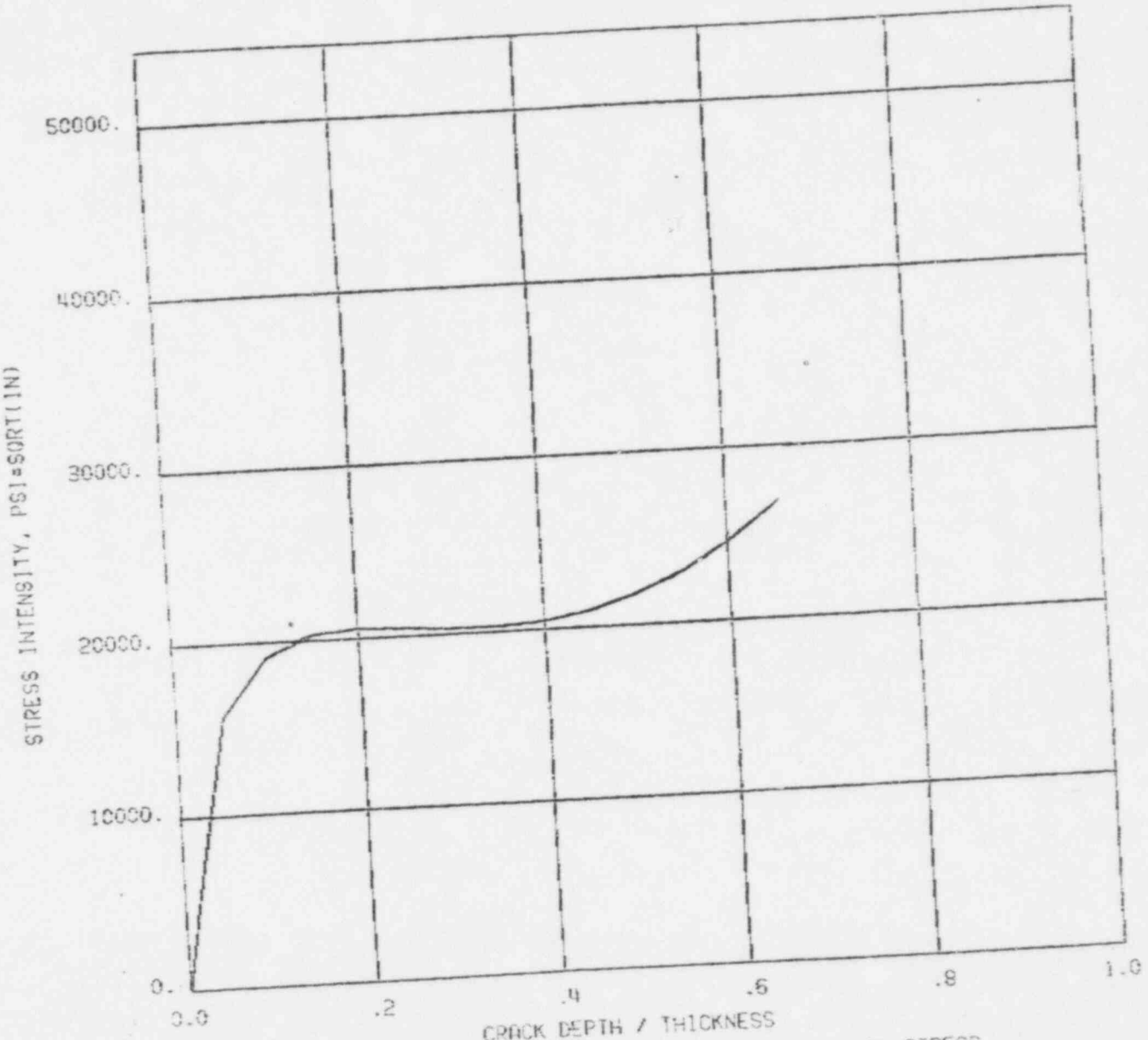


FIGURE 4 PERCH BOTTOM 2 RHR FLAW, LRG PIPE RESIDUAL STRESS

Figure 5(a) Crack Depth vs. Time; Weld Sensitized Material
Crack Growth Data (Curve 1 in Figure 3);
(Large Pipe Residual Stress + Applied Stress = 13 KSI)

