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HINTZ, D. C. Wisconsin Public Service Corp.
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SUBJECT: Notifies that util performing non-destructive exams of piping & pressure vessels as part of inservice insp program at station. Draft evaluation analyses & exam results encl.

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March 28, 1988

10 CFR 50.55a

U. S. Nuclear Regulatory Commission
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Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Steam Generator Girth Weld Fracture Analyses

Reference: 1. WCAP-11476, Revision 1; "Handbook on Flaw Evaluation Kewaunee Unit 1 Steam Generators Upper Shell to Cone Weld", November 1987.

Wisconsin Public Service Corporation (WPSC) is currently performing non-destructive examinations of piping and pressure vessels as part of the Inservice Inspection Program at the Kewaunee Nuclear Power Plant. Included in these examinations was an ultrasonic examination of the entire length of the Steam Generator 'A' transition weld, SG-W2 (see figure 1) in accordance with IWC-2500(a) of the 1980 Edition of the ASME Code including Addenda through Winter 1981.

The results of the examination were evaluated and fourteen indications were determined to exceed the code allowable limits specified in Table IWB-3511-1 of the code. As required by IWB-3122.1 components which do not meet the acceptance standards shall be corrected by repair, replacement or evaluation. The indications were evaluated as required by IWB-3122.4 and found to be acceptable.

Article IWB-3125(b) states:

> "Evaluation analyses of examination results as required by IWB-3122.4 shall be submitted to the regulatory authority having jurisdiction at the plant site."

By attachment to this letter we provide the draft evaluation analyses and examination results as required. The steam generators are expected to be placed in operation on April 5, 1988; therefore, your immediate attention to review the

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attached document is essential. The final version of this report will be submitted as a revision to the previously submitted and accepted WCAP-11476, Rev. 1 (reference 1).

Sincerely,

D. C. Hintz
Vice-President - Nuclear Power

PMF/cmg

Attach.

cc - Mr. Robert Nelson, US NRC
US NRC, Region III

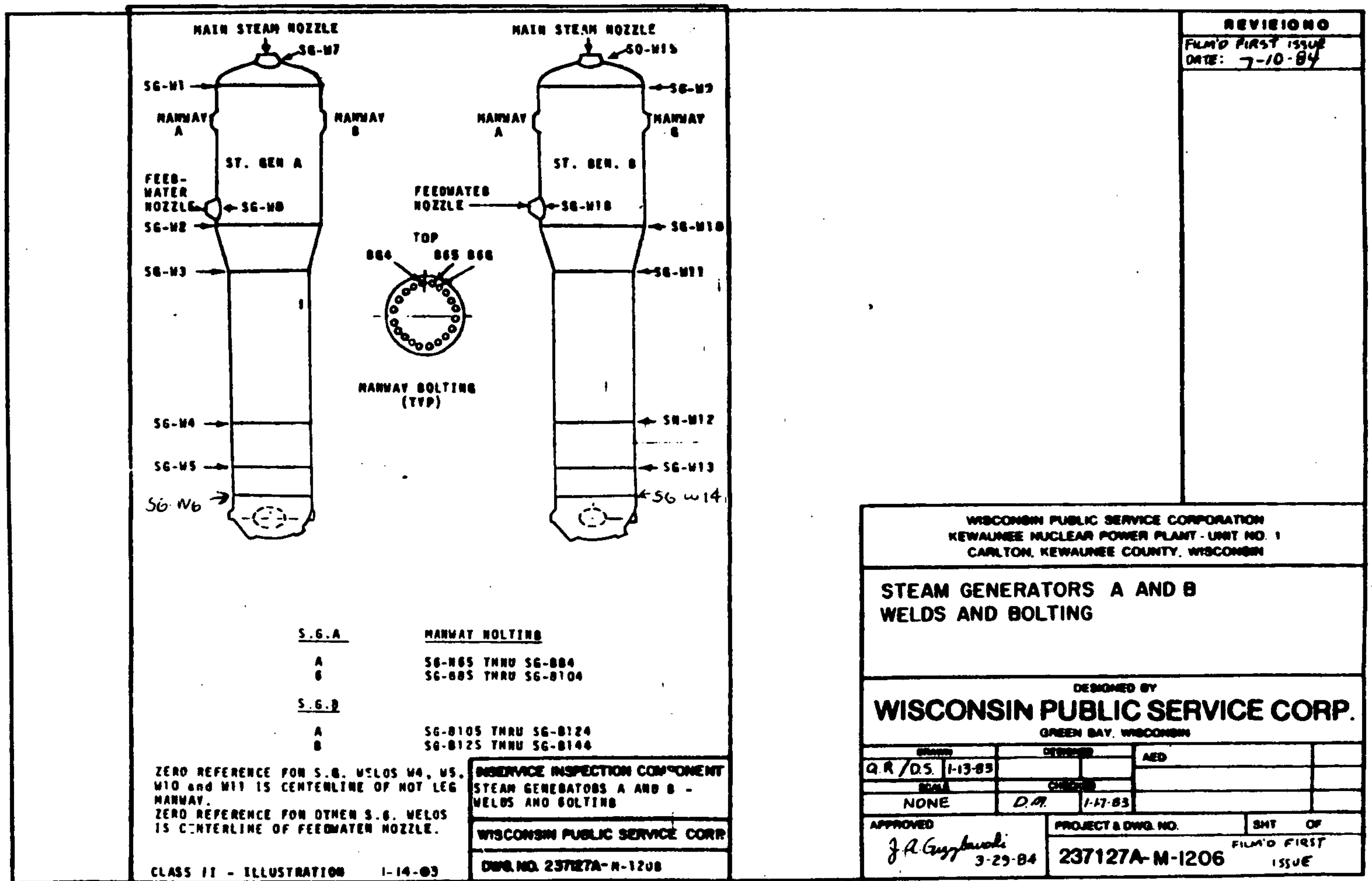
MAIN STEAM NOZZLE
SG-W7
SG-W1
MANWAY A
MANWAY B
ST. GEN A
FEED-WATER NOZZLE
SG-W8
SG-W2
SG-W3
SG-W4
SG-W5
SG W6
MAIN STEAM NOZZLE
SG-W15
SG-W9
MANWAY A
MANWAY B
ST. GEN. B
FEEDWATER NOZZLE
SG-W16
SG-W10
SG-W11
SG-W12
SG-W13
SG W14
TOP
B64
B65 B66
MANWAY BOLTING (TYP)
S.G.A
MANWAY BOLTING
A SG-B65 THRU SG-B84
B SG-B85 THRU SG-B104
S.G.B
A SG-B105 THRU SG-B124
B SG-B125 THRU SG-B144
ZERO REFERENCE FOR S.G. WELDS W4, W5, W10 and W11 IS CENTERLINE OF HOT LEG MANWAY.
ZERO REFERENCE FOR OTHER S.G. WELDS IS CENTERLINE OF FEEDWATER NOZZLE.
CLASS II - ILLUSTRATION 1-14-83
INSERVICE INSPECTION COMPONENT
STEAM GENERATORS A AND B - WELDS AND BOLTING
WISCONSIN PUBLIC SERVICE CORP.
DWG. NO. 237127A-M-1208
REVISIONS
FILM'D FIRST ISSUE DATE: 7-10-84
WISCONSIN PUBLIC SERVICE CORPORATION
KEWAUNEE NUCLEAR POWER PLANT - UNIT NO. 1
CARLTON, KEWAUNEE COUNTY, WISCONSIN
STEAM GENERATORS A AND B
WELDS AND BOLTING
DESIGNED BY
WISCONSIN PUBLIC SERVICE CORP.
GREEN BAY, WISCONSIN
DRAWN
DESIGNED
AED
Q.R./D.S. 1-13-83
SCALE
CHECKED
NONE
D.M. 1-17-83
APPROVED
J.A. Gryzbowski 3-29-84
PROJECT & DWG. NO.
SHT OF
237127A-M-1206
FILM'D FIRST ISSUE

