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March 16, 1994

William T. Russell, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Document Control Desk

Subject: Zion Station Unit 1 and 2
Steam Generator Girth Weld Inspection Results
NRC Docket Nos. 50-295 and 50-304

Dear Mr. Russell:

As a part of Zion Station's Dual Unit Outage activities, Commonwealth Edison Company has completed ultrasonic examinations of the upper shell-to-transition cone girth welds for the steam generators on both units. The purpose of this letter is to provide the NRC the results of these inspections.

The Attachment to this letter contains a brief discussion of previous inspection activities, and the results of the most recent examinations. For those indications that required the application of fracture mechanics to demonstrate continued acceptability, a copy of the fracture mechanics evaluation is included.

Please direct any questions to this office.

Sincerely,

Terrence W. Simpkin

T.W. Simpkin
Nuclear Licensing Administrator

TWS/gp

Attachment

cc: J.B. Martin - Region III
C.Y. Shiraki, Project Manager - NRR
J.D. Smith, Senior Resident Inspector - Zion

A001

ZION STEAM GENERATOR
DUAL UNIT OUTAGE
UPPER SHELL TO TRANSITION CONE GIRTH WELD
INSPECTION AND INDICATION EVALUATION RESULTS

Introduction:

Zion Station has used ASME Section XI Code acceptance criteria and fracture mechanics, to disposition as acceptable all indications (surface and subsurface) that were found in the steam generator upper shell to transition cone girth welds during the dual unit outage examinations.

Past Inspection History:

During the Zion Unit 1 Fall 1989 refueling outage, ultrasonic (UT) inspections were performed from the outside and multiple indications were found in each steam generator. All areas that had possible indications that plotted surface or near surface were examined from the inside using magnetic particle testing (MT). All surface indications that were confirmed with MT were removed by grinding and 1 boat sample was taken. Subsurface indications were within Section XI acceptance criteria or were dispositioned as acceptable by fracture mechanics.

During the Zion Unit 2 Spring 1990 refueling outage, UT inspections were performed from the outside and multiple indications were found in each steam generator. All areas that had possible indications that plotted surface or near surface were examined from the inside using MT. All surface indications that were confirmed by MT were removed by grinding and 2 boat samples were taken. Subsurface indications were within Section XI acceptance criteria or were dispositioned as acceptable by fracture mechanics.

The boat sample taken from the Unit 1 steam generator in 1989 was sent to Stanford Research Institute (SRI) for analysis. SRI performed the FRASTA (Fracture Reconstruction Applying Surface Topography Analysis) technique on the boat sample and concluded that: Cracks initiated from pits; Crack formation appeared to be a slow process; Crack propagation accelerated when crack penetrated into the heat affected zone, and slowed down when the crack reached into the base metal and may have possibly arrested. Boat sample analyses conducted by Commonwealth Edison on the Unit 1 and Unit 2 boat samples found that the heat affected zone had high hardness values and determined that the crack initiation began from pits that linked up in service and was caused by Environmentally Assisted Cracking due to transgranular stress corrosion cracking or corrosion fatigue.

During the internal inspections of the steam generator girth welds, a band of pitting was observed within approximately 1 foot above and below the upper shell to transition cone girth weld. The source of this pitting was determined to be oxygenated water in the secondary side of the steam generator. Past wet layup practices at Zion resulted in the water level being at the girth weld during wet layup. Oxygen at the air to water interface was determined to cause pitting at the girth weld. In addition, the effectiveness of hydrazine, which was added as an oxygen scavenger, was not known since no mixing capability existed.

The results of the Unit 1 and Unit 2 boat sample analyses were presented to the NRC in the December 18, 1990 presentation.

Past Inspection History:(continued)

During the Zion Unit 1 Spring 1992 outage, MT examinations were performed on 100% of all four girth welds from the inside diameter. One steam generator had no indications. The other three steam generators had multiple clusters of indications with skewed orientation. Most of the indications found in 1989 and 1990 had circumferential orientation. Most (80%) of these indications had minimal depth (<1/18 inches). The remaining (20%) indications (mostly in D Steam Generator) had grind out depths averaging 0.15 inches with the deepest grindout area being 0.330 inches. All surface indications that were found were removed.

Because most of the indications did not exhibit characteristics of those typically associated with the girth weld cracking phenomena (circumferential indications at the heat affected zone) and since most of the shallow indications were removed with minimal grinding, it was concluded that most of the indications were surface blemishes. No indications were found in areas that were ground out during the Fall 1989 inspections.

Dual Unit Outage Inspection Results:

During the Fall 1993 Dual Unit outage all eight steam generator upper shell to transition cone girth welds were inspected using UT from the outside. Unit 1 steam generators were examined this outage in accordance with IWC-2420. Unit 2 steam generators were not required to be inspected until the Spring 1995 but were inspected in an effort to gain further understanding of the condition of the Unit 2 steam generator girth welds.

Unit 1 Results

Unit 1 Steam Generators were inspected by Ebasco Services using the P-Scan automated UT system. This method of inspection is different from the conventional manual technique that was used in Unit 2. The data acquired using this technique is stored on computer disk and is evaluated using specialized software which is able to image the data at different DAC (distance amplitude curve) reference levels.

ASME Section XI 1980 Edition (Winter 1981 Addenda) requires that indications greater than 50% DAC be recorded, these indications were noted on the examiner's data sheets as "recordable indications". Zion Station requires that indications with amplitudes greater than 20% and less than 50% DAC be noted as "non-recordable" indications. Data interpretation was performed at the 20% DAC level. Indications were recorded and sized at the 20% DAC level for evaluation purposes. This practice is conservative since it results in the recording and evaluation of indications which would otherwise go unrecorded.

The data acquired is presented in the accompanying tables and is summarized below. This data was used to evaluate the indications.

1A Steam Generator:

There were eight indications found in 1A Steam Generator, 3 of which were within Section XI acceptance criteria.

Three indications were found using the 45 degree angle transducer. One indication was classified as recordable and two indications were classified as non-recordable. Five indications were found using the 60 degree angle transducer. Two indications were classified as recordable and three were classified as non-recordable.

1A Steam Generator:(continued)

Two 60 degree indications were determined to be "repeat" indications found at 45 degrees. All of the indications were classified as surface. The longest indication was also the deepest and was found to be 3 inches long and 0.27 inches deep. The average indication was approximately 1.2 inches long and 0.2 inches deep.

All of the above indications were previously found in 1989 using UT but could not be confirmed as surface indications using MT in 1989 and 1992. No cracking was found in previously repaired areas.

Three of the indications were classified as recordable and were accepted by fracture mechanics. Five of the indications were classified as non-recordable, three of which were acceptable per Section XI acceptance criteria, the remaining two were accepted by fracture mechanics. All of the indications were sized and evaluated at the 20% DAC level.

1B Steam Generator:

1B Steam Generator had one spot indication that was non-recordable.

1C Steam Generator:

1C Steam Generator had no indications that were recorded at the 20% DAC level.

1D Steam Generator:

There were six indications found in 1D Steam Generator, one of which was within Section XI acceptance criteria.

Four indications were found using the 45 degree angle transducer. All four indications were considered non-recordable. Two indications were found using the 60 degree angle transducer and were also considered non-recordable. Both 60 degree angle indications were repeat indications which were also found using the 45 degree angle transducer.

All of the indications were classified as surface and were previously detected using UT in 1989 but were not confirmed as surface during the MT exams conducted in 1989 and 1992. No cracking was found in previously ground areas. The longest indication was also the deepest and was found to be 3 inches long and 0.19 inches deep. This 60 degree indication was found to contain two of the 45 degree indications. The average indication was found to be approximately 1.3 inches and 0.15 inches deep.

One indication was within Section XI acceptance criteria, the remaining indications were accepted by fracture mechanics. All indications were sized at the 20% DAC level.

Unit 2 Results

Unit 2 steam generators were inspected by Wesdyne (Westinghouse) using manual UT techniques. All four steam generator girth welds had multiple indications.

Unit 2 Results(continued)

ASME Section XI 1980 Edition (Winter 1981 Addenda) requires that indications greater than 50% DAC be recorded, these indications were noted on the examiner's data sheets as "recordable indications". Zion Station requires that indications with amplitudes greater than 20% and less than 50% DAC be noted as "non-recordable" indications. Indications were sized using the 50% of peak amplitude method, in which the end points of the indication are determined when the UT signal is 50% of the maximum signal.

Some of the indications were re-evaluated by Commonwealth Edison to confirm the sizing and to better characterize the flaws. Longitudinal waves were used to characterize the inside surface and higher frequency shear waves were used for sizing purposes. Many of the indications found in the Unit 2 steam generators were "repeat" indications which are repeat signals from the same indication that were also found when scanning in different directions and/or using different beam angles. These repeat indications were also evaluated using Section XI acceptance criteria or fracture mechanics.

No cracking was found in previously repaired areas.

The data acquired is presented in the accompanying tables and is summarized below. Indications which were determined to have resulted from signals due to ID geometry were omitted from this presentation. This data was used to evaluate the indications.

2A Steam Generator:

There were 48 indications found in 2A Steam Generator, 33 of which were within Section XI acceptance criteria.

2A Steam Generator had 24 indications that were detected using the 45 degree angle transducer. Eight of those indications were classified as recordable, sixteen indications were classified as non-recordable. There were also 24 indications that were detected using the 60 degree angle transducer. Nineteen indications were classified as non-recordable and five indications were classified as recordable.

Five indications were classified as surface. The remaining indications were classified as subsurface. The longest surface indication was 2.05 inches long (0.14 inches deep). The deepest surface indication was 0.23 inches deep and 0.85 inches long. The average surface indication was approximately 0.8 inches long and 0.15 inches deep.

One surface indication was classified as recordable and was within Section XI acceptance criteria. The remaining indications were classified as non-recordable. Two of those indications were within Section XI acceptance criteria, the other two were acceptable by fracture mechanics.

All of the subsurface indications were either within Section XI acceptance criteria or acceptable by fracture mechanics.

2B Steam Generator:

There were 18 indications found in 2B Steam Generator, eight of which were within Section XI acceptance criteria.

2B Steam Generator:(continued)

2B Steam Generator had 13 indications that were detected using the 45 degree angle transducer 7 of which were classified as non-recordable, the remaining 6 were classified as recordable. Five indications were detected using the 60 degree angle transducer three of which were recordable, the other two were classified as non-recordable.

Eight indications were classified as surface. The remaining indications were classified as subsurface. The longest surface indication was also the deepest and was found to be 1.3 inches long and 0.32 inches deep. The average surface indication was 1.2 inches long and 0.15 inches deep.

Four surface indications were classified as recordable, one of which was acceptable per Section XI criteria, the other three were accepted by fracture mechanics. The remaining surface indications were classified as non-recordable, one indication was acceptable per Section XI criteria, the remaining indications were accepted by fracture mechanics.

All of the subsurface indications were either within Section XI acceptance criteria or acceptable by fracture mechanics.

2C Steam Generator:

There were 47 indications found in 2C Steam Generator, 24 of which were within Section XI acceptance criteria.

2C Steam Generator had 19 indications that were detected using the 45 degree angle transducer only one of which was classified as recordable. Twenty eight indications were detected using the 60 degree angle transducer four of which were classified as recordable.

Eleven indications were classified as surface. The remaining indications were classified as subsurface. The longest surface indication was 1.6" long and had a depth of 0.24". The deepest surface indication was 0.3 inches deep and 1 inch long. The average surface indication was approximately 0.85 inches long and 0.2 inches deep.

Two of the surface indications were classified as recordable and were acceptable per fracture mechanics. The remaining surface indications were classified as non-recordable. All of the surface indications were acceptable by fracture mechanics.

All of the subsurface indications were either within Section XI acceptance criteria or acceptable by fracture mechanics.

2D Steam Generator:

There were 51 indications in 2D Steam Generator, 40 of which were within Section XI acceptance criteria.

2D Steam Generator had 1 laminar indication that was detected with the zero degree transducer which was classified as a recordable indication and was found to be within Section XI acceptance criteria. Forty indications were found using the 45 degree angle transducer, nine of which were classified as recordable. Ten indications were detected using the 60 degree angle transducer, four of which were classified as recordable.

2D Steam Generator:(continued)

Seven indications were classified as surface indications. The deepest surface indication was 0.8 inches long and 0.41 inches deep. The longest surface indication was 1.6 inches long and 0.2 inches deep. The average surface indication was approximately 1.2 inches long and 0.23 inches deep.

One of the surface indications was classified as recordable. The remaining surface indications were classified as non-recordable. All surface indication were accepted by fracture mechanics.

All of the subsurface indications were either within Section XI acceptance criteria or acceptable by fracture mechanics.

Discussion of Inspection Results:

The results of these examinations were compared to the results from previous examinations. Indications that were previously accepted by fracture mechanics were monitored for crack growth.

The indications in 1A and 1D Steam Generator were previously identified by UT in 1989. Subsequent MT inspection performed on the ID in 1989 and 1992 failed to confirm these indications as surface. Comparisons made for indications monitored by fracture mechanics found no increase in flaw depth. Flaw length growth in most cases was not significant. Direct correlation of flaw lengths is not possible due to the different methods that were used in acquiring the data.

