ALTERNATE STANDARDS FOR THE INTERPRETATION OF EDDY-CURRENT DATA FOR STEAM GENERATOR TUBING[(a)(b)(c)]

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INTRODUCTION

Single frequency eddy-current testing is the current as-practiced nondestructive method used to inspect small diameter, thin walled Inconel-600 heat exchanger tubes in steam generators of Pressurized Water Reactors (PWR). The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code[(1)] (referred: ASME Code) has specific calibration and procedure requirements for the eddy-current testing of steam generator tubes. Specifically, the tube calibration standards in the ASME Code contain a series of flat-bottom drill holes (FBH) of varying diameters and depths. The calibration standard is used to calibrate the eddy-current system, and used to generate a flaw depth interpretation curve to relate the phase angle of the eddy-current signal pattern to the flat-bottom hole depth. The flaw depth interpretation curve is used to determine the depth of service induced tube flaws of unknown geometry during inservice inspection of the steam generator.

Extensive laboratory data from Phase I of the Steam Generator Tube Integrity Program[(2)] showed results for machine flawed tubes indicating that flaw

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(b) U.S. Nuclear Regulatory Commission Contract Fin No. B 2097, RSR Technical Monitor: Dr. J. Muscara.

(c) Work conducted as a task under the Steam Generator Tube Integrity Program, Program Manager: Dr. R. A. Clark.

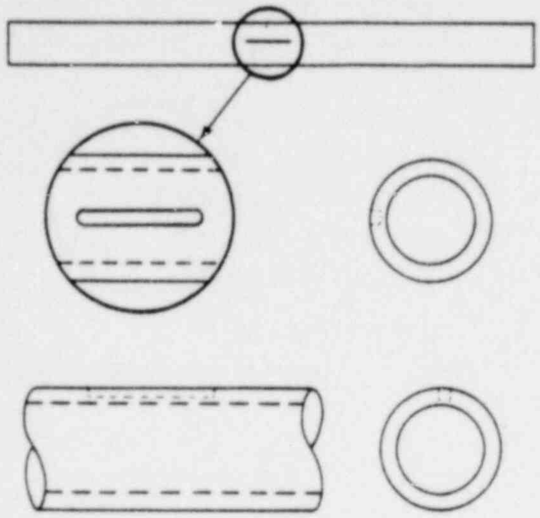
geometry is a dominant factor in determining single frequency eddy-current measurement accuracy. Using flaw depth interpretation curves generated from ASME Code flat-bottom hole calibration standards, the depth of several hundred machine flawed tube specimens was determined. The flawed tube specimen matrix consisted of small volume electro-discharged machine (EDM) slots and medium volume (elliptical) and large volume (uniform thinning) wastage flaws (Figure 1). The eddy-current results from Phase I suggested that the EDM slots, elliptical wastage, and uniform thinning wastage flaws could be more accurately sized for depth using flaw depth interpretation curves generated from calibration standards other than the ASME flat-bottom hole standards.

This paper discusses work done to develop alternate flaw tube standards for EDM slot, elliptical wastage and uniform thinning wastage flaws in steam generator tubes. Single frequency eddy-current data is presented comparing the flaw depth measurement results obtained using the new alternate standards to the ASME Code flat-bottom hole standards.