Figure 1

Attachment

to

Letter from D. C. Hintz (WPSC)

to

Document Control Desk (NRC)

Dated

March 28, 1988

APPENDIX B

RESULTS OF THE INSPECTION OF MARCH 1988
ON STEAM GENERATOR "A"

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B-1 SUMMARY

During the March 1988 ultrasonic examination of the Kewaunee Unit 1 steam generator "A" upper shell to cone weld [SG-W2 (Weld 1-5)], nineteen recordable indications were noted. Seven of these were detected with the 45 degree, 2.25 MHz shear wave examinations, and the remaining twelve were detected with the 6D degree, 2.25 MHz shear wave examinations. The location of these indications in the weld, past experience with the same weld in other steam generators at other plants, and supplemental examinations performed on this steam generator indicate that all these indications are volumetric in nature, i.e., small slag inclusions and/or voids. An evaluation of these indications (using -6 dB drop or half maximum amplitude sizing criteria) to the acceptance standards in table IWB-3511-1 of the ASME Code Section XI, 1980 Edition with the Winter 1981 Addenda results in fourteen indications which are unacceptable.

Using the fracture analysis rules of IWB-3600 and the guidelines of appendix A, both from the ASME Code Section XI, 1980 Edition with the Winter 1981 Addenda, all the indications are acceptable using 50% DAC sizing levels (2.25 MHz transducer data), and using -6 dB drop or half maximum amplitude sizing levels (5.0 MHz transducer data).

These examinations were performed with the same personnel and procedures utilized on numerous other plants. These other plants exhibited both inner diameter cracking conditions, sub-surface fabrication flaws, or combination of both at the recording levels established in the test procedures. The evaluation of examination data and the performance of supplemental investigations were conducted by engineering personnel directly involved with the evaluation of data from the same plants as specified above.

B-2 ULTRASONIC EVALUATION AND DISCUSSION

Nineteen recordable indications were noted during the recent examinations of the Kewaunee Unit 1 steam generator "A" upper shell to cone weld. Summary tables of the indications are presented in tables B-1 and B-2. Table B-1 provides the measured "2a" value, the measured "S" value, and the measured length all with respect to the normal to the inside pressure retaining surface of the component and determined using a 5.0 MHz transducer and -6 dB drop or half maximum amplitude sizing criteria. Table B-2 shows the same parameters using a 2.25 MHz transducer and 50% DAC sizing criteria. These values are measured using indication plots rather than calculated from the raw data due to the geometry of the weld. This evaluation scheme is to maintain adherence to the flaw indication characterization criteria provided in IWA-3300 and table IWB-3511-1 of Section XI. The majority of the indications were detected from the other diameter surface of the transition cone, but are physically located in the upper shell portion of the weld. The indication parameters ("2a", "ℓ", and "S"), therefore, have been taken primarily from the surfaces of the upper shell. The 45 degree sizing data, with the exception of indications 4, 5, and 6, was taken using a 5.0 MHz, 45 degree shear wave transducer and a -6 dB drop or half maximum amplitude sizing criteria. The 45 degree shear wave indications 4, 5, and 6 were sized only using the detection data (2.25 MHz, 45 degree shear wave transducer, and 50% DAC sizing criteria). The 60 degree sizing data was taken using a 5.0 MHz, 60 degree shear wave transducer and -6 dB drop or half maximum amplitude sizing criteria. Sizing data using a 60 degree, 2.25 MHz transducer and 50% DAC sizing criteria were also taken. Although both 2.25 MHz and 5.0 MHz sizing data were taken, the primary sizing data used for the fracture mechanics analysis was based on that taken with the 5.0 MHz transducer. Experience has shown that 2.25 MHz testing is excellent for detection in this application, but tends to oversize when used in conjunction with the Section XI criteria, and volumetric-type reflectors.

The 2.25 MHz transducer produces a beam spread which is wider than that of a similar size 5.0 MHz transducer. This factor typically results in an unavoidable over-estimate of the true size of volumetric reflectors such as slag, which is believed to be present in this case. An example will illustrate this fact. Consider an indication which is being sized with a 2.25 MHz, 45 degree shear wave transducer and 50% DAC sizing criteria, as shown in figure B-1.

As the transducer is moved along the examination surface it picks up an indication (shown by the dot), and the first step is to locate the peak response of the indication, as shown in illustration (b). For illustration purposes, assume the amplitude is 100% of the distance amplitude correction curve (DAC). The peak response of the indication is then plotted in illustration (e), at an angle of 45 degrees from the transducer location. The distance along the 45 degree line is determined from the time base of the ultrasonic test instrument, which is a function of the speed of sound in the material.

The extent of the indication is then determined by moving the transducer along the surface until the amplitude drops to 50% DAC. This point is shown in illustration (c) for one direction, and corresponds to a reduction in the signal amplitude of the indication of 6 dB or one half in this case. Section XI requires this point to also be plotted at an angle of 45 degrees [see (f)] even though it is clear from (c) that the angle is less than 45 degrees. A similar procedure is then followed to get the extent of the indication in the other direction (d) and the location is again plotted at 45 degrees [see (g)] even though in this case the angle is clearly greater than 45 degrees. The through-wall dimension of the indication, "2a", is then determined from projection of a line through the peak point perpendicular to the vessel inside surface, as shown in (g). The through-wall dimension then follows from projection of the end points onto the perpendicular.

An illustration of how the flaw sizing and location changes with a narrower beam is shown in figure B-2. Here the example is exactly the same, but a 5.0 MHz transducer of similar size is used. The peak location or center of the indication is found to be identical to the previous example as shown in (e), but the outer extent of the indication is considerably different, because the beam is narrower, and the projection of the outer 50% DAC limits (or in this case -6 dB drop or half maximum amplitude limits) of the indication is less, as shown in (f) and (g). The through-wall depth is much smaller, and also the distance from the inside surface is also much greater. This is exactly the situation which occurred with the indications in steam generator A, although the actual details were more complex.

Therefore, in the case of volumetric flaws a reduction in beam spread is desired to obtain a more realistic size. There are a number of ways to minimize the beam spread, including use of a higher frequency transducer, a focused transducer, a larger transducer size or a combination of these. The beam spread, θ, can be shown by simple physics [B1] to be related to the diameter (D) of the transducer and its frequency (f) as follows:

$$\sin \theta = \frac{k\lambda}{D} = \frac{kC}{fD}$$

where K = a constant

C = speed of sound in the material

λ = wave length

θ = beam spread angle, defined in figures B-1 and B-2

f = frequency

Beam spread effects can also be minimized by use of beam spread correction, which is essentially a correction on the plotted extremities of the indications, but data to support the accuracy of these calculations is limited. The use of other transducers is permitted by Paragraph T-451.1 of the ASME Code Section V, Article 4, which states that "other ultrasonic techniques and nondestructive examination methods may be helpful in determining a relfector's true position, size, and orientation".