For Unit 2 steam generators, it can be concluded that there was no significant increase in flaw depth. In general, flaw lengths were larger.

Fracture Mechanics and Fatigue Evaluation Summary:

Engineering and Applied Sciences, Inc. performed fracture mechanics and fatigue evaluations for surface indications. Their analysis (reference 1) is included with this submittal. Stress analysis was performed on a girth weld model which included loadings from six different transients. Inputs from this analysis were used to perform fracture mechanics and fatigue evaluations.

Fatigue evaluation was performed in accordance with non-mandatory Appendix A of the 1992 Edition (including the 1992 addenda) of Section XI on one surface indication model and one subsurface indication model. The 1992 Edition of Section XI provides guidance for fatigue evaluation which are not included in earlier editions of the code. The subsurface indication model showed negligible growth over one cycle. The surface indication model showed a relatively small crack growth rate of 0.04 inches per cycle.

Since the Section XI fatigue analysis may not fully take into account the environmental aspects which can affect crack growth for surface indications, statistical analysis was performed on the grindout depths found during previous inspections. The statistical analysis of the grindout depths found that the actual crack growth rates for surface indications may be larger than what was predicted by Section XI fatigue analysis.

Fracture Mechanics and Fatigue Evaluation Summary:(continued)

A crack growth rate of 0.32 inches per one cycle was estimated based upon the grindout depths found in the 1D Steam Generator during the Spring 1992 MT inspections conducted from the inside. This rate projection is conservative since it is based upon a 95% confidence level, where 95% of the grindout depths were at or below 0.32 inches. In 1992, 100% of the inside surface of the 1D Steam Generator girth weld was inspected. However in 1989, only those areas which plotted as surface or near surface were inspected. This leads to the possibility that some of the indications (particularly the deeper indications) may have been present before they were identified in 1989, which can lead to the conclusion that the actual crack growth rate will actually be less than 0.32 inches per cycle.

Fracture mechanics of surface indications was performed in accordance with non-mandatory Appendix A of the 1989 Edition of Section XI using the Allowable Stress Intensity Factor criteria. The details of this evaluation are included with this submittal.

All indications were initially evaluated by Commonwealth Edison according to Table IWC-3510-1 of the ASME Boiler and Pressure Vessel Code Section XI, 1989 Edition. Surface indications were evaluated by Commonwealth Edison using the Engineering and Applied Sciences, Inc. report (reference 1) and subsurface indications were evaluated by Commonwealth Edison using Westinghouse WCAP-12047 (reference 2).

Surface indications outside Section XI acceptance criteria were evaluated using Figure 7-6 of reference 1. The points plotted and shown in the tables are the predicted end of cycle stress intensity factors. In the evaluation, the aspect ratio was computed and is assumed to be unchanged. Then, the crack growth rate of 0.32 inches is added to the depth and plotted with the corresponding aspect ratio. The resulting value is the end of cycle stress intensity factor. This value was entered into the indication data table and compared with the allowable stress intensity factor. All of the surface indications outside Section XI acceptance criteria had an end of cycle stress intensity factor less than the allowable stress intensity factor of 63.3 ksi$\sqrt{in}$ and therefore are acceptable for continued service.

Excluding the growth rate would result in significantly lower stress intensity factors and would widen the margin of acceptability.

Subsurface indications were evaluated using Figure A-6.4 of reference 2. Reference 2 was presented to the NRC in a previous presentation. The evaluation data and corresponding figures are included with this submittal.

All indications were either accepted by ASME Section XI acceptance criteria or by fracture mechanics. Crack growth rate projections based on historical data were factored into the fracture mechanics analysis. These calculations show that a surface indication at the worst case growth rate would not lead to an end of cycle indication that could not be dispositioned by fracture mechanics.

Conclusion:

All of the indications were accepted for continued service using fracture mechanics.

The UT evaluation of the indications is conservative because indications that produced signals greater than 20% DAC were noted, sized, and evaluated even though Section XI requires that only indications greater than 50% DAC be recorded. This results in the evaluation of indications which would otherwise not be recorded. In addition, UT data and boat sample studies have shown that UT tends to oversize indications. These oversized indications were used in the evaluations adding additional conservatism.

Girth weld cracking is not severe at Zion and has not been found to recur in previously repaired areas. Most of the cracking found to date has been relatively shallow. (The deepest grindout area was approximately 9/16 inches). The deepest UT indication found this outage was 0.41 inches. No significant flaw depth growth was observed for the indications that were monitored. In many cases flaw depth decreased when compared to previous exams. All indications were found acceptable per Section XI acceptance criteria or by fracture mechanics evaluation which considered crack growth.

Crack growth in the Zion steam generators is not rapid. No indications had been found in 1B Steam Generator during the MT exam in 1990 and only a non-recordable spot indication was found during the UT exam in 1993 after two refueling cycles. No indications were found in 1C Steam Generator during the 1993 UT exam after one refueling cycle. In addition, no significant flaw depth growth was observed for the indications which were monitored. These observations support the conclusion that cracking phenomena at Zion is not rapid. In addition, boat sample analysis has shown that crack growth rates decreased as the crack grew deeper as it moved from the heat affected zone to base metal with increasing depth.

Fatigue crack growth rate estimates which were based on historical data as well as ASME fatigue crack growth analysis indicate that a surface indication even at the worst case crack growth scenario would not lead to a flaw size that would exceed fracture mechanics limits before the next inspection.

Zion has made significant changes in wet layup practices to reduce dissolved oxygen concentration and reduce the pitting potential inside the steam generator. Specifically, the steam generators are filled to 90% wide range to eliminate the air/water interface at the girth weld. A blowdown modification was installed to add the capability of nitrogen sparging which enables chemical mixing inside the steam generator during wet layup. Aluminox (carbohydrazide), which reacts at lower temperatures, is added as an oxygen scavenger. Comparisons of pitting inside Unit 1 steam generators between 1989 and 1992 did not show a significant change in the magnitude of pitting.

Future Inspection Plans:

Unit 1

Indications in 1A and 1D Steam Generators will be monitored by UT as required by IWC-2420, which requires that flaws which were conditionally acceptable for service be monitored during the next inspection period.

Future Inspection Plans:(continued)

Unit 2

UT exams will be performed next refueling outage to monitor the indications in all four steam generators. In addition, UT examinations will also be performed as required by IWC-2420 which requires that flaws that were conditionally acceptable for service be monitored during the next inspection period which is estimated to end approximately December 1998.

Future UT inspections will be performed using automated systems. This will provide more descriptive characterization of girth weld flaws and will reduce operator variability.

The conservative approach taken with regards to data recording, as well as, the fracture mechanics and fatigue evaluation ensures the integrity of the steam generators. Changes in wet layup practices reduce the potential for pitting and crack initiation inside the steam generator.

References:

1. Engineering and Applied Sciences, Inc. report "Zion Steam Generator Girth Weld Flaw Evaluation." by Begley, et. al.

2. WCAP-12047, "Handbook on Flaw Evaluation For Zion Units 1 and 2 Steam Generator and Pressurizers." by Lee, et. al.

3. ASME Boiler and Pressure Vessel Code Section XI 1989 Edition, "Rules for Inservice Inspection of Nuclear Power Plant Components."

INDICATION DATA AND DISPOSTION TABLES

Zion Steam Generator Indications

SG	Indication Number	UT beam angle	Indication start	Indication finish	UT thru wall (2a)	UT depth (a)	Indication length (l)	Surface proximity (S)	Wall thickness (t)	Peak DAC	Proximity Ratio (Y)
1A	1	45	150.7	151.57	N/A	0.12	0.87	0	3.75	55	0
1A	2	45	335.3	335.3	N/A	0.05	0	0	3.75	20	0
1A	3	45	535.2	536.3	N/A	0.27	1.1	0	3.75	32	0
1A	2A	60	335	335.6	N/A	0.05	0.6	0	3.75	32	0
1A	3A	60	534.9	537.9	N/A	0.27	3	0	3.75	50	0
1A	4	60	498.1	498.9	N/A	0.1	0.8	0	3.75	36	0
1A	5	60	540.68	541.6	N/A	0.28	0.92	0	3.75	32	0
1A	6	60	542.28	544.36	N/A	0.28	2.08	0	3.75	50	0
1B	1	60	337.2	337.2	N/A	0.15	0	0	3.75	25	0
1D	1	45	313	313	N/A	0.07	0	0	3.75	20	0
1D	2	45	312.9	314.3	N/A	0.19	1.4	0	3.75	36	0
1D	3	45	314.9	316.47	N/A	0.19	1.57	0	3.75	36	0
1D	4	45	480.18	481.2	N/A	0.18	1.02	0	3.75	36	0
1D	2A/3A	30	313.7	316.7	N/A	0.19	3	0	3.75	40	0
1D	4A	60	480.8	481.6	N/A	0.18	0.8	0	3.75	40	0
2A	1	45	0' 5.65"	0' 10.2"	0.2	0.1	4.55	0.35	3.8	45	1
2A	2	45	1' 1.2"	1' 4.1"	0.4	0.2	2.9	0.21	3.8	30	1
2A	3	45	3' 7.8"	3' 8.6"	0.3	0.15	0.8	0.69	3.8	30	1
2A	4	45	4' 9"	4' 10.6"	0.55	0.275	1.6	0.53	3.8	75	1
2A	5	45	8' 3.1"	8' 3.1"	0.03	0.015	1.1	0.06	3.8	30	1
2A	6	45	8' 3"	8' 3.95"	0.13	0.065	0.95	0.34	3.8	100	1
2A	7	45	31' 2.9"	31' 4.65"	0.15	0.075	1.75	0.16	3.8	35	1
2A	8	45	31' 2.8"	31' 4.7"	0.11	0.055	1.9	0.23	3.8	30	1
2A	9	45	34' 1.4"	34' 3.45"	N/A	0.14	2.05	0.02	3.8	25	0.14
2A	10	45	35' 5.2"	35' 6.3"	0.44	0.22	1.1	0.66	3.8	25	1
2A	11	45	36' 3.5"	36' 4.6"	0.35	0.175	1.1	0.23	3.8	50	1
2A	12	45	36' 9.1"	36' 11.5"	0.49	0.245	2.4	0.17	3.8	25	0.69
2A	13	45	37' 4.15"	37' 5.05"	0.09	0.045	0.9	0.33	3.8	40	1
2A	14	45	37' 7.9"	37' 8.55"	0.36	0.18	0.65	1.6	3.8	55	1
2A	15	45	38' 0.1"	38' 1.1"	0.04	0.02	1	1.43	3.8	45	1
2A	16	45	38' 2.1	38' 3.5"	0.22	0.11	1.4	0.06	3.8	25	0.55
2A	17	45	38' 6.4"	38' 7.5"	N/A	0.08	1.1	0	3.8	55	0
2A	18	45	38' 6.3"	38' 7.45"	0.08	0.04	1.15	0.32	3.8	40	1
2A	19	45	39' 1.5"	39' 4.4"	0.21	0.105	0.9	0.12	3.8	25	1

Zion Steam Generator Indications

SG	Indication Number	Indication Class	Depth Ratio (a/t)	Aspect Ratio (a/l)	Code (a/t) Allowable	Code Accepted	End of Cycle K(I)	Surface Distance	Fr. Mech Accepted	Comments
1A	1	Surface	3.20%	13.79%	2.50%	N	43	N/A	Y	
1A	2	Surface	1.33%	50.00%	6.10%	Y	N/A	N/A	N/A	Spot indication
1A	3	Surface	7.20%	24.55%	3.80%	N	37	N/A	Y	
1A	2A	Surface	1.33%	8.33%	2.40%	Y	N/A	N/A	N/A	Same as indication 2 w/45
1A	3A	Surface	7.20%	8.00%	2.50%	N	50	N/A	Y	Same as indication 3 w/45
1A	4	Surface	2.67%	12.50%	2.72%	Y	N/A	N/A	N/A	
1A	5	Surface	7.47%	30.43%	4.40%	N	35	N/A	Y	
1A	6	Surface	7.47%	13.46%	2.70%	N	47	N/A	Y	
1B	1	Surface	4.00%	50.00%	6.10%	Y	N/A	N/A	N/A	Spot indication
1D	1	Surface	1.87%	50.00%	6.10%	Y	N/A	N/A	N/A	Spot indication
1D	2	Surface	5.07%	13.57%	2.70%	N	43	N/A	Y	
1D	3	Surface	5.07%	12.10%	2.70%	N	43	N/A	Y	
1D	4	Surface	4.80%	17.65%	3.00%	N	40	N/A	Y	
1D	2A/3A	Surface	5.07%	6.33%	2.30%	N	48	N/A	Y	Same as indications 2 and 3 w/ 45
1D	4A	Surface	4.80%	22.50%	3.60%	N	36	N/A	Y	Same as indication 4 w/45
2A	1	Subsurface	2.63%	2.20%	2.30%	N	N/A	11.84%	Y	
2A	2	Subsurface	5.26%	6.90%	2.60%	N	N/A	10.79%	Y	
2A	3	Subsurface	3.95%	18.75%	3.78%	N	N/A	22.11%	Y	SMAD resize data
2A	4	Subsurface	7.24%	17.19%	3.40%	N	N/A	21.18%	Y	
2A	5	Subsurface	0.39%	1.36%	2.30%	Y	N/A	N/A	N/A	
2A	6	Subsurface	1.71%	6.84%	2.60%	Y	N/A	N/A	N/A	
2A	7	Subsurface	1.97%	4.29%	2.60%	Y	N/A	N/A	N/A	
2A	8	Subsurface	1.45%	2.89%	2.30%	Y	N/A	N/A	N/A	Same as 7
2A	9	Surface	4.20%	7.80%	2.30%	N	48	N/A	Y	
2A	10	Subsurface	5.79%	20.00%	3.90%	N	N/A	23.16%	Y	
2A	11	Subsurface	4.61%	15.91%	3.40%	N	N/A	10.66%	Y	
2A	12	Subsurface	6.45%	10.21%	2.00%	N	N/A	10.92%	Y	
2A	13	Subsurface	1.18%	5.00%	2.60%	Y	N/A	N/A	N/A	
2A	14	Subsurface	4.74%	27.69%	4.80%	Y	N/A	N/A	N/A	
2A	15	Subsurface	0.53%	2.00%	2.30%	Y	N/A	N/A	N/A	
2A	16	Subsurface	2.89%	7.86%	1.40%	N	N/A	4.47%	Y	
2A	17	Surface	2.11%	7.27%	2.20%	Y	N/A	N/A	N/A	
2A	18	Subsurface	1.05%	3.48%	2.30%	Y	N/A	N/A	N/A	Same as 17
2A	19	Subsurface	2.76%	11.67%	2.90%	Y	N/A	N/A	N/A	