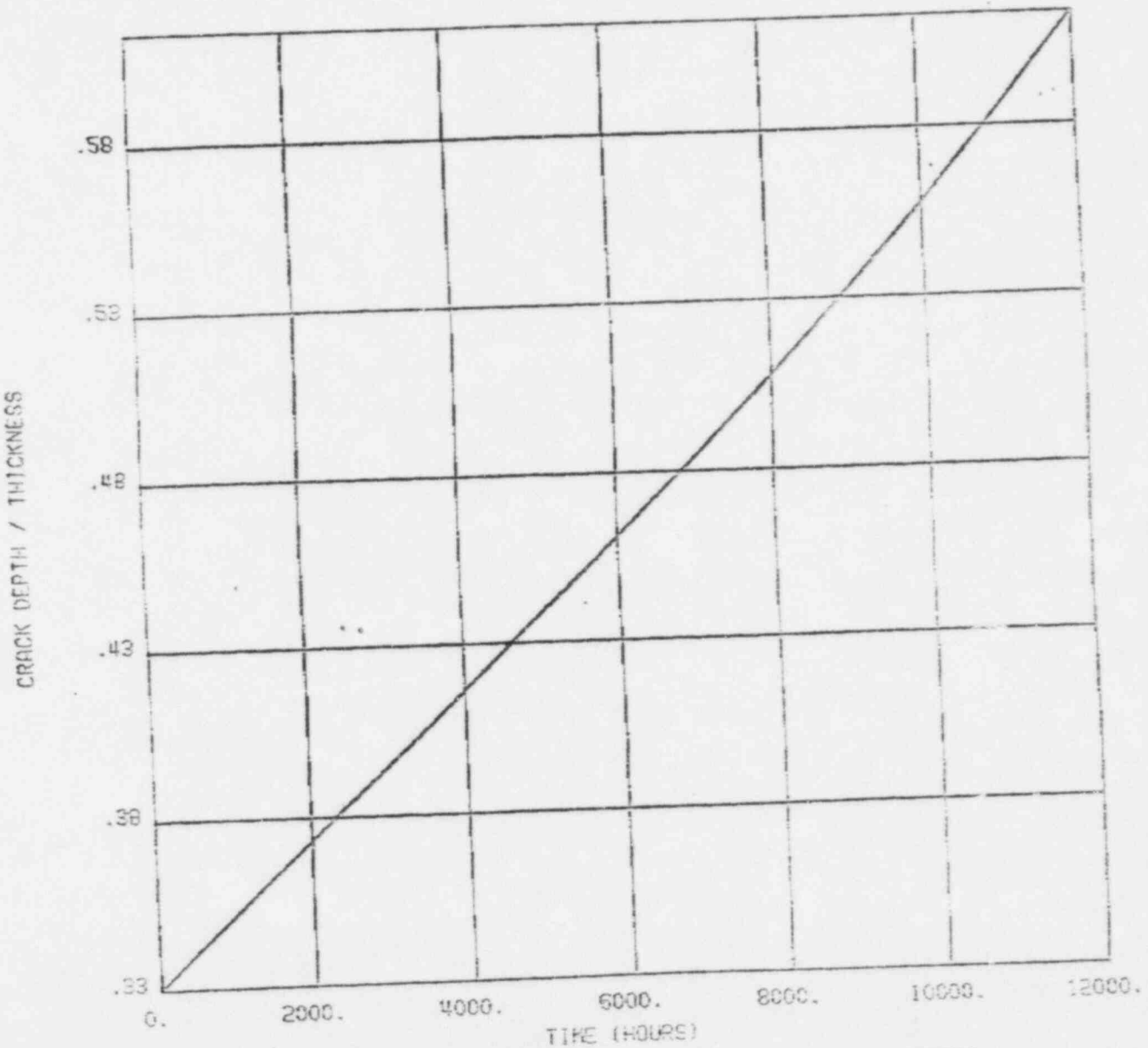


FIGURE 5a PERCH BOTTOM 2 RHR FLRH, LRG PIPE RESIDUAL STRESS
Weld Sensitized Material Growth Data

Figure 5(b): End-of-Period Flaw Size After 4000 Hours
$A_{f/t}$ = 0.42 on the Failure Diagram