The raw indication data from the detection examinations in steam generator A clearly indicate that the detected reflectors are embedded rather than surface. This is seen in the location of the peak responses. No peak response is observed at or near the inner diameter surface which would be expected for a surface breaking flaw. In addition, the test operators did not observe any low-level amplitude signals below the recording level located at the inner diameter surface indicative of those found in plants having an inner diameter surface cracking condition. Supplemental examinations on three of the 60 degree shear wave indications originally determined to be surface by the rules established in Section XI resulted in the fact that these indications could be observed from both sides of the weld in a normal half-vee technique fashion as well as a 5/8-node technique with the peak locations embedded within the weld. The longest indication (approximately 12 inches long) was scanned with a 0 degree, 5 MHz longitudinal wave probe resulting in a confirmation of a cluster of reflectors at positions approximately 3.2 to 3.4 inches below the outer diameter surface for the entire length of the indication. At the same transducer position that this cluster was detected, a backwall response at 3.9 inches below the outer diameter surface was noted. This indicates a thickness of 3.9 inches and a difference in position between the volumetric reflectors and the inner diameter surface of 0.5 to 0.7 inch. All examination data, therefore, clearly suggest embedded flaws.

B-2.2 Experience With Other Plants

The indications in steam generator A at KNPP appear to be quite characteristic of experience with various welds in steam generators and pressurizers at other plants where pre-service ultransonic examination results based on 2.25 MHz, 50% DAC sizing methods predicted reflectors detected in weld backchip regions had dimensions in excess of those allowable values provided in Section XI of the ASME Code. Attempts were made at other plants to confirm the size, location, and orientation of these indications by complementary nondestructive examination methods, i.e., 0 degree longitudinal wave examinations, and both fabrication and field radiography. No reliable responses could be observed from the shear wave indictions using the straight beam examinations. In terms of the radiography, the fabrication radiographs of the areas in question were reviewed with no conclusive results. Additionally, field radiography was performed in selected areas at those plants, but again no confirmation of the shear wave examination indications could be obtained.

These inconclusive results led to physical removal of some of the suspect indications by mechanical means for complete metallurgical characterization. The indictions were found to have been caused by small slag inclusions and voids between weld passes in the weld backchip area near the inside surface. Measurements made during the destructive analysis showed that the ultrasonic sizing using 2.25 MHz, 50% DAC sizing methods exaggerated the true size of the discontinuities in terms of length and/or through-wall dimensions. These results are presented in table B-3, and plotted in figure B-3. These results agree closely with the illustrations previously presented.

Furthermore, this experience correlates well with investigations to date which have shown that when sizing volumetric-type reflectors by amplitude drop methods, i.e., 2.25 MHz, 50% DAC, the typical result is that the beam size rather than the reflector size is measured. For example, the lower the test frequency, the larger the beam width resulting in a larger than actual apparent flaw size (references B2-B7).

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B-2.3 1988 Inspection Conclusions

Since the data clearly suggested volumetric-type reflectors at KNPP the use of a more realistic volumetric flaw sizing approach was implemented. This sizing approach consisted of using a 5.0 MHz transducer and a -6 dB or half maximum amplitude sizing criteria. The angle used in sizing was dependent on the angle which detected the indication. The 5.0 MHz transducer resulted in a smaller beam spread in comparison with the true size of the suspect reflectors. The -6 dB or half maximum sizing criteria was selected because it has provided the better accuracies when compared with 50% DAC or 20% DAC sizing levels (reference B8).

Using the data in tables B-3 and B-4, two sets of evaluation calculations were performed. The first evaluation compared the characteristics of the 2.25 MHz detection data to the acceptance standards described in table IWB-3511-1 of the ASME Code Section XI, 1980 Edition with the Winter 1981 Addenda. This evaluation resulted in sixteen indications which were unacceptable (table B-5). The second evaluation compared the characteristics of the data composite sizing (5.0 MHz and 2.25 MHz data) to the acceptance standards described in table IWB-3511-1 of the ASME Code Section XI, 1980 Edition with the Winter 1981 Addenda. This resulted in fourteen indications which were unacceptable (table B-4). All indications sized with the 5.0 MHz transducer are classified as subsurface indications.

Since the indications found in these examinations are ultrasonically similar to those detected at other plants, it was appropriate to use higher frequency transducers to obtain more realistic data concerning the through-wall dimensions of the indications,. Since 45 degree indications numbers 4, 5, and 6 sized with 2.25 MHz, 50% DAC methods were within the acceptance standards in table IWB-3511-1 (ASME Section XI, 1980 Edition with the Winter 1981 Addenda), no high frequency data were taken.

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B.3 Fracture Analysis

There are two alternative sets of acceptance criteria for continued service without repair in paragraph IWB-3600 of the ASME Code Section XI:

1. Acceptance criteria based on flaw size (IWB-3611)
2. Acceptance criteria based on stress intensity factor (IWB-3612)

The choice of criteria is at the convenience of the user per IWB-3610. The more beneficial criteria of IWB-3612 have been used for evaluating the nineteen indications.

To determine the allowable flaw sizes in a weld, finite element analysis methods were used.

All applicable plant transients were analyzed to select the most severe stress profiles through the thickness of the weld. The actual stress profiles were then approximated by third order polynomials and used for calculating the stress intensity factor (K_I) for various crack sizes and aspect ratios.

The resulting K_I values were compared to fracture toughness values (K_{Ia} and K_{Ic}). Critical flaw sizes were then obtained, and allowable flaw sizes determined using the acceptance criteria discussed above.

The final step involves a calculation of crack growth due to fatigue loading. All anticipated plant transients were utilized in determining the resulting flaw size for a specified period of time. This was done for 10, 20, and 20 year intervals.

In addition to satisfying the fracture criteria, it is required that the primary stress limits of Section III paragraph NC-3000 be satisfied. A local area reduction of pressure retaining membrane must be used, equal to the area of indication; and the stresses increased to reflect the smaller cross section.

The nineteen indications found are all sub-surface flaws as defined by IWB-3500. As shown in figure B-4, all nineteen indications are acceptable per the fracture analysis criteria of IWB-3600. The fracture evaluation methods used for these analyses have been documented in WCAP 11476, Revision 1.

It should be mentioned that some elevation of the hydrotest and leak test temperatures over the specified temperature will be required to ensure the margins of IWB-3600 are maintained, and these temperatures have been provided along with the complete technical details of the analysis in WCAP 11476, Revision 1. The revised hydrotest and leak test temperatures from this inspection are provided in figures B-5 and B-6.

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B-4 REFERENCES

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B8. Willetts, A. J., Ammirato, F. V., and Kietzman, E. K., Jones, J. A. Applied Research Company. Accuracy of Ultrasonic Flaw Siszing Techniques for Reactor Pressure Vessels, EPRI RP1570-2 Draft Interim Report, March 1988.