Zion Steam Generator Indications

SG	Indication Number	UT beam angle	Indication start	Indication finish	UT thru wall (2a)	UT depth (a)	Indication length (l)	Surface proximity (S)	Wall thickness (t)	Peak DAC	Proximity Ratio (Y)
2A	20	45	39' 10.2"	39' 11.95"	0.13	0.065	1.75	2.02	3.8	50	1
2A	21	45	40' 8.75"	40' 10.25"	0.01	0.005	1.5	0.27	3.8	25	1
2A	22	45	42' 8.9"	42' 10.25"	0.01	0.005	1.35	3.39	3.8	100	1
2A	23	45	44' 6.45"	44' 7.4"	0.57	0.285	0.95	0.47	3.8	55	1
2A	24	45	45' 1.15"	45' 2.2"	0.06	0.03	0.85	0.28	3.8	40	1
2A	1	60	1' 5.7"	1' 6.3"	0.17	0.085	0.15	0.6	3.8	25	1
2A	2	60	2' 7.6"	2' 8.5"	0.03	0.015	0.9	0.3	3.8	35	1
2A	3	60	2' 8.15"	2' 8.7"	0.1	0.05	0.55	0.28	3.8	30	1
2A	4	60	3' 7.65"	3' 8.55"	0.21	0.105	0.9	2.65	3.8	40	1
2A	5	60	7' 8.7"	7' 10"	0.17	0.085	1.3	0.16	3.8	25	1
2A	6	60	8' 2.1"	8' 3.5"	0.08	0.04	1.4	0.07	3.8	50	1
2A	7	60	10' 1.25"	10' 2.3"	0.17	0.085	1.05	0.05	3.8	45	0.59
2A	8	60	17' 0.7"	17' 2"	0.02	0.01	1.3	0.3	3.8	25	1
2A	9	60	20' 6.6"	20' 6.9"	0.1	0.05	0.3	0.22	3.8	30	1
2A	10	60	23' 0.8"	23' 1.65"	0.18	0.09	0.85	0.85	3.8	25	1
2A	11	60	28' 7.8"	28' 8.7"	0.01	0.005	0.9	0.06	3.8	55	1
2A	12	60	34' 2.3"	34' 3"	0.04	0.02	0.7	0.18	3.8	25	1
2A	13	60	34' 5.3"	34' 6.15"	0.04	0.02	0.85	0.11	3.8	25	1
2A	14	60	35' 7.6"	35' 8.45"	N/A	0.23	0.85	0.03	3.8	25	0.13
2A	15	60	35' 1.2"	35' 1.75"	0.02	0.01	0.55	0.07	3.8	25	1
2A	16	60	38' 6.05"	38' 7.55"	0.18	0.09	1.5	0.07	3.8	30	0.78
2A	17	60	38' 9.35"	38' 9.9"	N/A	0.09	0.55	0.01	3.8	25	0.11
2A	18	60	38' 6.55"	38' 7.8"	0.12	0.06	1.25	0.08	3.8	35	1
2A	19	60	39' 10.5"	39' 11.5"	0.35	0.175	1.25	0.12	3.8	90	0.69
2A	20	60	42' 8.55"	42' 9.35"	N/A	0 07	0.8	0.01	3.8	35	0.014
2A	21	60	42' 8.8"	42' 10.2"	0.05	0.025	1.4	0.02	3.8	50	0.8
2A	22	60	43' 0.65"	43' 2.3"	0.34	0.17	1.65	0.84	3.8	55	1
2A	23	60	43' 5.05"	43' 5.7"	0.13	0.065	0.65	1.08	3.8	25	1
2A	24	60	43' 8.5"	43' 9.25"	0.28	0.14	0.75	1.24	3.8	25	1
2B	1	45	2' 6.2"	2' 7.4"	N/A	0.12	1.2	0	3.75	60	0
2B	2	45	4' 3.2"	4' 4.4"	N/A	0.23	1.2	0.06	3.75	50	0.26
2B	3	45	6' 4.3"	6' 5.3"	N/A	0.18	1	0.07	3.7	25	0.39
2B	4	45	8' 7.5"	8' 9.9"	N/A	0.12	2.4	0	3.8	55	0
2B	5	45	8' 10.9"	9' 1"	0.12	0.06	2.1	0.61	3.75	40	1

Zion Steam Generator Indications

SG	Indication Number	Indication Class	Depth Ratio (a/t)	Aspect Ratio (a/l)	Code (a/t) Allowable	Code Accepted	End of Cycle K(I)	Surface Distance	Fr. Mech Accepted	Comments
2A	20	Subsurface	1.71%	3.71%	2.30%	Y	N/A	N/A	N/A	
2A	21	Subsurface	0.13%	0.33%	2.30%	Y	N/A	N/A	N/A	
2A	22	Subsurface	0.13%	0.37%	2.30%	Y	N/A	N/A	N/A	
2A	23	Subsurface	7.50%	30.00%	5.20%	N	N/A	19.87%	Y	
2A	24	Subsurface	0.79%	3.53%	2.30%	Y	N/A	N/A	N/A	
2A	1	Subsurface	2.24%	56.67%	9.30%	Y	N/A	N/A	N/A	
2A	2	Subsurface	0.39%	1.67%	2.30%	Y	N/A	N/A	N/A	
2A	3	Subsurface	1.32%	9.09%	2.60%	Y	N/A	N/A	N/A	
2A	4	Subsurface	2.76%	11.67%	2.90%	Y	N/A	N/A	N/A	Same as 3 w/ 45
2A	5	Subsurface	2.24%	6.54%	2.60%	Y	N/A	N/A	N/A	
2A	6	Subsurface	1.05%	2.86%	2.30%	Y	N/A	N/A	N/A	Same as 6 w/ 45
2A	7	Subsurface	2.24%	8.10%	1.70%	N	N/A	3.55%	Y	
2A	8	Subsurface	0.26%	0.77%	2.30%	Y	N/A	N/A	N/A	
2A	9	Subsurface	1.32%	16.67%	3.40%	Y	N/A	N/A	N/A	
2A	10	Subsurface	2.37%	10.59%	2.90%	Y	N/A	N/A	N/A	
2A	11	Subsurface	0.13%	0.56%	2.30%	Y	N/A	N/A	N/A	
2A	12	Subsurface	0.53%	2.86%	2.30%	Y	N/A	N/A	N/A	
2A	13	Subsurface	0.53%	2.35%	2.30%	Y	N/A	N/A	N/A	
2A	14	Surface	6.80%	30.60%	4.45%	N	35	N/A	Y	
2A	15	Subsurface	0.26%	1.82%	2.30%	Y	N/A	N/A	N/A	
2A	16	Subsurface	2.37%	6.00%	2.10%	N	N/A	4.21%	Y	Same as 18 w/ 45
2A	17	Surface	2.60%	18.20%	3.00%	Y	N/A	N/A	N/A	
2A	18	Subsurface	1.58%	4.80%	2.60%	Y	N/A	N/A	N/A	
2A	19	Subsurface	4.61%	14.00%	2.30%	N	N/A	7.76%	Y	
2A	20	Surface	2.10%	10.00%	2.55%	Y	N/A	N/A	N/A	
2A	21	Subsurface	0.66%	1.79%	1.90%	Y	N/A	N/A	N/A	
2A	22	Subsurface	4.47%	10.30%	2.90%	N	N/A	26.58%	Y	Same as 21 w/ 45,(2a/t)<0.25
2A	23	Subsurface	1.71%	10.00%	2.90%	Y	N/A	N/A	N/A	
2A	24	Subsurface	3.68%	18.67%	3.78%	Y	N/A	N/A	N/A	
2B	1	Surface	3.20%	10.00%	2.50%	N	44	N/A	Y	
2B	2	Surface	7.70%	19.17%	3.20%	N	39	N/A	Y	
2B	3	Surface	6.80%	18.00%	2.90%	N	40	N/A	Y	
2B	4	Surface	3.16%	5.00%	2.30%	N	46	N/A	Y	
2B	5	Subsurface	1.60%	2.86%	2.30%	Y	N/A	N/A	N/A	

Zion Steam Generator Indications

SG	Indication Number	UT beam angle	Indication start	Indication finish	UT thru wall (2a)	UT depth (a)	Indication length (l)	Surface proximity (S)	Wall thickness (t)	Peak DAC	Proximity Ratio (Y)
2B	6	45	10' 2"	10' 3.1"	N/A	0.1	1.1	0	3.75	10	0
2B	7	45	14' 3"	14' 4.2"	N/A	0.06	1.2	0	3.75	40	0
2B	8	45	14' 5.2"	14' 6.35"	N/A	0.07	1.15	0	3.75	50	0
2B	9	45	21' 7.2"	21' 8.2"	N/A	0.2	1	0	3.75	10	0
2B	12	45	25' 5.7"	25' 7.7"	0.12	0.06	2	0.06	3.75	75	1
2B	13	45	34' 5.5"	34' 6.6"	0.05	0.025	1.1	0.34	3.9	25	1
2B	14	45	34' 10.4"	34' 11.5"	0.26	0.13	1.1	0.26	3.75	30	1
2B	15	45	34' 11"	35' 2"	0.2	0.1	3	0.22	3.75	50	1
2B	1	60	2' 6.3"	2' 7.8"	0.26	0.13	1.5	0.11	3.75	25	0.85
2B	2	60	5' 10.3"	5' 11.4"	0.07	0.035	1.1	2.45	3.75	60	1
2B	3	60	4' 3.3"	4' 4.8"	0.01	0.005	1.5	0.23	3.75	51	1
2B	4	60	7' 3.2"	7' 8"	0.02	0.01	4.8	2.42	3.75	25	1
2B	6	60	8' 7.9"	9' 0"	0.5	0.25	4.1	0.45	3.75	50	1
2C	1	45	4' 6.25"	4' 7.1"	0.18	0.09	0.85	0.04	3.7	25	0.44
2C	2	45	5' 5.75"	5' 6.6"	0.04	0.02	0.85	1.3	3.7	25	1
2C	4	45	8' 1.9"	8' 3.8"	0.55	0.275	1.9	0.33	3.7	30	1
2C	5	45	8' 4.55"	8' 6.35"	0.04	0.02	1.8	2.03	3.7	25	1
2C	6	45	16' 2.5"	16' 3.3"	0.16	0.08	0.8	0.12	3.7	25	1
2C	8	45	21' 8.70"	21' 10.0"	N/A	0.24	1.3	0	3.7	10	0
2C	9	45	21' 8.70"	21' 10.0"	N/A	0.24	1.3	0	3.7	10	0
2C	10	45	22' 0.4"	22' 1.4"	N/A	0.3	1	0	3.7	10	0
2C	11	45	30' 6.6"	30' 8.0"	N/A	0.22	1.4	0.02	3.7	110	0.09
2C	12	45	30' 4.55"	30' 5.4"	N/A	0.21	0.85	0.03	3.7	25	0.14
2C	13	45	32' 3.35"	32' 4.3"	N/A	0.21	0.95	0.04	3.7	10	0
2C	14	45	39' 7.4"	39' 8.4"	N/A	0.23	1	0	3.7	10	0
2C	15	45	40' 7.6"	40' 9"	0.48	0.24	1.4	0.17	3.7	30	0.71
2C	16	45	40' 11.4"	41' 0.3"	0.56	0.28	0.9	0.43	3.7	35	1
2C	17	45	40' 2.6"	40' 3.1"	0.04	0.02	0.5	0.09	3.7	25	1
2C	18	45	41' 4.8"	41' 6.1"	0.52	0.26	1.3	0.33	3.7	25	1
2C	19	45	41' 3.0"	41' 3.75"	0.8	0.4	0.75	0.4	3.7	30	1
2C	20	45	45' 6.7"	45' 7.4"	0.18	0.09	0.7	0.22	3.7	35	1
2C	21	45	45' 6.55"	45' 6.85"	0.04	0.02	0.3	0.04	3.7	25	1
2C	1	60	3' 11.3"	4' 0.2"	0.26	0.13	0.9	0.82	3.7	25	1
2C	2	60	4' 7"	4' 7.65"	0.04	0.02	0.65	0.67	3.7	25	1