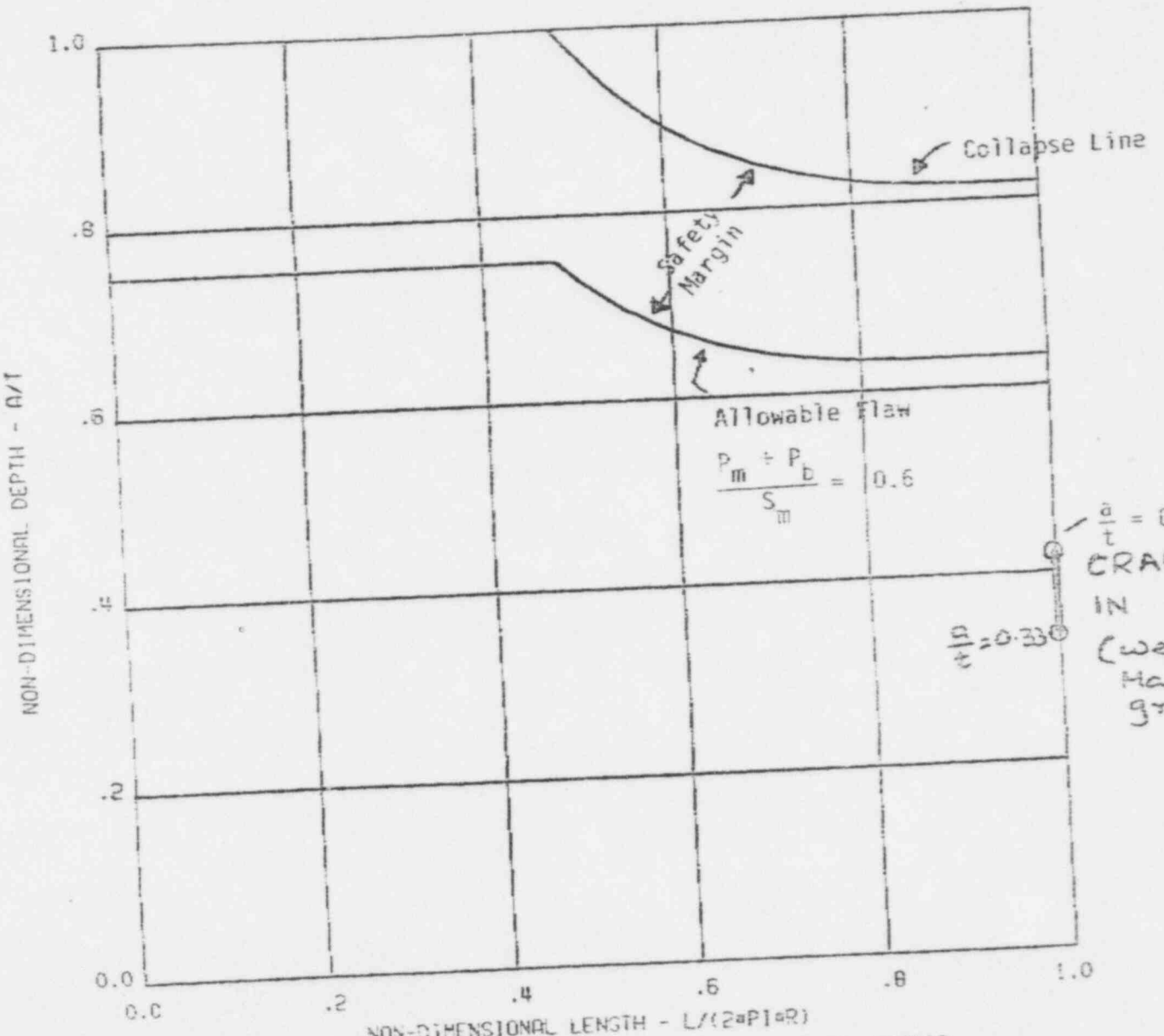


FIGURE5b PERCH BOTTOM 2 RHR FLAW. LRG PIPE RESIDUAL STRESS

Weld Sensitized Material
Growth Data

Figure 6(a): Crack Growth vs. Time Furnace Sensitized Material
Crack Growth Data (Curve 2 in Figure 3)
(Large Pipe Residual Stress + Applied Stress of 13 KSI)