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TABLE B-1

SUMMARY OF ULTRASONIC TEST INDICATIONS FOUND IN THE KEWAUNEE UNIT 1 STEAM GENERATOR "A" WELD 1-5 (5.0 MHZ TRANSDUCER, -6 dB DROP SIZING, SIZING DATA)

	DATA	INDICATION	MEASURED "2a"	"S" (inside surface)	LENGTH
1.	45 degree	1	0.14"	0.08"	0.35"
2.	45 degree	2	0.30"	1.04"	0.50"
3.	45 degree	3	0.37"	0.28"	0.95"
4.	45 degree	4	--	--	--
5.	45 degree	5	--	--	--
6.	45 degree	6	--	--	--
7.	45 degree	7	0.31"	0.59"	1.0"
8.	60 degree	1	0.23"	0.35"	0.75"
9.	60 degree	2	0.52"	0.26"	1.2"
10.	60 degree	3	0.35"	0.12"	1.55"
11.	60 degree	4	0.52"	0.26"	1.5"
12.	60 degree	5	D.30"	D.65"	2.1"
13.	60 degree	6	0.47"	0.41"	1.4"
14.	60 degree	7	D.30"	0.69"	2.9"
15.	60 degree	8	0.47"	0.20"	12.1"
16.	60 degree	9	0.35"	0.69"	13.25"
17.	60 degree	10	0.41"	0.71"	1.0"
18.	60 degree	11	0.47"	0.37"	1.8"
19.	60 degree	12	0.37"	0.30"	2.8"

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TABLE B-2

SUMMARY OF ULTRASONIC TEST INDICATIONS FOUND IN THE KEWAUNEE UNIT 1 STEAM GENERATOR "A" WELD 1-5 (2.25 MHZ TRANSDUCER, 50% DAC SIZING, DETECTION DATA)

	DATA	INDICATION	MEASURED "2a"	"S" (inside surface)	LENGTH
1.	45 degree	1	0.35"	D.12"	1.25"
2.	45 degree	2	0.43"	0.51"	0.85"
3.	45 degree	3	0.39"	0.39"	0.85"
4.	45 degree	4	0.12"	0.59"	0.60"
5.	45 degree	5	0.23"	0.67"	*
6.	45 degree	6	*	0.87"	*
7.	45 degree	7	0.23"	0.53"	1.4"
8.	60 degree	1	0.76"	0.0"	0.75"
9.	60 degree	2	0.46"	0.35"	1.0"
10.	60 degree	3	0.76"	0.12"	1.55"
11.	60 degree	4	0.52"	0.41"	0.9"
12.	60 degree	5	0.41"	0.34"	0.75"
13.	60 degree	6	0.64"	0.41"	1.0"
14.	60 degree	7	0.47"	0.64"	0.7"
15.	60 degree	8	0.42"	0.07"	12.1"
16.	60 degree	9	0.29"	0.82"	13.25"
17.	60 degree	10	0.46"	0.65"	1.0"
18.	60 degree	11	0.46"	0.47"	1.8"
19.	60 degree	12	0.58"	0.23"	1.8"

* To small to measure.

TABLE B-3

NONDESTRUCTIVE VERSUS DESTRUCTIVE TESTING RESULTS
USING 2.25 MHZ, 50% DAC SIZING

PHYSICAL SAMPLE	DISTANCE FROM ID SURFACE		THROUGH-WALL DEPTH		LENGTH	
	UT	ACTUAL	UT	ACTUAL	UT	ACTUAL
CORE #1 (Plant 1)	**	**	.37" to 1.03"	0.09"	1.18" to 3.18"	1.15"
CORE #2 (Plant 1)	**	**	.16" to .58"	0.02"	.63" to .75"	0.45"
CORE #1 (Plant 2)	0.00"	0.08" to 0.33" *	.24"	0.01" to 0.33"	0.88"	0.25" to 0.28"
CORE #2 (Plant 2)	0.16"	0.82"	0.53"	0.18"	0.88"	0.27"
GRINDING (Plant 2)	0.05"	**	0.37"	**	1.00"	**
GRINDING (Plant 2)	0.00"	0.375"	0.45"	0.094"	3.5"	**
GRINDING (Plant 2)	0.00"	0.125"	0.51"	0.156"	3.25"	**
GRINDING (Plant 2)	0.02"	0.156"	0.43"	0.219"	0.75"	0.375"
GRINDING (Plant 2)	0.00"	**	0.24"	**	0.75"	**
GRINDING (Plant 2)	0.00"	0.219"	0.33"	0.343"	1.0"	0.438"

* One UT indication was found to be four indications upon metallurgical evaluation. The values show the range of sizes for these four defects.

** Dimensions not reported.

TABLE B-4

RESULTS OF THE ASME SECTION XI, 1980 EDITION
WITH THE WINTER 1981 ADDENDA CALCULATIONS USING
THE ACCEPTANCE STANDARDS OF TABLE IWB-3511-1
(COMPOSITE SIZING DATA)

	DATA	INDICATION NO.	MEASURED "2a" (1)	TYPE OF IND.	"a"	"S"	"ℓ"	a/t ALLOW.	a/t ACTUAL
1.	45 deg.	1	0.14"	subsurf.	0.07"	0.08"	0.35"	3.6%	1.9%
2.	45 deg.	2	0.30"	subsurf.	0.15"	1.04"	0.50"	4.6%	4.0%
3.	45 deg.	3	0.37"	subsurf.	0.19"	0.28"	0.95"	3.6%	5.1%
4.	45 deg.	4	0.12"	subsurf.	0.06"	0.59"	0.60"	2.9%	1.6%
5.	45 deg.	5	0.23"	subsurf.	0.12"	0.67"	*	7.2%	3.2%
6.	45 deg.	6	*	subsurf.	*	0.87"	*	*	*
7.	45 deg.	7	0.31"	subsurf.	0.16"	0.59"	1.0"	3.3%	4.2%
8.	60 deg.	1	0.23"	subsurf.	0.12"	0.35"	0.75"	3.2%	3.2%
9.	60 deg.	2	0.52"	subsurf.	0.26"	0.26"	1.2"	3.8%	6.8%
10.	60 deg.	3	0.35"	subsurf.	0.35"	0.12"	1.55"	2.0%	4.8%
11.	60 deg.	4	0.52"	subsurf.	0.26"	0.26"	1.5"	3.4%	7.0%
12.	60 deg.	5	0.30"	subsurf.	0.15"	0.65"	2.1"	2.8%	4.0%
13.	60 deg.	6	0.47"	subsurf.	0.24"	0.41"	1.4"	3.4%	6.4%
14.	60 deg.	7	0.30"	subsurf.	0.15"	0.69"	2.9"	2.8%	4.0%
15.	60 deg.	8	0.47"	subsurf.	0.24"	0.20"	12.1"	2.2%	6.1%
16.	60 deg.	9	0.35"	subsurf.	0.18"	0.69"	13.25"	2.6%	4.9%
17.	60 deg.	10	0.41"	subsurf.	0.21"	0.71"	1.0"	3.7%	5.7%
18.	60 deg.	11	0.47"	subsurf.	0.24"	0.37"	1.8"	3.1%	6.4%
19.	60 deg.	12	0.37"	subsurf.	0.19"	0.30"	2.8"	2.8%	5.1%

* To small to measure.

(1) From table B-1 except for 45 degree indications 4, 5, and 6 which are from table B-2.