Zion Steam Generator Indications

SG	Indication Number	Indication Class	Depth Ratio (a/t)	Aspect Ratio (a/l)	Code (a/t) Allowable	Code Accepted	End of Cycle K(I)	Surface Distance	Fr. Mech Accepted	Comments
2B	6	Surface	2.67%	9.09%	2.50%	N	45	N/A	Y	SMAD resize data
2B	7	Surface	1.60%	5.00%	2.30%	Y	N/A	N/A	N/A	
2B	8	Surface	1.87%	6.09%	2.30%	Y	N/A	N/A	N/A	
2B	9	Surface	5.33%	20.00%	3.00%	N	40	N/A	Y	SMAD resize data
2B	12	Subsurface	1.60%	3.00%	2.30%	Y	N/A	N/A	N/A	
2B	13	Subsurface	0.64%	2.27%	2.30%	Y	N/A	N/A	N/A	
2B	14	Subsurface	3.47%	11.82%	2.90%	N	N/A	10.40%	Y	
2B	15	Subsurface	2.67%	3.33%	2.40%	N	N/A	8.53%	Y	
2B	1	Subsurface	3.47%	8.67%	2.20%	N	N/A	6.40%	Y	
2B	2	Subsurface	0.93%	3.18%	2.30%	Y	N/A	N/A	N/A	
2B	3	Subsurface	0.13%	0.33%	2.30%	Y	N/A	N/A	N/A	
2B	4	Subsurface	0.27%	0.21%	2.30%	Y	N/A	N/A	N/A	
2B	6	Subsurface	6.67%	6.10%	2.60%	N	N/A	18.67%	Y	
2C	1	Subsurface	2.43%	10.59%	1.30%	N	N/A	3.51%	Y	
2C	2	Subsurface	0.54%	2.35%	2.40%	Y	N/A	N/A	N/A	
2C	4	Subsurface	7.43%	14.47%	3.40%	N	N/A	16.35%	Y	
2C	5	Subsurface	0.54%	1.11%	2.30%	Y	N/A	N/A	N/A	
2C	6	Subsurface	2.16%	10.00%	2.90%	Y	N/A	N/A	N/A	
2C	8	Surface	6.49%	18.46%	2.90%	N	41	N/A	Y	SMAD resize data
2C	9	Surface	6.49%	18.46%	2.90%	N	41	N/A	Y	SMAD resize data, same as 8
2C	10	Surface	8.11%	30.00%	4.45%	N	36	N/A	Y	SMAD resize data
2C	11	Surface	6.40%	17.10%	3.10%	N	41	N/A	Y	
2C	12	Surface	6.40%	28.20%	4.00%	N	34	N/A	Y	
2C	13	Surface	5.68%	22.11%	3.20%	N	38	N/A	Y	SMAD resize data
2C	14	Surface	6.22%	23.00%	2.90%	N	37	N/A	Y	SMAD resize data
2C	15	Subsurface	6.49%	17.14%	2.60%	N	N/A	11.08%	Y	
2C	16	Subsurface	7.57%	31.11%	5.20%	N	N/A	19.19%	Y	
2C	17	Subsurface	0.54%	4.00%	2.60%	Y	N/A	N/A	N/A	
2C	18	Subsurface	7.03%	20.00%	3.90%	N	N/A	15.95%	Y	
2C	19	Subsurface	10.81%	53.33%	9.30%	N	N/A	21.62%	Y	
2C	20	Subsurface	2.43%	12.86%	3.20%	Y	N/A	N/A	N/A	
2C	21	Subsurface	0.54%	6.67%	2.60%	Y	N/A	N/A	N/A	Same as 20
2C	1	Subsurface	3.51%	14.44%	3.40%	N	N/A	25.68%	Y	(2a/t)<0.25
2C	2	Subsurface	0.54%	3.08%	2.60%	Y	N/A	N/A	N/A	

Zion Steam Generator Indications

SG	Indication Number	UT beam angle	Indication start	Indication finish	UT thru wall (2a)	UT depth (a)	Indication length (l)	Surface proximity (S)	Wall thickness (t)	Peak DAC	Proximity Ratio (Y)
2C	3	60	5' 5.95"	5' 6.65"	0.01	0.005	0.7	0.75	3.7	25	1
2C	4	60	5' 6.15"	5' 7.25"	0.16	0.08	1.1	1.39	3.7	30	1
2C	5	60	7' 10.2"	7' 11.6"	0.32	0.16	1.4	0.66	3.7	50	1
2C	6	60	7' 7.35"	7' 8.85"	0.21	0.105	1.5	0.15	3.7	35	1
2C	7	60	16' 2.75"	16' 3.65"	0.1	0.05	0.9	0.06	3.7	25	1
2C	8	60	17' 7.9"	17' 8.6"	0.11	0.055	0.7	0.34	3.7	25	1
2C	10	60	21' 1.75"	21' 2.8"	N/A	0.33	1.05	0	3.7	50	0
2C	11	60	21' 1.15"	21' 2.0"	0.16	0.08	0.85	0.48	3.7	30	1
2C	12	60	21' 1.65"	21' 2.8"	0.34	0.17	1.15	0.31	3.7	25	1
2C	13	60	21' 2.5"	21' 4.3"	0.11	0.055	1.8	1.76	3.7	25	1
2C	14	60	21' 8.8"	21' 9.95"	N/A	0.24	1.3	0	3.7	10	0
2C	15	60	21' 9.1"	21' 9.9"	N/A	0.24	1.3	0	3.7	10	0
2C	16	60	21' 8.7"	21' 9.5"	N/A	0.24	1.3	0	3.7	10	0
2C	17	60	22' 3.3"	22' 4.35"	0.04	0.02	1.05	0.18	3.7	30	1
2C	18	60	26' 11.65"	27' 0.45"	0.09	0.045	0.8	0.24	3.7	25	1
2C	19	60	26' 11.5"	27' 0.35"	0.03	0.015	0.85	0.1	3.7	30	1
2C	20	60	29' 1.35"	29' 2.25"	0.19	0.095	0.9	0.3	3.7	55	1
2C	22	60	30' 7.2"	30' 8.45"	0.07	0.035	1.25	0.08	3.7	75	1
2C	23	60	37' 8.5"	37' 9.1"	0.02	0.01	0.6	0.83	3.7	25	1
2C	24	60	37' 10.9"	37' 11.25"	0.25	0.125	0.35	0.08	3.7	25	0.64
2C	25	60	38' 1.55"	38' 2.4"	0.33	0.165	0.85	0.66	3.7	30	1
2C	26	60	38' 1.3"	38' 2.0"	0.1	0.05	0.7	0.35	3.7	25	1
2C	27	60	40' 2.4"	40' 3.3"	0.06	0.03	0.9	0.05	3.7	25	1
2C	28	60	42' 1.1"	42' 1.7"	0.17	0.085	0.6	0.15	3.7	25	1
2C	29	60	41' 11.7"	42' 0.35"	0.02	0.01	0.65	0.03	3.7	25	1
2C	30	60	45' 7"	45' 7.5"	N/A	0.26	0.5	0	3.7	10	0
2D	2	0	27' 5"	27' 7"	N/A	N/A	N/A	3.4	3.75	80	1
2D	1	45	0' 10.2"	0' 11.2"	N/A	0.13	1	0	3.75	26	0
2D	2	45	2' 4.3"	2' 5.6"	0.01	0.005	1.3	0.06	3.75	26	1
2D	4	45	2' 9.15"	2' 10.1"	0.3	0.15	0.95	1.1	3.75	10	1
2D	5	45	3' 7.5"	3' 8.4"	0.03	0.015	0.9	0.06	3.75	50	1
2D	6	45	4' 9.5"	4' 10.8"	0.03	0.015	1.3	0.1	3.75	40	1
2D	7	45	6' 4.3"	6' 5.15"	0.02	0.01	0.85	1.01	3.75	30	1
2D	8	45	7' 6.5"	7' 7.7"	0.04	0.02	1.2	0.02	3.75	25	1

Zion Steam Generator Indications

SG	Indication Number	Indication Class	Depth Ratio (a/t)	Aspect Ratio (a/l)	Code (a/t) Allowable	Code Accepted	End of Cycle K(I)	Surface Distance	Fr. Mech Accepted	Comments
2C	3	Subsurface	0.14%	0.71%	2.35%	Y	N/A	N/A	N/A	
2C	4	Subsurface	2.16%	7.27%	2.30%	Y	N/A	N/A	N/A	Same as 2 w/ 45
2C	5	Subsurface	4.32%	11.43%	2.60%	N	N/A	22.16%	Y	
2C	6	Subsurface	2.84%	7.00%	2.70%	N	N/A	6.89%	Y	
2C	7	Subsurface	1.35%	5.56%	2.60%	Y	N/A	N/A	N/A	
2C	8	Subsurface	1.49%	7.86%	2.60%	Y	N/A	N/A	N/A	
2C	10	Surface	8.92%	31.43%	2.60%	N	36	N/A	Y	
2C	11	Subsurface	2.16%	9.41%	2.50%	Y	N/A	N/A	N/A	
2C	12	Subsurface	4.59%	14.78%	2.40%	N	N/A	12.97%	Y	
2C	13	Subsurface	1.49%	3.06%	2.60%	Y	N/A	N/A	N/A	
2C	14	Surface	6.49%	18.46%	2.90%	N	41	N/A	Y	Same as 8, 9 w/45
2C	15	Surface	6.49%	18.46%	2.90%	N	41	N/A	Y	Same as 8, 9 w/45
2C	16	Surface	6.49%	18.46%	2.90%	N	41	N/A	Y	Same as 8, 9 w/45
2C	17	Subsurface	0.54%	1.90%	2.30%	Y	N/A	N/A	N/A	
2C	18	Subsurface	1.22%	5.63%	2.60%	Y	N/A	N/A	N/A	
2C	19	Subsurface	0.41%	1.76%	2.30%	Y	N/A	N/A	N/A	
2C	20	Subsurface	2.57%	10.56%	2.90%	Y	N/A	N/A	N/A	
2C	22	Subsurface	0.95%	2.80%	2.30%	Y	N/A	N/A	N/A	
2C	23	Subsurface	0.27%	1.67%	2.30%	Y	N/A	N/A	N/A	
2C	24	Subsurface	3.38%	35.71%	3.90%	Y	N/A	N/A	N/A	
2C	25	Subsurface	4.46%	19.41%	3.90%	N	N/A	22.30%	Y	
2C	26	Subsurface	1.35%	7.14%	2.70%	Y	N/A	N/A	N/A	Same as 25
2C	27	Subsurface	0.81%	3.33%	2.60%	Y	N/A	N/A	N/A	Same as 17 w/45
2C	28	Subsurface	2.30%	14.17%	3.40%	Y	N/A	N/A	N/A	
2C	29	Subsurface	0.27%	1.54%	2.30%	Y	N/A	N/A	N/A	
2C	30	Surface	7.03%	52.00%	6.10%	N	26	N/A	Y	SMAD resize data
2D	2	Subsurface	1.85 sq in	N/A	6 sq in	Y	N/A	N/A	N/A	Laminar indication
2D	1	Surface	3.47%	13.00%	2.60%	N	41	N/A	Y	
2D	2	Subsurface	0.13%	0.38%	2.30%	Y	N/A	N/A	N/A	
2D	4	Subsurface	4.00%	15.79%	3.40%	N	N/A	33.33%	Y	SMAD resize data, (2a/t)<0.25
2D	5	Subsurface	0.40%	1.67%	2.30%	Y	N/A	N/A	N/A	
2D	6	Subsurface	0.40%	1.15%	2.30%	Y	N/A	N/A	N/A	
2D	7	Subsurface	0.27%	1.18%	2.30%	Y	N/A	N/A	N/A	
2D	8	Subsurface	0.53%	1.67%	2.30%	Y	N/A	N/A	N/A	