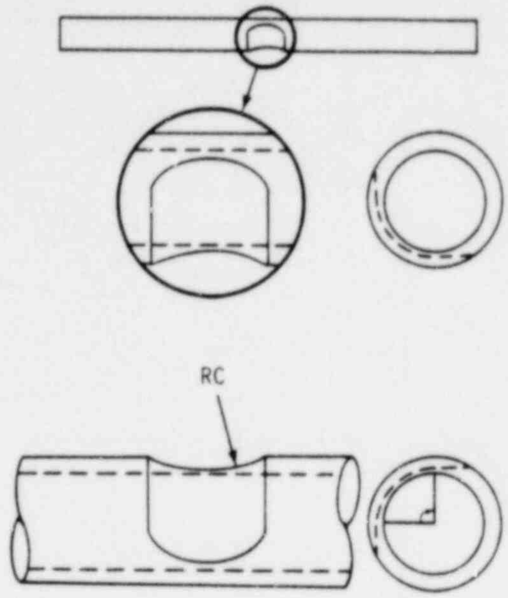
RESULTS

EDM slot, elliptical wastage and uniform thinning wastage standards were fabricated from Inconel-600 tubing with outer diameter and wall thickness dimensions, 0.875 x 0.050 in. Each standard was inspected in the laboratory at a set frequency of 400 kHz using a differential wound (2 coil) eddy-current bobbin probe and an EM3300 eddy-current excitation generator.

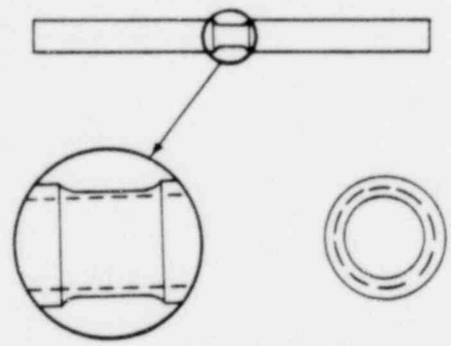
Figure 2 shows plots of interpretation curves for EDM slot, elliptical wastage, uniform thinning and ASME flat-bottom hole (FBH) standards. These curves show the relationship between the eddy-current pattern phase angle and true flaw depth, as determined by optical and mechanical gauging techniques. Figure 2 shows that the EDM slot and uniform thinning wastage curves exhibit a different relationship between pattern phase angle and flaw depth compared to the ASME FBH curve. The elliptical wastage curve closely approximates the ASME FBH curve.



(a) EDM Slot



(b) Elliptical Wastage



(c) Uniform Thinning

FIGURE 1. EDM Slots, Elliptical Wastage, and Uniform Thinning Wastage Flaw Specimens

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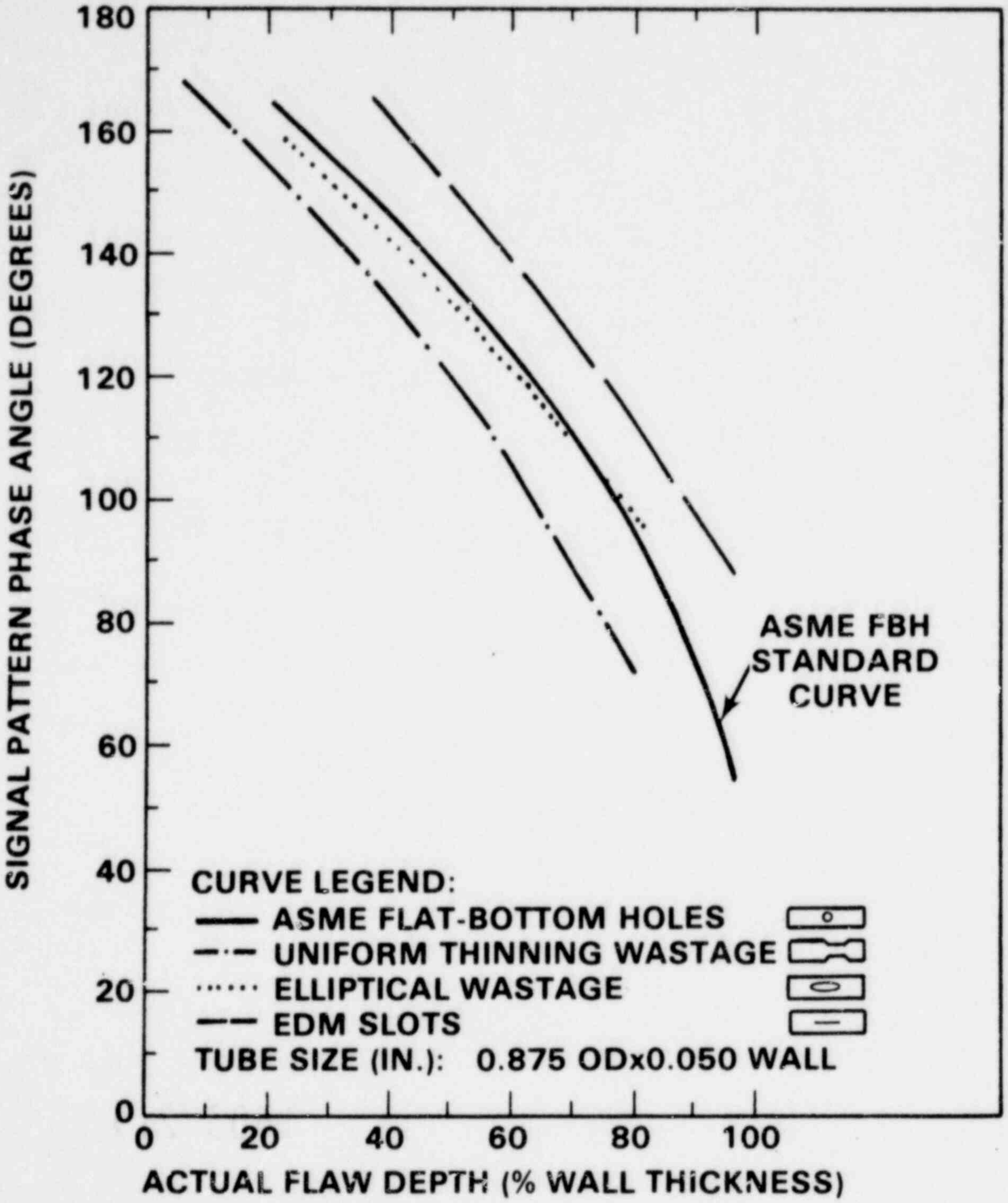