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TABLE B-5

RESULTS OF THE ASME SECTION XI, 198D EDITION
WITH THE WINTER 1981 ADDENDA IWB CALCULATIONS USING
THE ACCEPTANCE STANOARDS OF TABLE 3511-1
2.25 MHZ TRANSDUCER, 50% DAC SIZING DETECTION DATA

	DATA	INDICATION NO.	MEASURED "2a" (1)	TYPE OF IND.	"a"	"S"	"ℓ"	a/t ALLOW.	a/t ACTUAL
1.	45 deg.	1	0.35"	subsurf.	0.18"	0.12"	1.25"	2.1%	4.8%
2.	45 deg.	2	0.43"	subsurf.	0.22"	0.51"	0.85"	4.2%	5.9%
3.	45 deg.	3	0.39"	subsurf.	0.20"	0.39"	0.85"	4.0%	5.4%
4.	45 deg.	4	0.12"	subsurf.	0.06"	0.59"	0.60"	2.9%	1.6%
5.	45 deg.	5	0.23"	subsurf.	0.12"	0.67"	*	7.2%	3.2%
6.	45 deg.	6	*	subsurf.	*	0.87"	*	*	*
7.	45 deg.	7	0.23"	subsurf.	0.12"	0.53"	1.4"	2.9%	3.1%
8.	60 deg.	1	0.76"	surface	0.76"	0.0"	0.75"	3.7%	20.4%
9.	60 deg.	2	0.46"	subsurf.	0.23"	0.35"	1.0"	3.9%	6.2%
10.	60 deg.	3	0.76"	surface	0.76"	0.12"	1.55"	3.7%	20.4%
11.	60 deg.	4	0.52"	subsurf.	0.26"	0.41"	0.9"	4.5%	7.0%
12.	60 deg.	5	0.41"	subsurf.	0.21"	0.34"	0.75"	4.3%	5.5%
13.	60 deg.	6	0.64"	subsurf.	0.32"	0.41"	1.0"	4.8%	8.6%
14.	60 deg.	7	0.47"	subsurf.	0.23"	0.64"	0.7"	5.1%	6.17%
15.	60 deg.	8	0.42"	surface	0.42"	0.07"	12.1"	1.7%	11.4%
16.	60 deg.	9	0.29"	subsurf.	0.15"	0.82"	13.25"	2.64%	4.1%
17.	60 deg.	10	0.46"	subsurf.	0.23"	0.65"	1.0"	3.9%	6.3%
18.	60 deg.	11	0.46"	subsurf.	0.23"	0.47"	1.8"	3.08%	6.17%
19.	60 deg.	12	0.58"	subsurf.	0.29"	0.23"	1.8"	2.59%	7.77%

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* To small to measure.

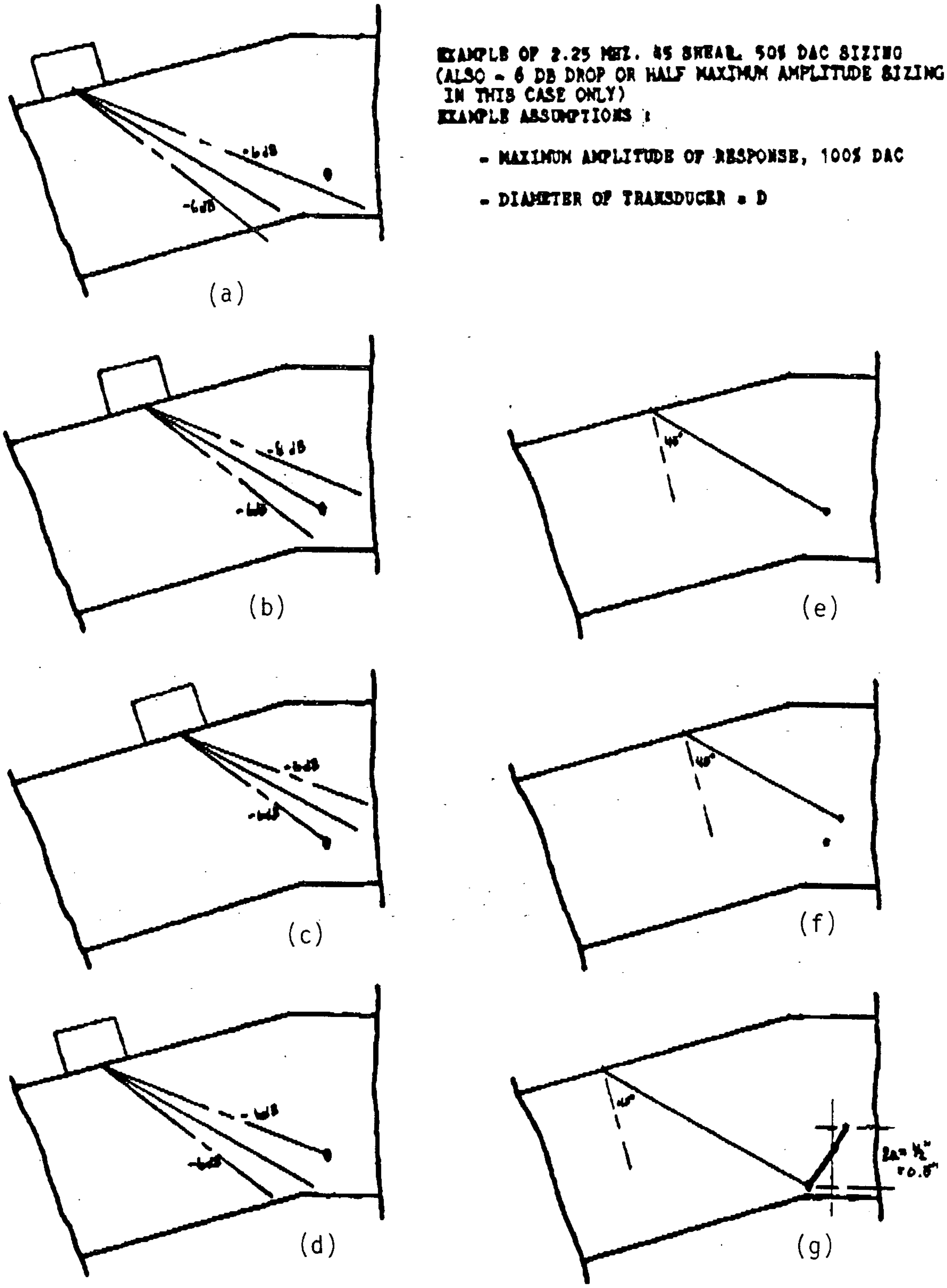
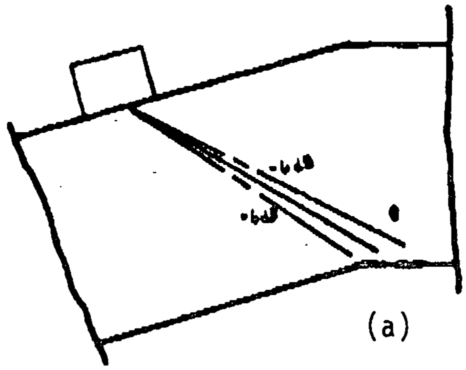


Figure B-1. Schematic Example of Flaw Sizing with 2.25 MHz Transducer Using 50% DAC Sizing Levels. (This particular example also shows -6 dB drop or half maximum amplitude sizing.)