Zion Steam Generator Indications

SG	Indication Number	UT beam angle	Indication start	Indication finish	UT thru wall (2a)	UT depth (a)	Indication length (l)	Surface proximity (S)	Wall thickness (t)	Peak DAC	Proximity Ratio (Y)
2D	9	45	8' 6.4"	8' 7.2"	N/A	0.27	0.8	0.06	3.75	10	0
2D	10	45	3"	5"	0.06	0.03	2	0.02	3.75	90	0.67
2D	11	45	10' 6.3"	10' 8.1"	0.01	0.005	1.8	0.06	3.75	35	1
2D	12	45	10' 11.5"	11' 0.5"	0.02	0.01	1	0.06	3.75	30	1
2D	13	45	13' 8.9"	13' 10.4"	0.03	0.015	1.5	0.09	3.75	30	1
2D	14	45	14' 1.2"	14' 3.85"	0.04	0.02	2.65	0.02	3.75	45	1
2D	15	45	14' 4.5"	14' 5.6"	0.07	0.04	1.1	1.06	3.75	45	1
2D	16	45	14' 11.0"	15' 0"	0.13	0.065	1	0.06	3.75	25	0.92
2D	17	45	14' 9.3"	14' 10"	0.17	0.085	0.7	1.26	3.75	25	1
2D	18	45	15' 3"	15' 4.9"	0.04	0.02	1.9	0.12	3.75	25	1
2D	19	45	16' 3.55"	16' 4.2"	0.02	0.01	0.65	0.02	3.75	40	1
2D	20	45	16' 1.6"	16' 2.3"	0.01	0.005	1	0.25	3.75	45	1
2D	21	45	17' 0.8"	17' 2"	0.04	0.02	1.2	0.02	3.75	25	1
2D	22	45	17' 7.9"	17' 8.85"	0.04	0.02	0.95	0.02	3.75	25	1
2D	23	45	20' 1.75"	20' 5.5"	0.15	0.075	3.75	1.41	3.75	25	1
2D	24	45	4.3"	5.4"	0.1	0.05	1.1	0.15	3.75	105	1
2D	26	45	4.7"	5.5"	0.09	0.045	0.8	0.06	3.75	25	1
2D	27	45	20' 7.8"	20' 8.3"	0.19	0.095	0.5	0.08	3.75	25	0.84
2D	28	45	20' 8.2"	20 8.7"	0.16	0.08	0.5	0.09	3.75	100	1
2D	29	45	20' 8.7"	21' 10"?	0.03	0.015	1.3	0.06	3.75	25	1
2D	30	45	21' 11.5"	22' 1.4"	0.1	0.05	1.9	0.46	3.75	25	1
2D	31	45	22' 4.8"	22' 5.6"	N/A	0.27	0.8	0	3.75	10	0
2D	32	45	24' 7.4"	24' 8.4"	N/A	0.17	1	0	3.75	30	0
2D	33	45	24' 7.9"	24' 8.5"	0.03	0.015	0.6	0.06	3.75	50	1
2D	35	45	25' 9.3"	25' 10"	0.01	0.005	0.7	0.16	3.75	25	1
2D	36	45	27' 8.7"	27' 9.3"	0.09	0.045	0.6	0.09	3.75	28	1
2D	37	45	29' 3.4"	29' 4.4"	0.05	0.025	1	0.59	3.75	26	1
2D	38	45	31' 6.3"	31' 7.9	0.02	0.01	1.6	0.04	3.75	75	1
2D	39	45	32' 1"	32' 1.7"	0.12	0.09	0.7	0.44	3.75	50	1
2D	40	45	3.6"	5.3"	0.09	0.045	1.7	0.09	3.75	100	1
2D	41	45	1.3"	1.8"	0.58	0.29	0.5	1.43	3.75	25	1
2D	42	45	41' 2.6"	41' 3.6"	0.08	0.04	1	0.81	3.75	40	1
2D	43	45	43' 0.2"	43' 0.9"	0.09	0.045	0.7	0.09	3.75	125	1
2D	1	60	0' 6.3"	0' 7.1"	N/A	0.41	0.8	0	3.75	10	0

Zion Steam Generator Indications

SG	Indication Number	Indication Class	Depth Ratio (a/t)	Aspect Ratio (a/l)	Code (a/t) Allowable	Code Accepted	End of Cycle K(i)	Surface Distance	Fr. Mech Accepted	Comments
2D	9	Surface	7.20%	33.75%	4.40%	N	30	N/A	Y	
2D	10	Subsurface	0.80%	1.50%	1.50%	Y	N/A	N/A	N/A	Axial indication
2D	11	Subsurface	0.13%	0.28%	2.30%	Y	N/A	N/A	N/A	
2D	12	Subsurface	0.27%	1.00%	2.30%	Y	N/A	N/A	N/A	
2D	13	Subsurface	0.40%	1.00%	2.30%	Y	N/A	N/A	N/A	
2D	14	Subsurface	0.53%	0.75%	2.30%	Y	N/A	N/A	N/A	
2D	15	Subsurface	1.07%	3.64%	2.30%	Y	N/A	N/A	N/A	
2D	16	Subsurface	1.73%	6.50%	2.70%	Y	N/A	N/A	N/A	
2D	17	Subsurface	2.27%	12.14%	2.90%	Y	N/A	N/A	N/A	
2D	18	Subsurface	0.53%	1.05%	2.30%	Y	N/A	N/A	N/A	
2D	19	Subsurface	0.27%	1.54%	2.30%	Y	N/A	N/A	N/A	
2D	20	Subsurface	0.13%	0.50%	2.30%	Y	N/A	N/A	N/A	
2D	21	Subsurface	0.53%	1.67%	2.30%	Y	N/A	N/A	N/A	
2D	22	Subsurface	0.53%	2.11%	2.30%	Y	N/A	N/A	N/A	
2D	23	Subsurface	2.00%	2.00%	2.30%	Y	N/A	N/A	N/A	
2D	24	Subsurface	1.33%	4.55%	2.30%	Y	/A	N/A	N/A	Axial indication
2D	26	Subsurface	1.20%	5.63%	2.30%	Y	N/A	N/A	N/A	Axial indication
2D	27	Subsurface	2.53%	19.00%	3.30%	Y	N/A	N/A	N/A	
2D	28	Subsurface	2.13%	16.00%	3.40%	Y	N/A	N/A	N/A	
2D	29	Subsurface	0.40%	1.15%	2.30%	Y	N/A	N/A	N/A	
2D	30	Subsurface	1.33%	2.63%	2.30%	Y	N/A	N/A	N/A	
2D	31	Surface	7.20%	33.75%	4.40%	N	30	N/A	Y	SMAD resize data
2D	32	Surface	4.53%	17.00%	3.10%	N	40	N/A	Y	
2D	33	Subsurface	0.40%	2.50%	2.30%	Y	N/A	N/A	N/A	
2D	35	Subsurface	0.13%	0.71%	2.30%	Y	N/A	N/A	N/A	
2D	36	Subsurface	1.20%	7.50%	2.40%	Y	N/A	N/A	N/A	
2D	37	Subsurface	0.67%	2.50%	2.30%	Y	N/A	N/A	N/A	
2D	38	Subsurface	0.27%	0.63%	2.30%	Y	N/A	N/A	N/A	
2D	39	Subsurface	2.40%	12.86%	2.90%	Y	N/A	N/A	N/A	
2D	40	Subsurface	1.20%	2.65%	2.30%	Y	N/A	N/A	N/A	
2D	41	Subsurface	7.73%	58.00%	9.30%	Y	N/A	N/A	N/A	
2D	42	Subsurface	1.07%	4.00%	2.00%	Y	N/A	N/A	N/A	
2D	43	Subsurface	1.20%	6.43%	2.20%	Y	N/A	N/A	N/A	
2D	1	Surface	10.93%	51.25%	6.10%	N	28	N/A	Y	SMAD resize data

Zion Steam Generator Indications

SG	Indication Number	UT beam angle	Indication start	Indication finish	UT thru wall (2a)	UT depth (a)	Indication length (l)	Surface proximity (S)	Wall thickness (t)	Peak DAC	Proximity Ratio (Y)
2D	2	60	2' 9"	2' 11"	0.3	0.15	0.95	0.96	3.75	55	1
2D	3	60	21' 2.3"	21' 4.3"	0.03	0.015	2	0.33	3.75	25	1
2D	4	60	21' 5.9"	21' 7"	N/A	0.26	1.1	0	3.75	25	0
2D	5	60	24' 4.6"	24' 6"	N/A	0.2	1.4	0.03	3.75	75	0.15
2D	6	60	24' 7.2"	24' 9"	0.08	0.04	1.8	0.13	3.75	30	1
2D	7	60	25' 1"	25' 4.6"	0.27	0.135	3.6	0.23	3.75	30	1
2D	9	60	29' 3.3"	29' 4.4"	0.11	0.055	1.1	0.72	3.75	40	1
2D	10	60	32' 0.45"	32' 2.5"	0.02	0.01	2.05	0.7	3.75	50	1
2D	11	60	32' 0.5"	32' 3.7"	0.1	0.05	3.2	1.15	3.75	60	1

Zion Steam Generator Indications

SG	Indication Number	Indication Class	Depth Ratio (a/t)	Aspect Ratio (a/l)	Code (a/t) Allowable	Code Accepted	End of Cycle K(I)	Surface Distance	Fr. Mech Accepted	Comments
2D	2	Subsurface	4.00%	15.79%	2.20%	N	N/A	29.60%	Y	Same as 2 w/45, (2a/t)<0.25
2D	3	Subsurface	0.40%	0.75%	2.00%	Y	N/A	N/A	N/A	
2D	4	Surface	6.93%	23.64%	3.30%	N	39	N/A	Y	SMAD resize data
2D	5	Surface	6.10%	16.40%	2.90%	N	42	N/A	Y	
2D	6	Subsurface	1.07%	2.22%	2.00%	Y	N/A	N/A	N/A	Same as 33 w/ 45
2D	7	Subsurface	3.60%	3.75%	2.00%	N	N/A	9.73%	Y	
2D	9	Subsurface	1.47%	5.00%	2.20%	Y	N/A	N/A	N/A	Same as 37 w/ 45
2D	10	Subsurface	0.27%	0.49%	2.00%	Y	N/A	N/A	N/A	Same as 39 w/ 45
2D	11	Subsurface	1.33%	1.56%	2.00%	Y	N/A	N/A	N/A	

Notes on Tables:

SG - Steam Generator in which indication was identified.

Indication number - Each indication was numbered. Indications resulting from ID geometry were excluded from the presentation.

Indication Start/Finish - Circumferential distance from reference point (centerline of the feedwater nozzle) where the indication was found. Unit 1 data is presented in inches from the feedwater nozzle, Unit 2 data is presented in feet and inches from the feedwater nozzle.

UT thru wall depth (2a) - Through wall depth of subsurface indication.

UT depth (a) - Half depth of subsurface indication or depth of surface indication.

Indication length - Length of indication.

Surface proximity (S) - Distance of indication from ID. For surface indications, this dimension was added to the UT depth for evaluation.

Wall thickness - Measured wall thickness of generator.

Peak DAC - Maximum signal based on the distance amplitude curve.

Proximity Ratio (Y) = (S/a), if Y >0.4 the indication is classified as subsurface.

Depth ratio (a/t) - Provides a through wall percentage of indication (expressed in percentage).

Aspect ratio (a/l) - Flaw shape factor expressed in percentage.

Code allowable (a/t) - Through wall depth allowed by Section XI 1989 Edition.

Code accepted - If code allowable for a given aspect ratio was greater than the depth ratio the indication is acceptable.

End of cycle K_I - Stress intensity factor at the end of refueling cycle taken from Figure 7-6. Used to evaluate surface indications exceeding Section XI criteria

Surface Distance ratio = (S+a)/t - Used to evaluate subsurface indications using figure A-6.4.

Fracture Mechanics Acceptable - If $K_I < 63.3$ ksi$\sqrt{in}$ for surface indication, or if the subsurface indication plotted within the acceptable region, the indication was acceptable. For subsurface indications whose surface distance ratio > 0.25, the indications were acceptable if $(2a/t) \leq 0.25$ and were noted in the comment section.