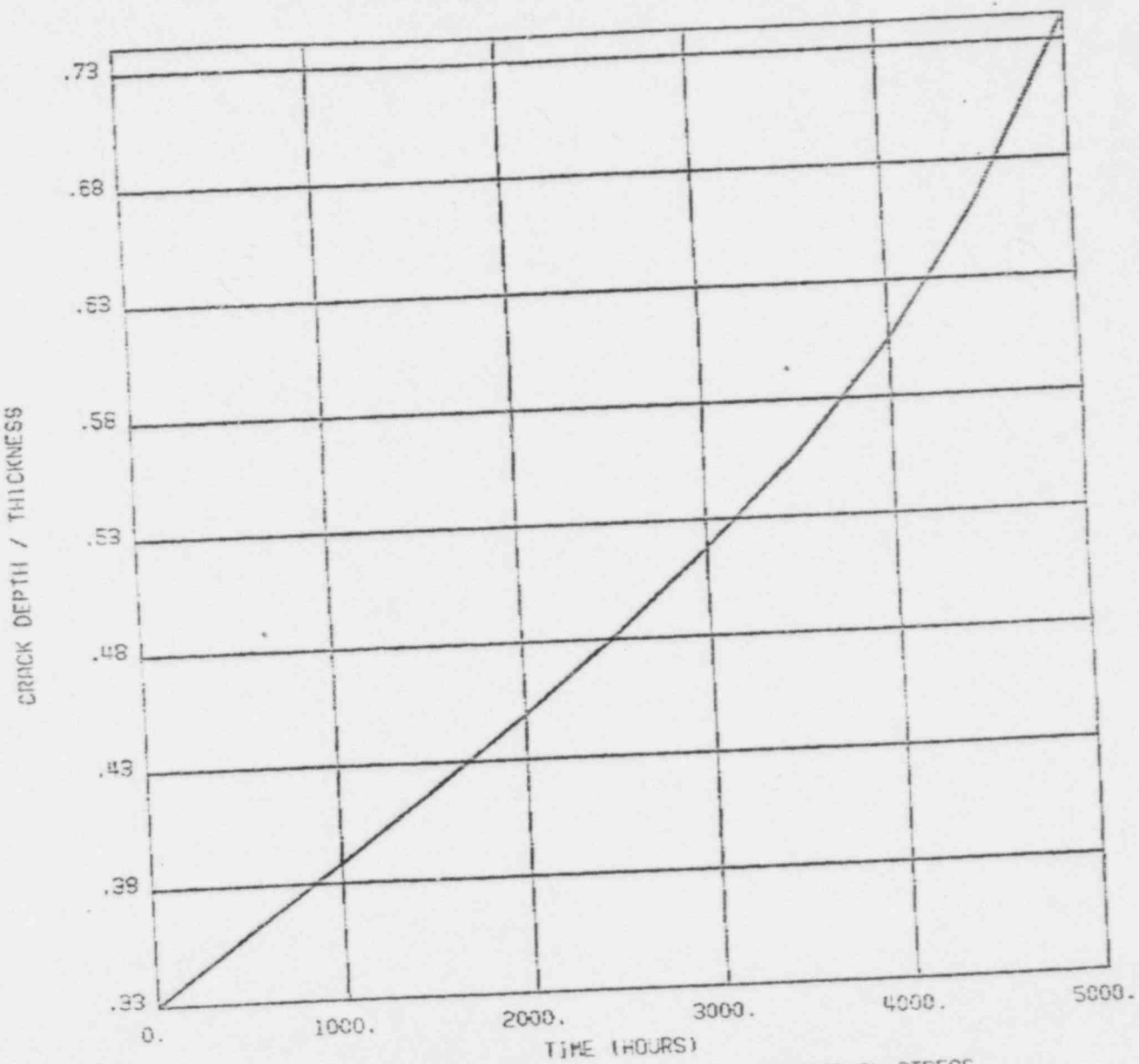
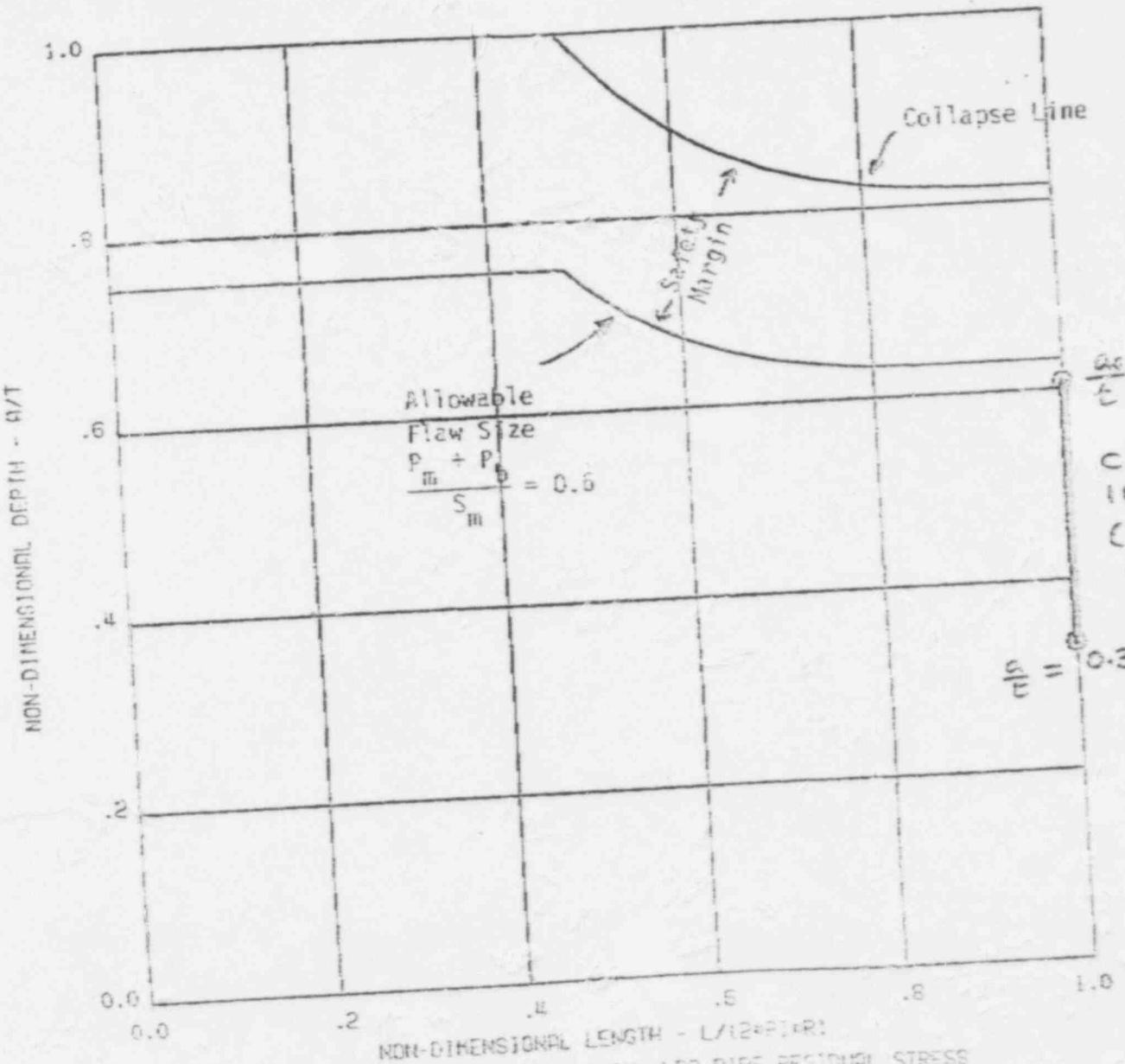


FIGURE 6aPEACH BOTTOM 2 RHR FLAW,LRG PIPE RESIDUAL STRESS

Furnace Sensitized Material
Growth Data

Figure 6(b): Crack Depth After 4000 Hours
$a_{f/t}$ = 0.6 on the Failure Diagram



CRACK GROWTH IN 4000 HOURS (Furnace Sensitized crack growth data)

Furnace Sensitized Material Growth Data