EXAMPLE OF 5.0 MHZ, 45 SHEAR, 50% DAC SIZING
(ALSO - 6 DB DROP OR HALF MAXIMUM AMPLITUDE SIZING
IN THIS CASE ONLY)

EXAMPLE ASSUMPTIONS :

- MAXIMUM AMPLITUDE OF RESPONSE, 100% DAC
- DIAMETER OF TRANSDUCER = D



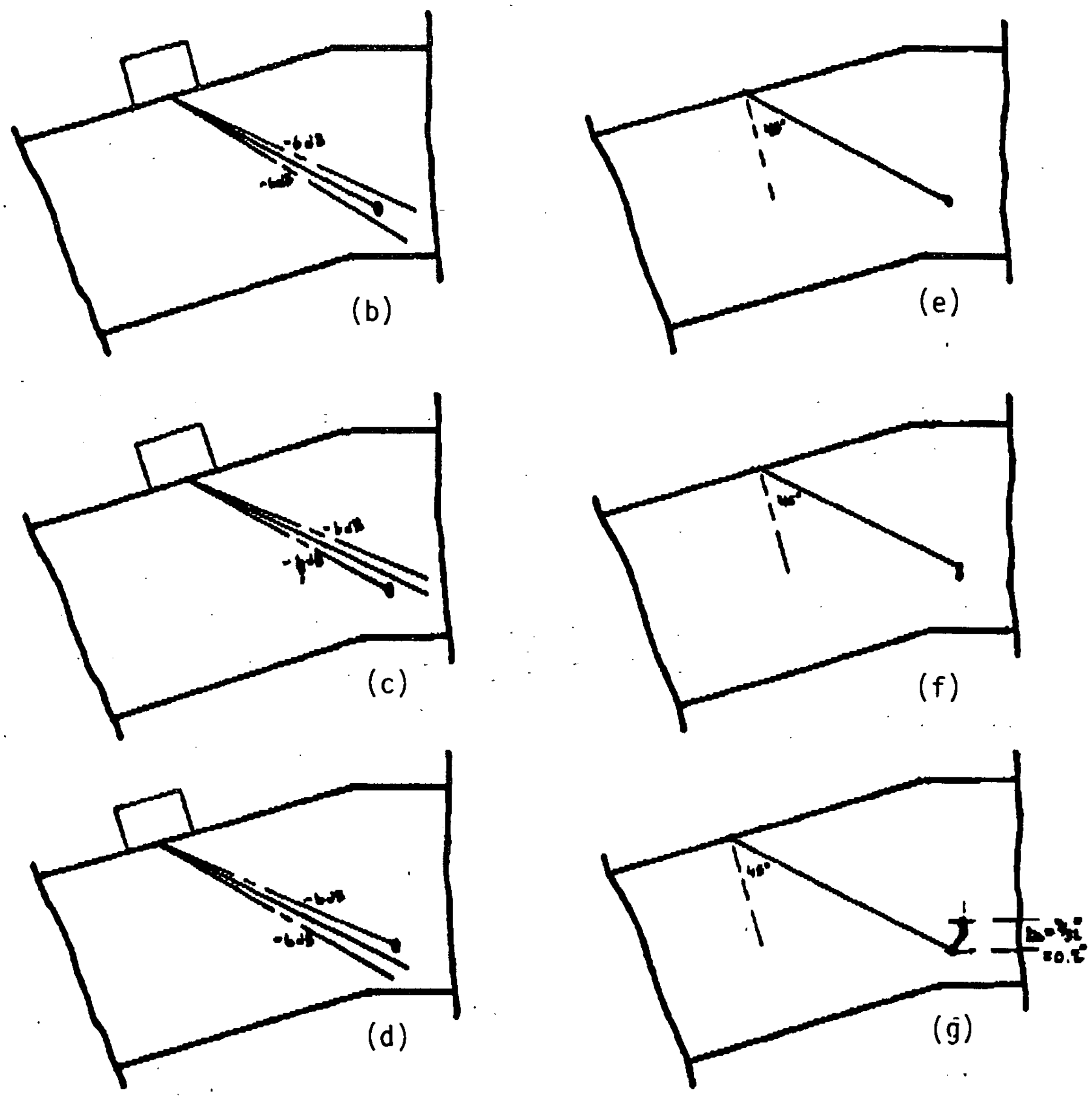


Figure B-2. Schematic Example of Flaw Sizing With 5.0 MHz Transducer Using 50% DAC Sizing Levels. (This particular example also shows -6dB drop or half maximum amplitude sizing.)