FRACTURE MECHANICS DISPOSITIONING FIGURES

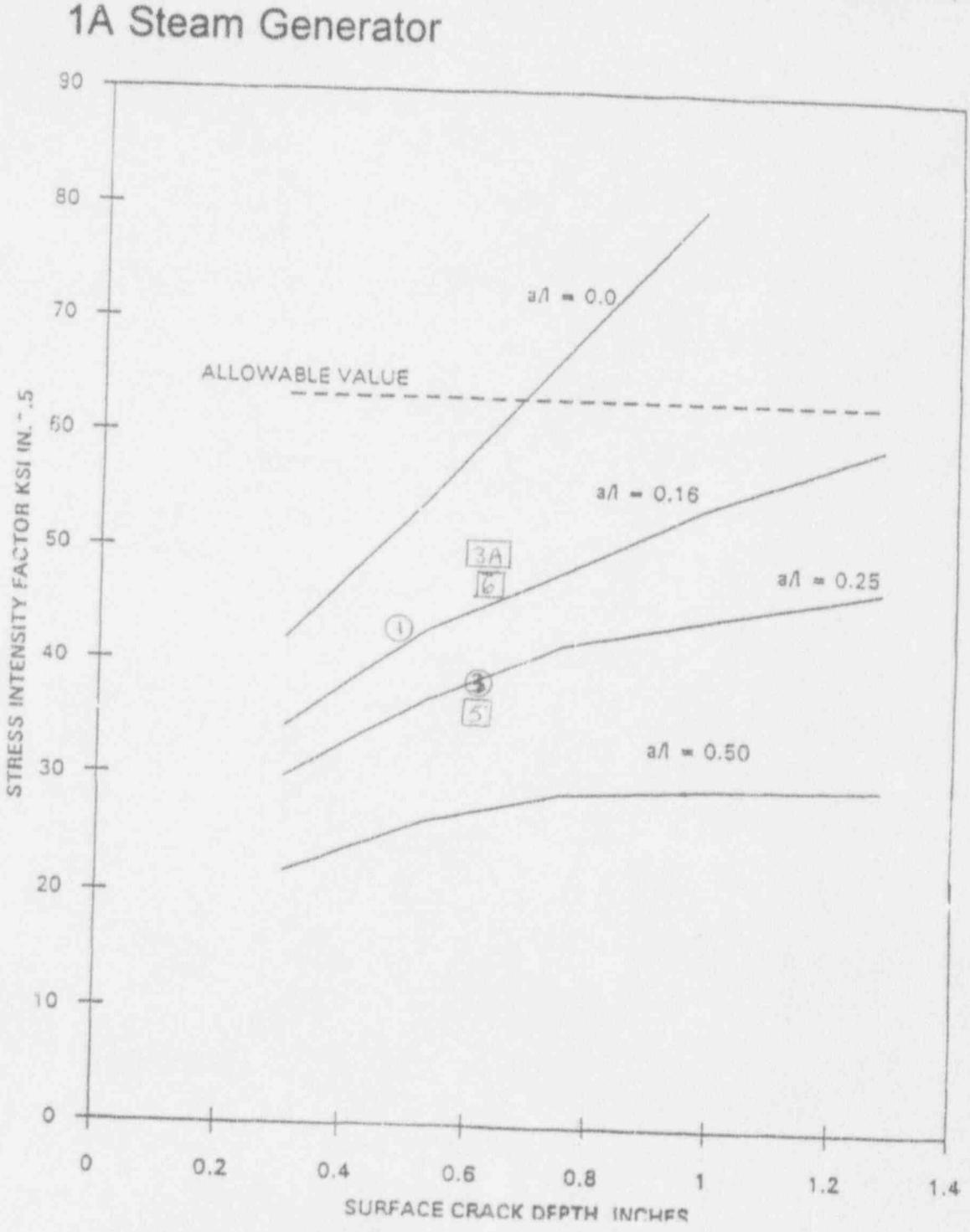

Figure 7-6. Stress Intensity Factor Versus Surface Crack Depth During Maximum Normal/Upset Condition Loading

Reference 1

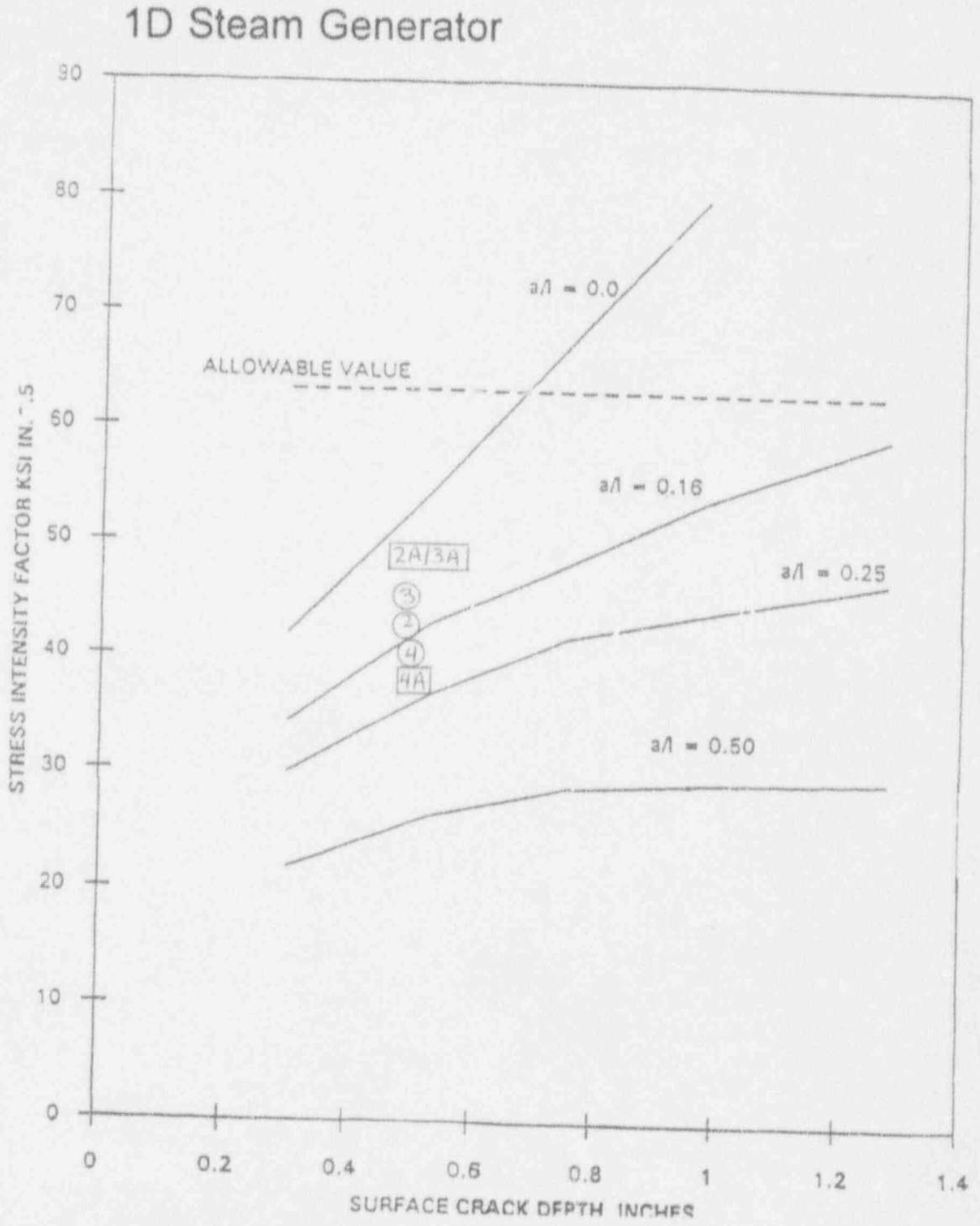

Figure 7-6. Stress Intensity Factor Versus Surface Crack Depth During Maximum Normal/Upset Condition Loading

Reference 1

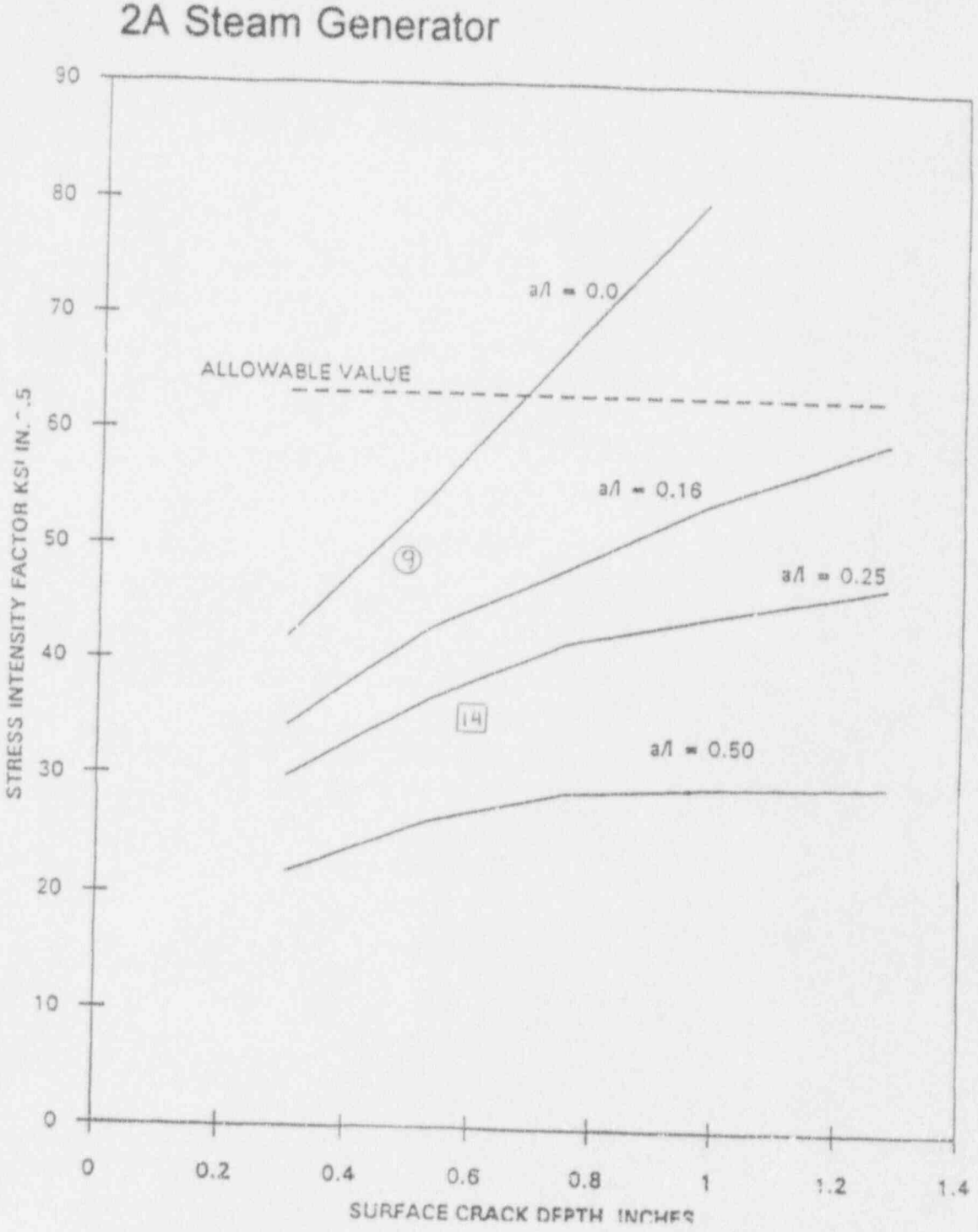

Figure 7-6. Stress Intensity Factor Versus Surface Crack Depth During Maximum Normal/Upset Condition Loading

Reference 1

2A Steam Generator

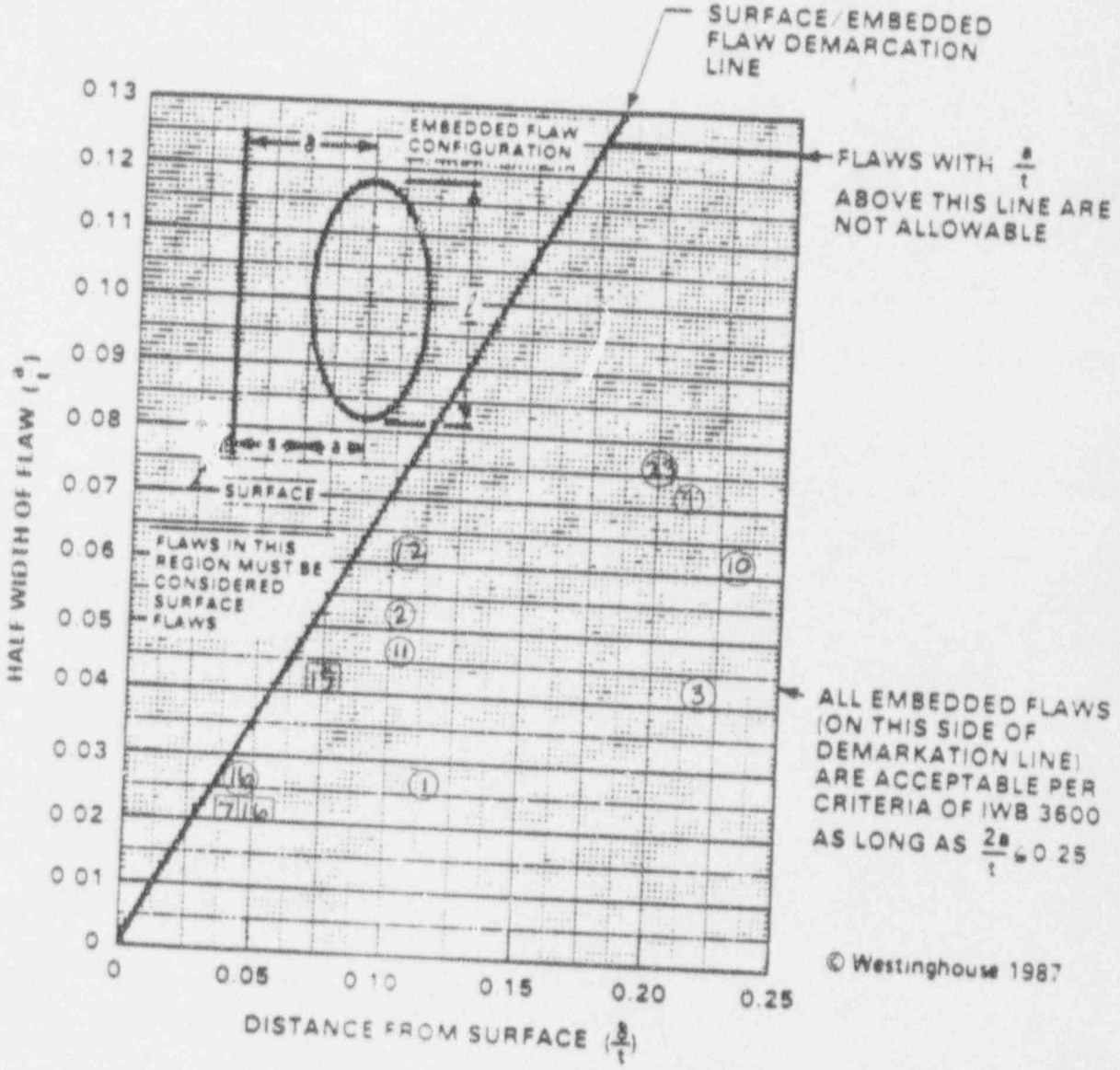

Figure A-6.4 Flaw Evaluation Chart for the Upper Shell-Cone Weld - Steam Generator