FIGURE 2. Single Frequency Eddy-Current Interpretation Curves Generated From ASME FBH, EDM Slot, Elliptical Wastage, and Uniform Thinning Wastage Standards

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The eddy-current data from Phase I was reevaluated using the new interpretation curves of Figure 2. Figures 3, 4 and 5 show the eddy-current indicated depth for EDM slots, elliptical wastage, and uniform thinning wastage plotted against the actual depth of the flaw; both depths are presented as a percentage of wall thickness. The solid line represents the linear relationship that would result if there were no eddy-current measurement error. Points above the line represent overestimations of flaw depth, or "conservative" measurement results; points below the line indicate underestimations, or "nonconservative" measurement results. Figures 3, 4, and 5 show data comparing the depth sizing results achieved using the EDM slot, elliptical wastage and uniform thinning wastage curves, respectively, compared to the ASME FBH curve results. The figures show that the data exhibits different trends for each flaw type at a given flaw depth.

The objective of this study was to determine the degree of improvement that may result with the use of alternate standards to assess flaw depth. The analysis approach taken in the study was first to determine the eddy-current flaw depth measurement error which is defined as:

[a]Flaw Depth Measurement Error (% wall thickness) = [Eddy-current indicated flaw depth (% wall)] - [Actual flaw depth (% wall)] (1)

for each depth measurement (see Appendices A, B and C). Statistical calculations of eddy-current flaw depth measurement accuracy and precision, which are measured by the mean ($\overline{X}$) and standard deviation (S) were then calculated using Equations (2) and (3), respectively. The mean of the flaw depth measurement error values (mean error) is calculated as follows:

$$\overline{X} = \frac{1}{N} \sum_{i=1}^{N} X_i \quad (2)$$

(a) As an example, a measurement error of 20% of wall would be equivalent to an error of 0.010 in. (0.2 x 0.050 in.) for a 0.050-in. wall tube.