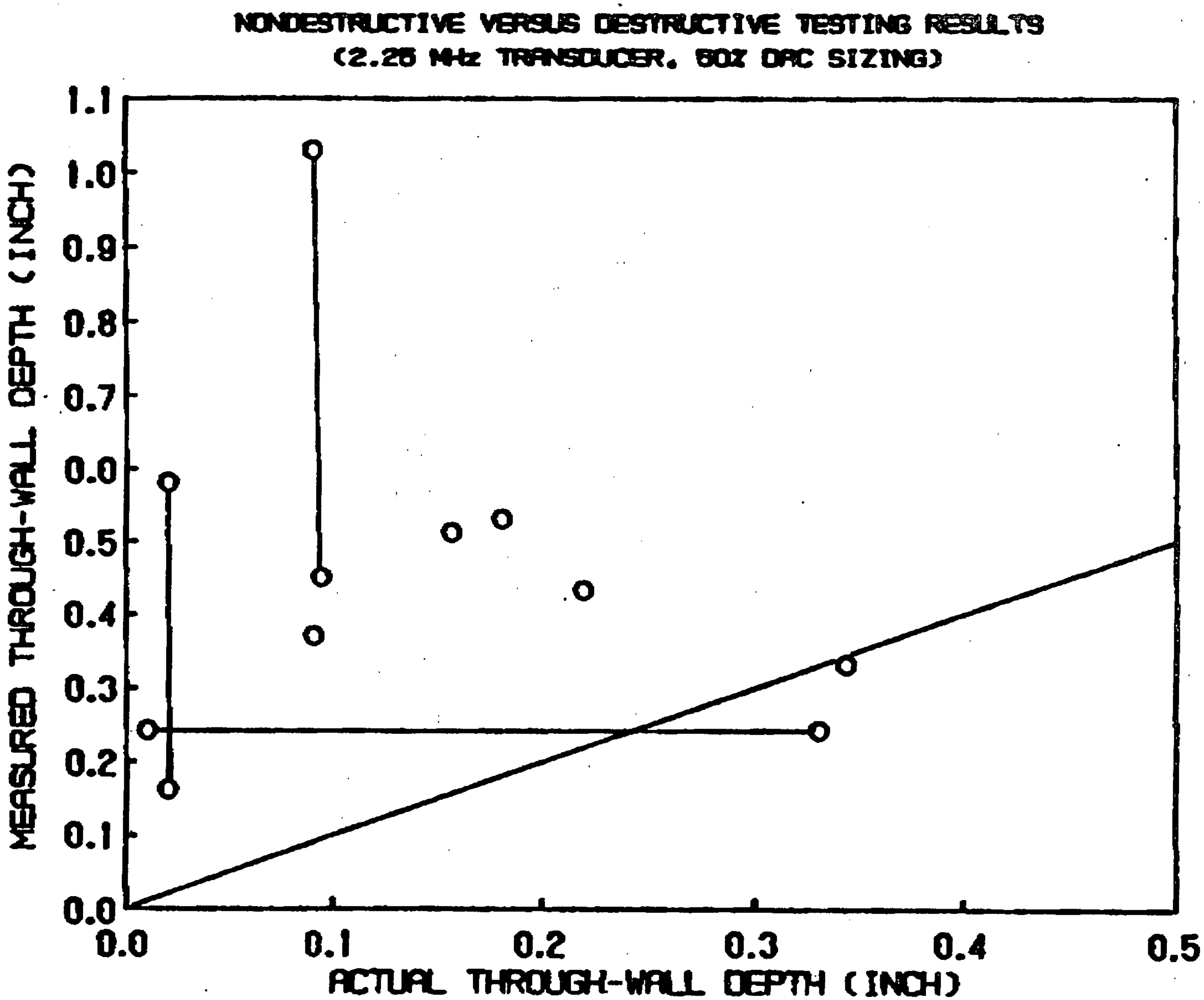
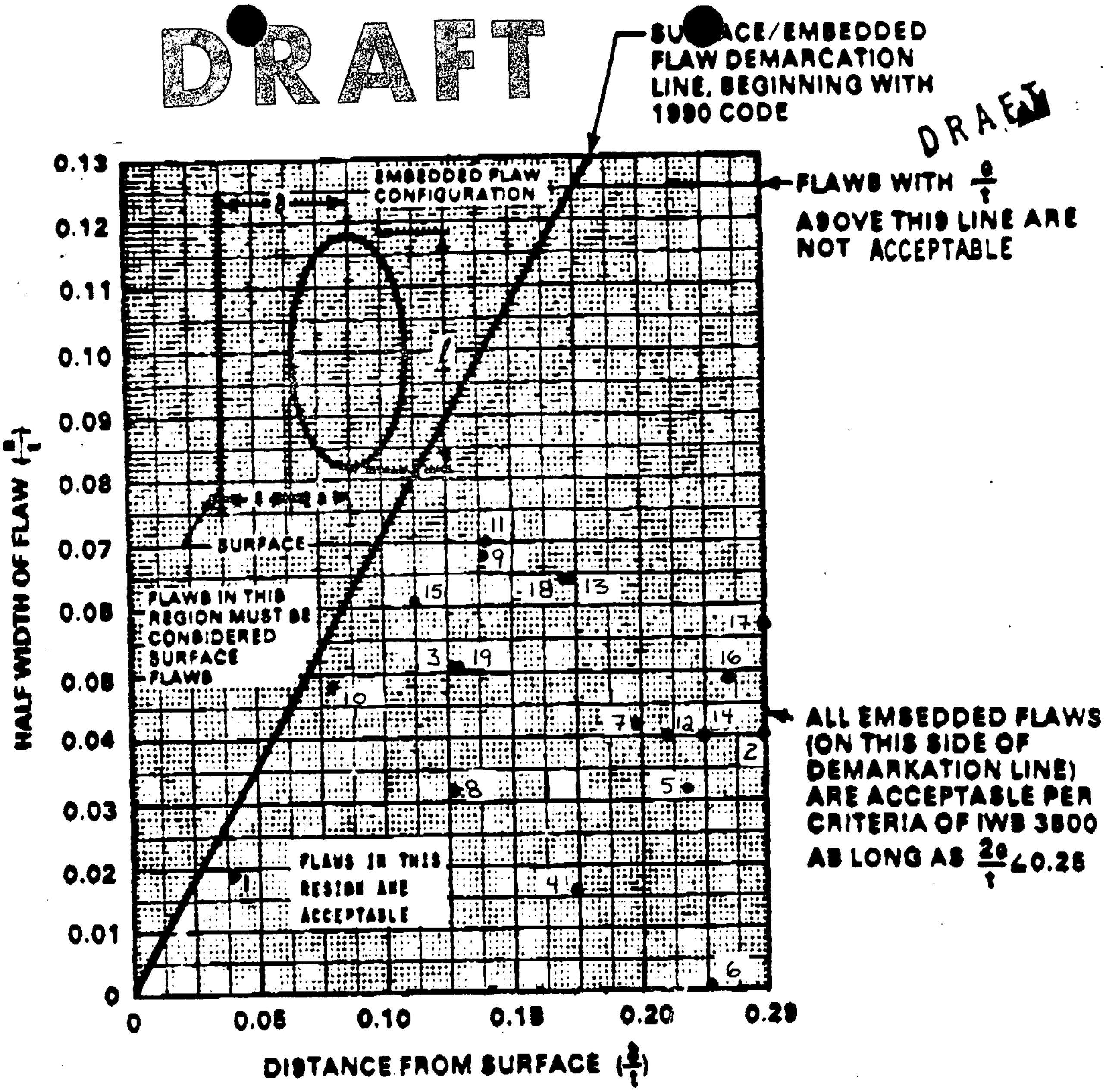


Figure B-3. Nondestructive vs. Destructive Testing Results, 2.25 MHz Transducer with 50% DAC Sizing



DATA	IND.	TYPE OF IND.	MEASURED "2a"	MEASURED "S"	MEASURED "t"	a/t	S/t	ACCEPTABLE
1. 45 deg.	1	subsurf.	0.14"	0.08"	3.73"	0.019	0.040	yes
2. 45 deg.	2	subsurf.	0.30"	1.04"	3.73"	0.040	0.320	yes
3. 45 deg.	3	subsurf.	0.37"	0.28"	3.73"	0.051	0.126	yes
4. 45 deg.	4	subsurf.	0.12"	0.59"	3.73"	0.016	0.174	yes
5. 45 deg.	5	subsurf.	0.23"	0.67"	3.73"	0.032	0.212	yes
6. 45 deg.	6	subsurf.	0.00"	0.87"	3.73"	0.000	0.233	yes
7. 45 deg.	7	subsurf.	0.31"	0.59"	3.85"	0.042	0.195	yes
8. 60 deg.	1	subsurf.	0.23"	0.35"	3.73"	0.032	0.126	yes
9. 60 deg.	2	subsurf.	0.52"	0.26"	3.73"	0.068	0.139	yes
10. 60 deg.	3	subsurf.	0.35"	0.12"	3.73"	0.048	0.030	yes
11. 60 deg.	4	subsurf.	0.52"	0.26"	3.73"	0.070	0.139	yes
12. 60 deg.	5	subsurf.	0.30"	0.65"	3.79"	0.040	0.211	yes
13. 60 deg.	6	subsurf.	0.47"	0.41"	3.73"	0.064	0.178	yes
14. 60 deg.	7	subsurf.	0.30"	0.69"	3.37"	0.040	0.225	yes
15. 60 deg.	8	subsurf.	0.47"	0.20"	3.93"	0.061	0.112	yes
16. 60 deg.	9	subsurf.	0.35"	0.69"	3.68"	0.049	0.236	yes
17. 60 deg.	10	subsurf.	0.41"	0.71"	3.68"	0.057	0.250	yes
18. 60 deg.	11	subsurf.	0.47"	0.37"	3.73"	0.064	0.164	yes
19. 60 deg.	12	subsurf.	0.37"	0.30"	3.73"	0.051	0.131	yes

Figure B-4. Fracture Analysis Results for Indications Found in the Kewaunee Unit 1 Steam Generator "A" Weld 1-5 (Composite Sizing Data)