X	Inside Surface		Surface Flaw		Longitudinal Flaw
X	Outside Surface	X	Embedded Flaw	X	Circumferential Flaw

Reference 2

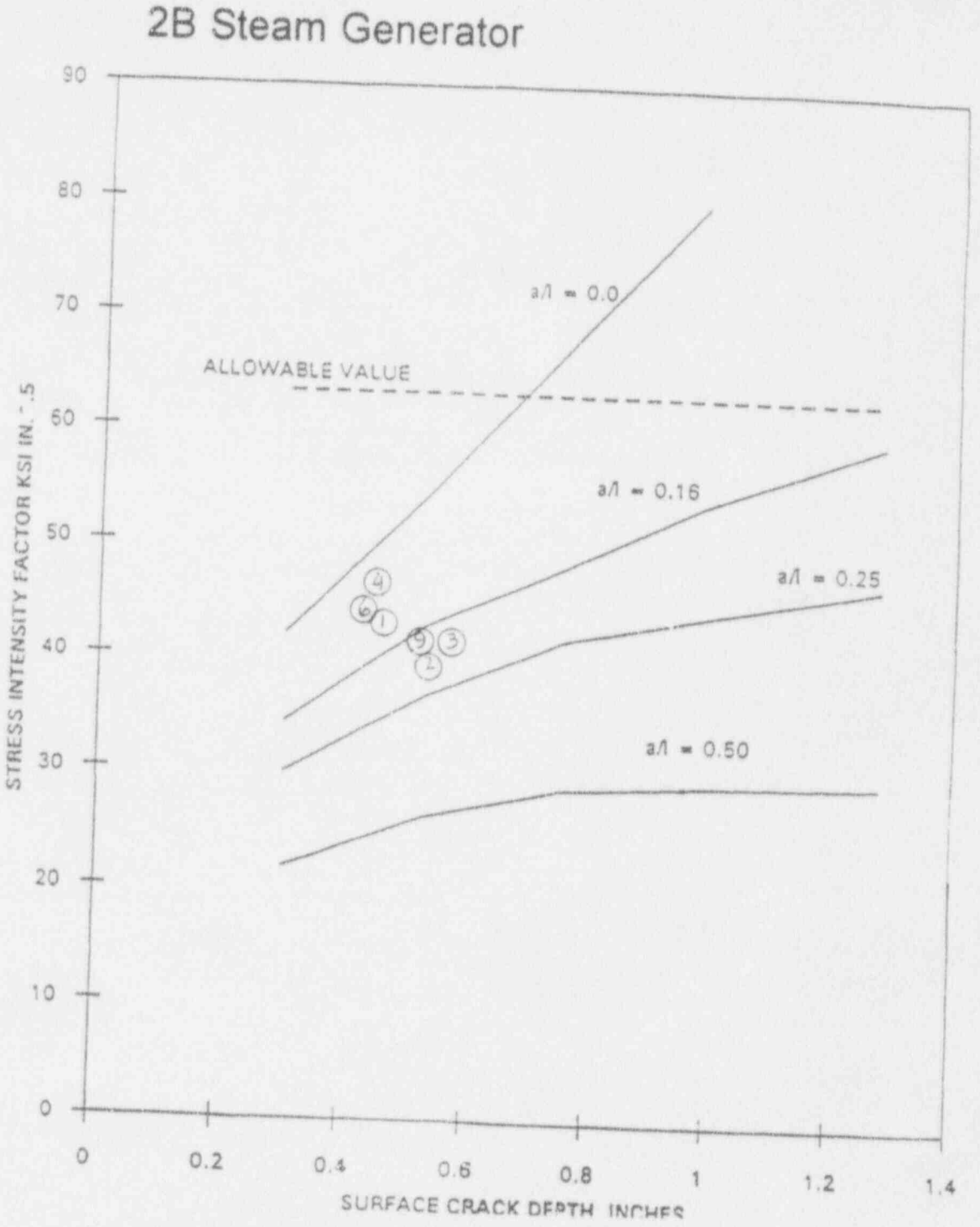

Figure 7-6. Stress Intensity Factor Versus Surface Crack Depth During Maximum Normal/Upset Condition Loading

2B Steam Generator

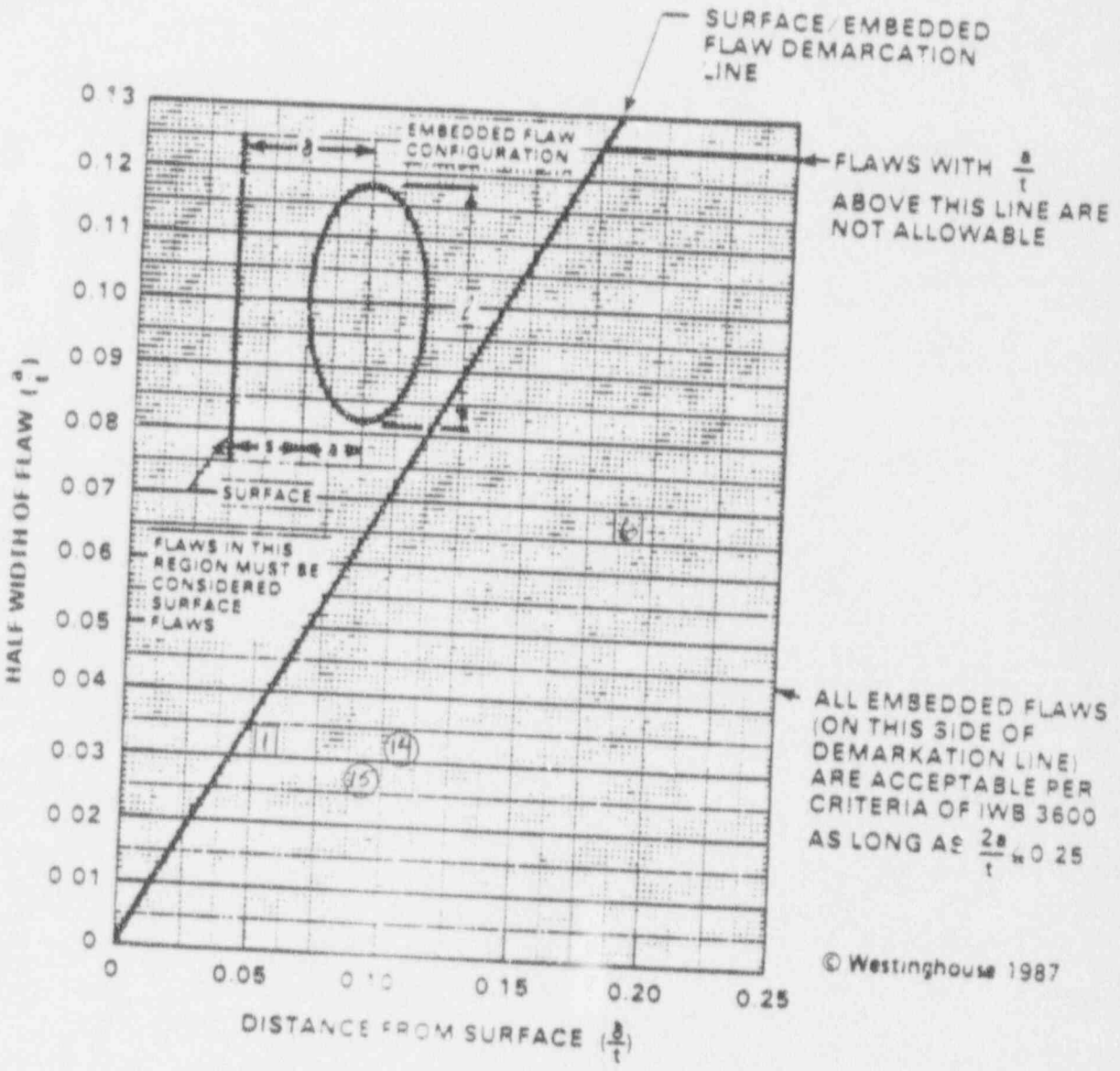

Figure A-6.4 Flaw Evaluation Chart for the Upper Shell-Cone Weld - Steam Generator

X	Inside Surface		Surface Flaw		Longitudinal Flaw
X	Outside Surface	X	Embedded Flaw	X	Circumferential Flaw

Reference 2

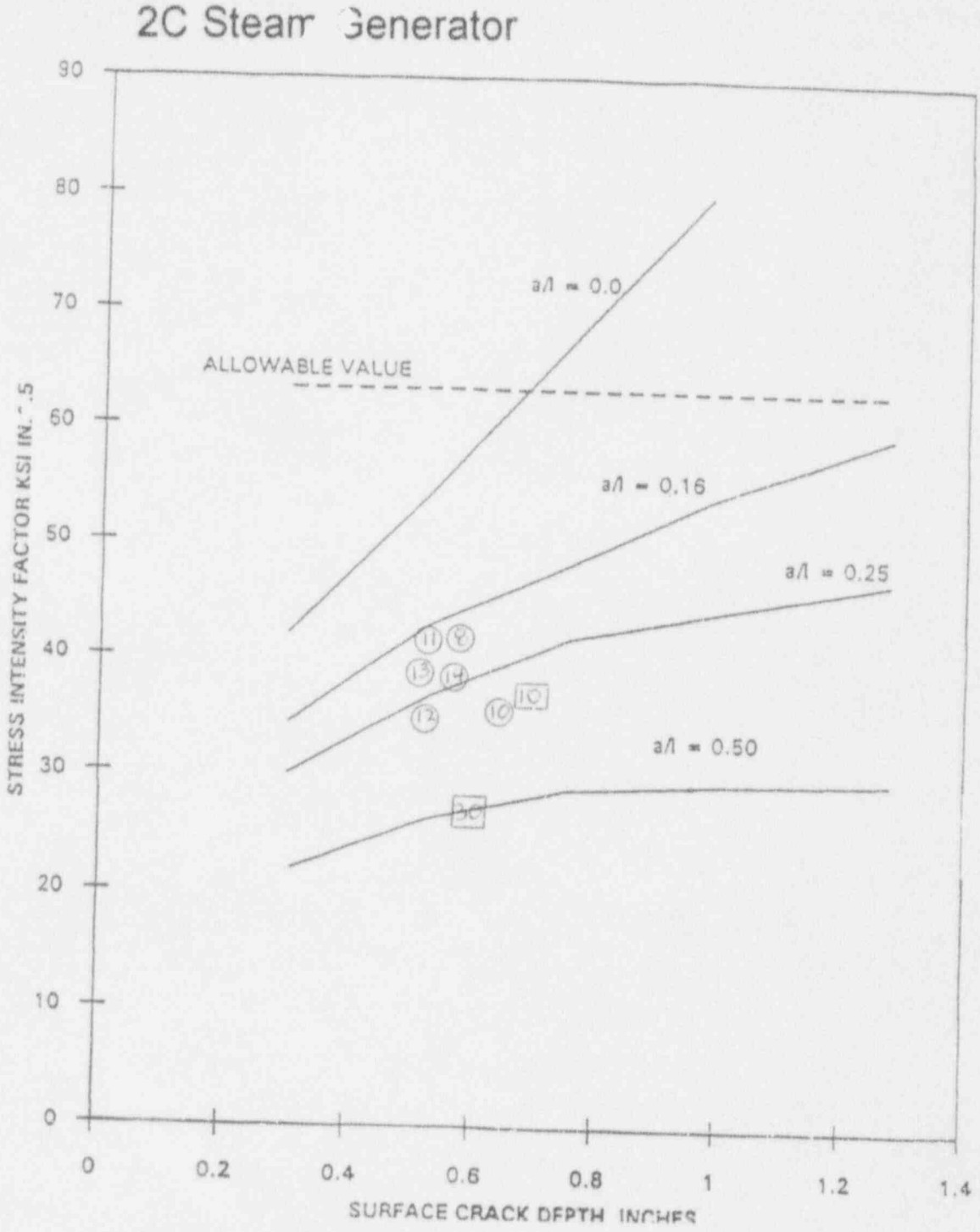

Figure 7-6. Stress Intensity Factor Versus Surface Crack Depth During Maximum Normal/Upset Condition Loading