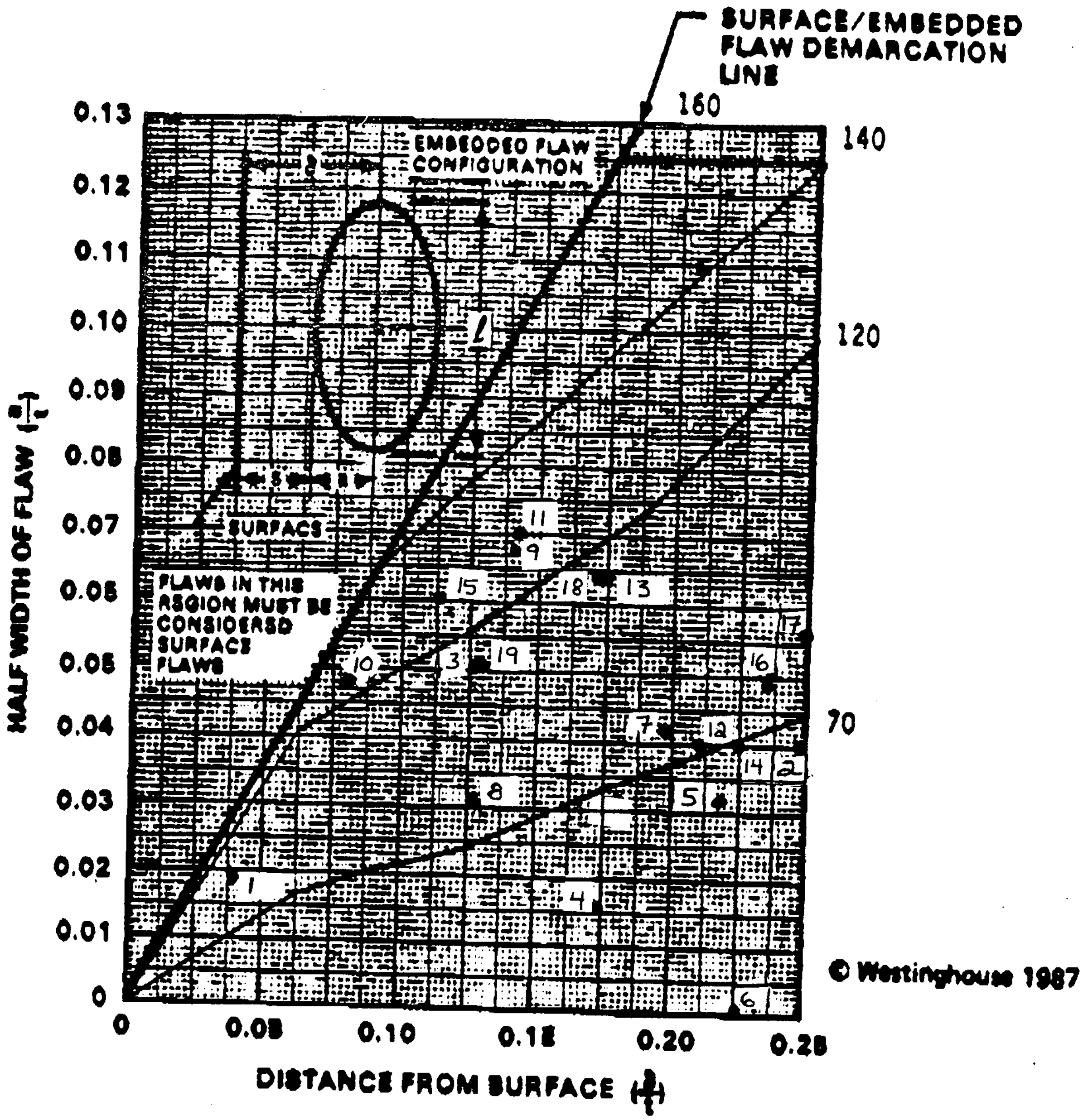


Figure B-5. Determination of Hydrostatic Test Temperatures from Results of the March 1988 Inspection (Composite Sizing Data)

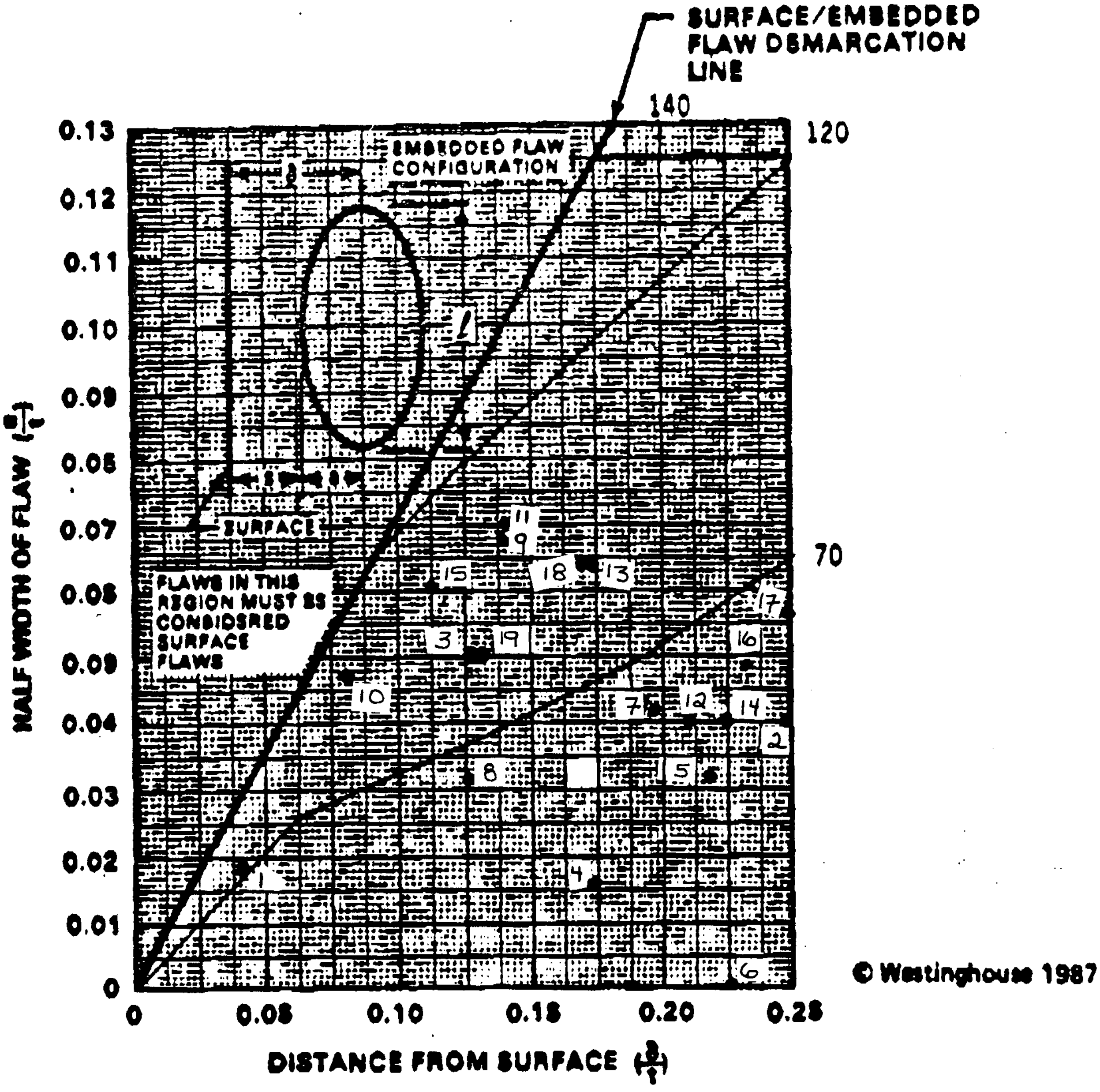


Figure B-6. Determination of Leakage Test Temperatures from Results of the March 1988 Inspections (Composite Sizing Data)