Reference 1

2C Steam Generator

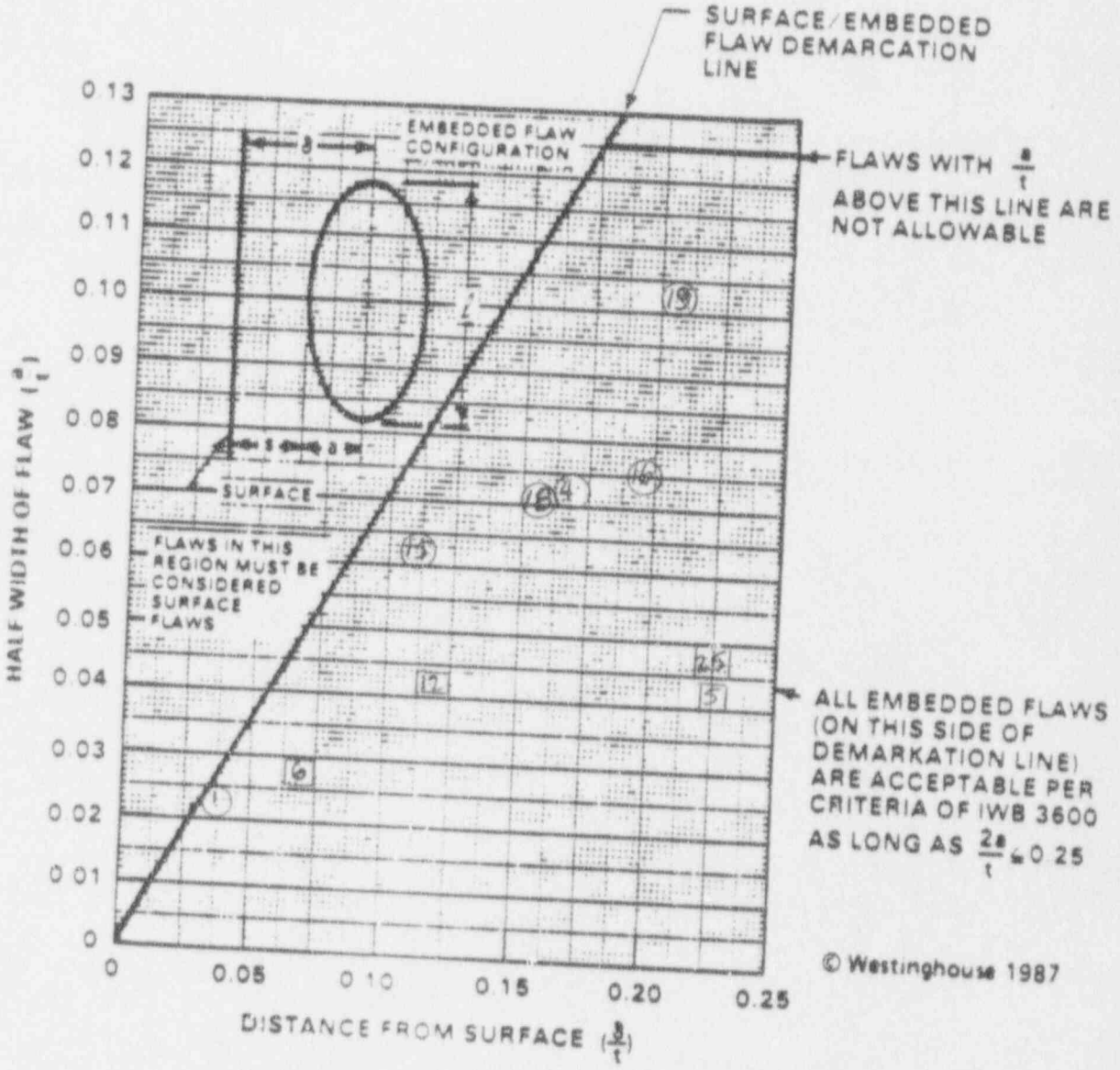

Figure A-6.4 Flaw Evaluation Chart for the Upper Shell-Cone Weld - Steam Generator

X	Inside Surface	___	Surface Flaw	___	Longitudinal Flaw
X	Outside Surface	X	Embedded Flaw	X	Circumferential Flaw

3380s/111688 10

Reference 2

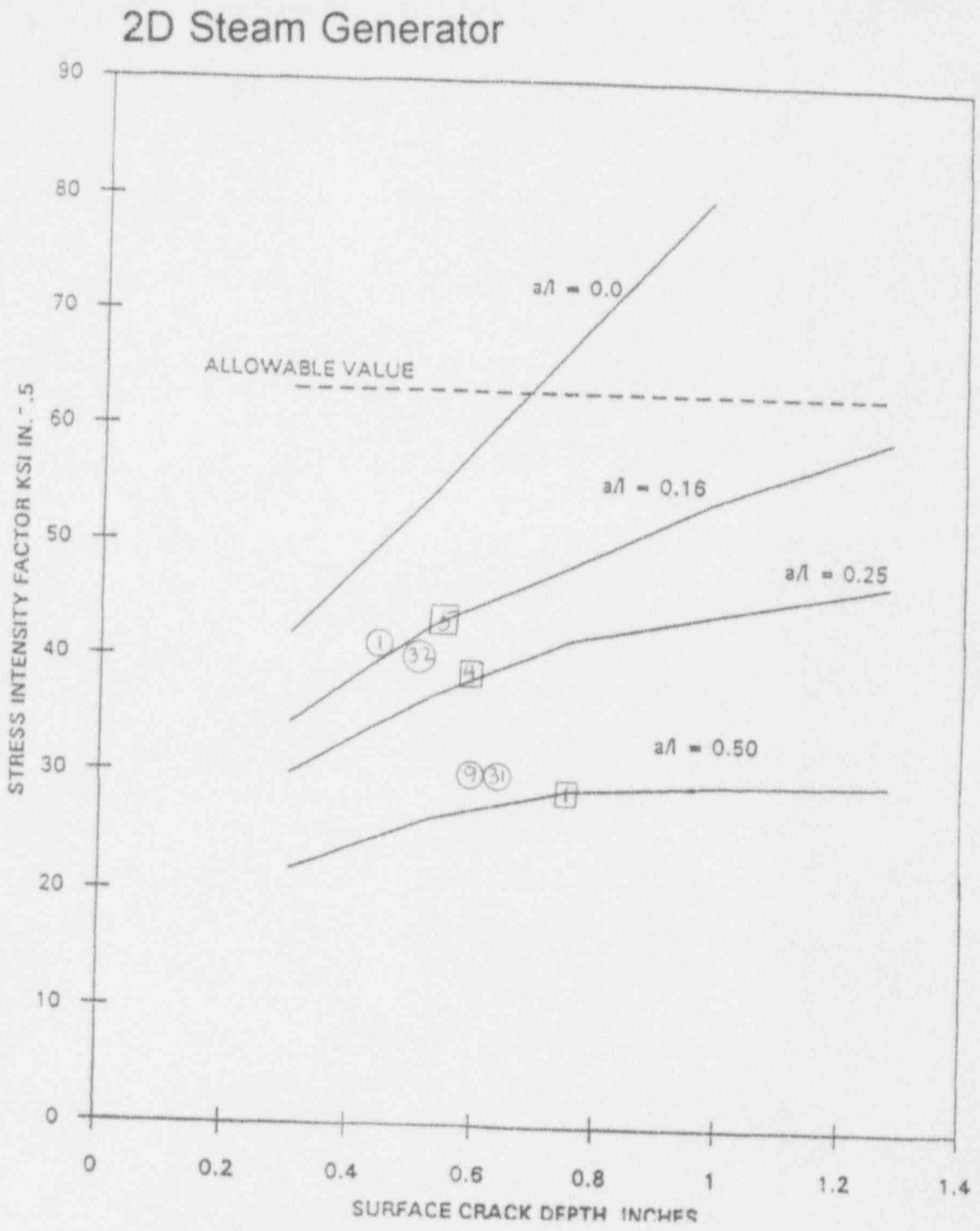

Figure 7-6. Stress Intensity Factor Versus Surface Crack Depth During Maximum Normal/Upset Condition Loading

Reference 1

2D Steam Generator

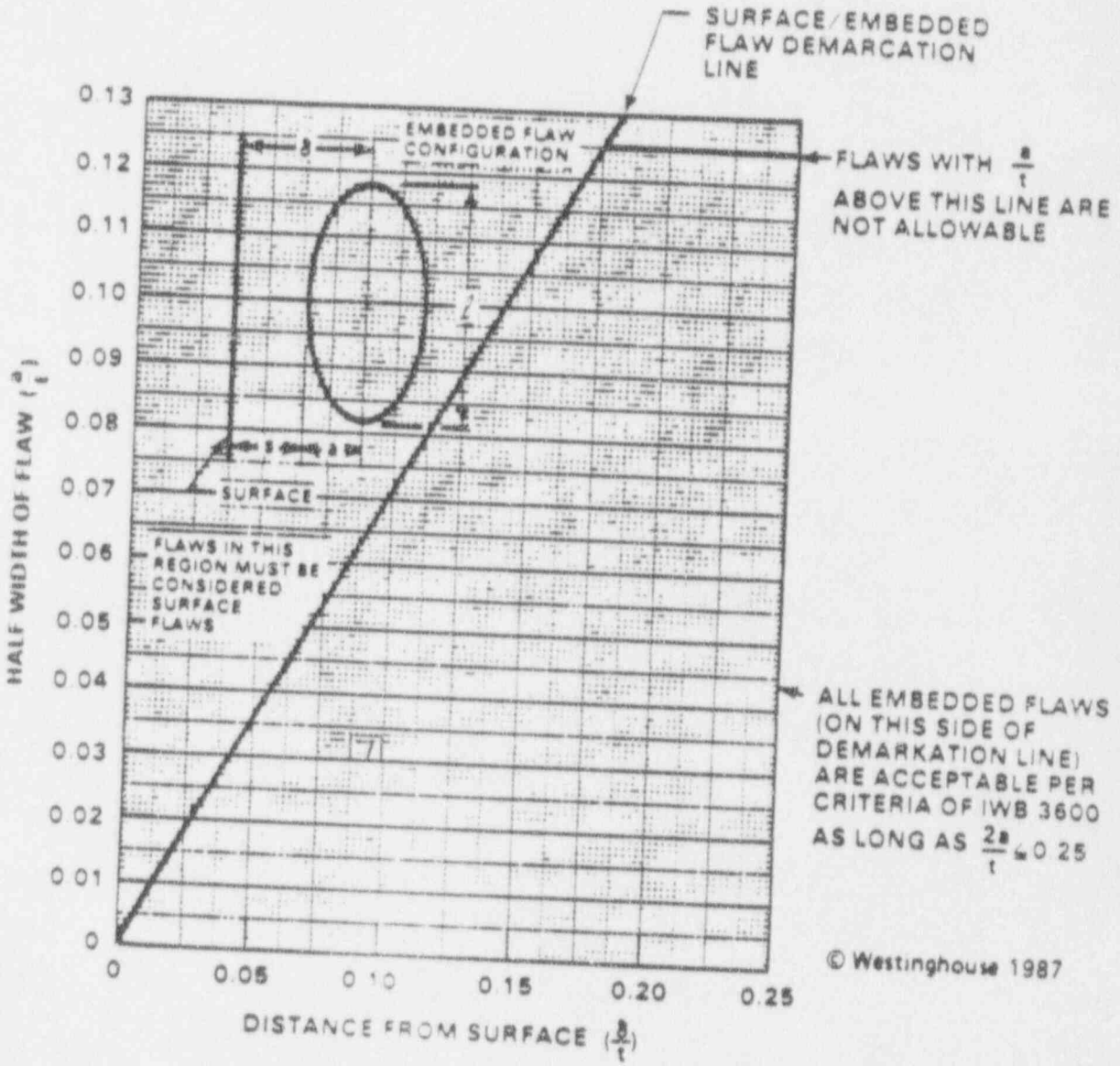

Figure A-6.4 Flaw Evaluation Chart for the Upper Shell-Cone Weld - Steam Generator

X	Inside Surface	___	Surface Flaw	___	Longitudinal Flaw
X	Outside Surface	X	Embedded Flaw	X	Circumferential Flaw

Notes on Graphs:

Figure A-6.4 from Westinghouse WCAP-12047 (reference 2) was used to evaluate Subsurface indications. Circled points designate 45 degree indications with the indication number contained within the circle. Boxed points designate 60 degree indications with the indication number contained in the circle.

Figure 7-6 from EASI report (reference 1) was used to evaluate surface indications. Circled points designate 45 degree indications with the indication number contained within the circle. Boxed points designate 60 degree indications with the indication number contained in the circle.

Points plotted are approximate locations.