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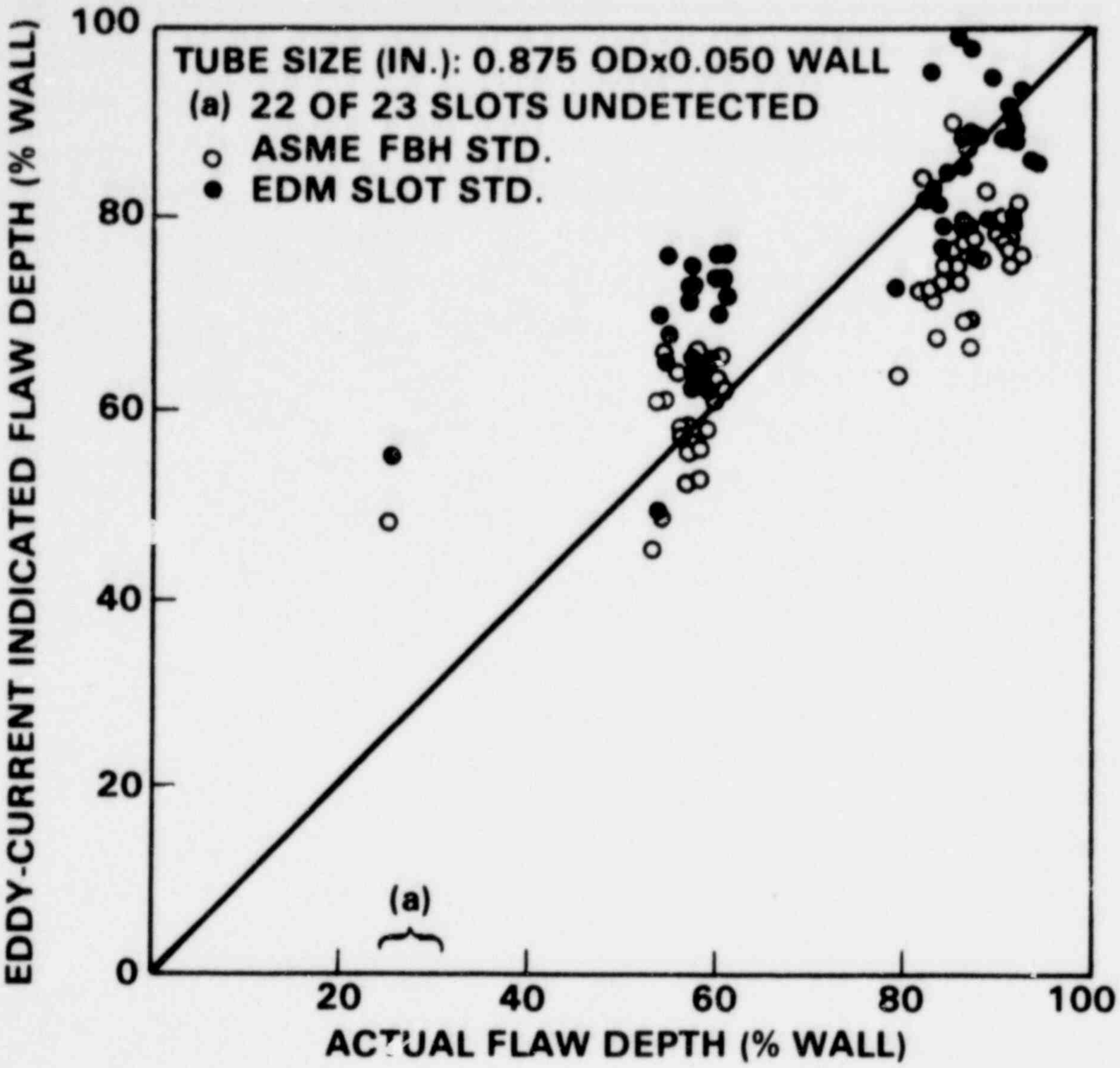

FIGURE 3. EDM Slot Specimen Eddy-Current Depth Sizing Results Achieved Using ASME Flat-Bottom Hole and EDM Slot Standards

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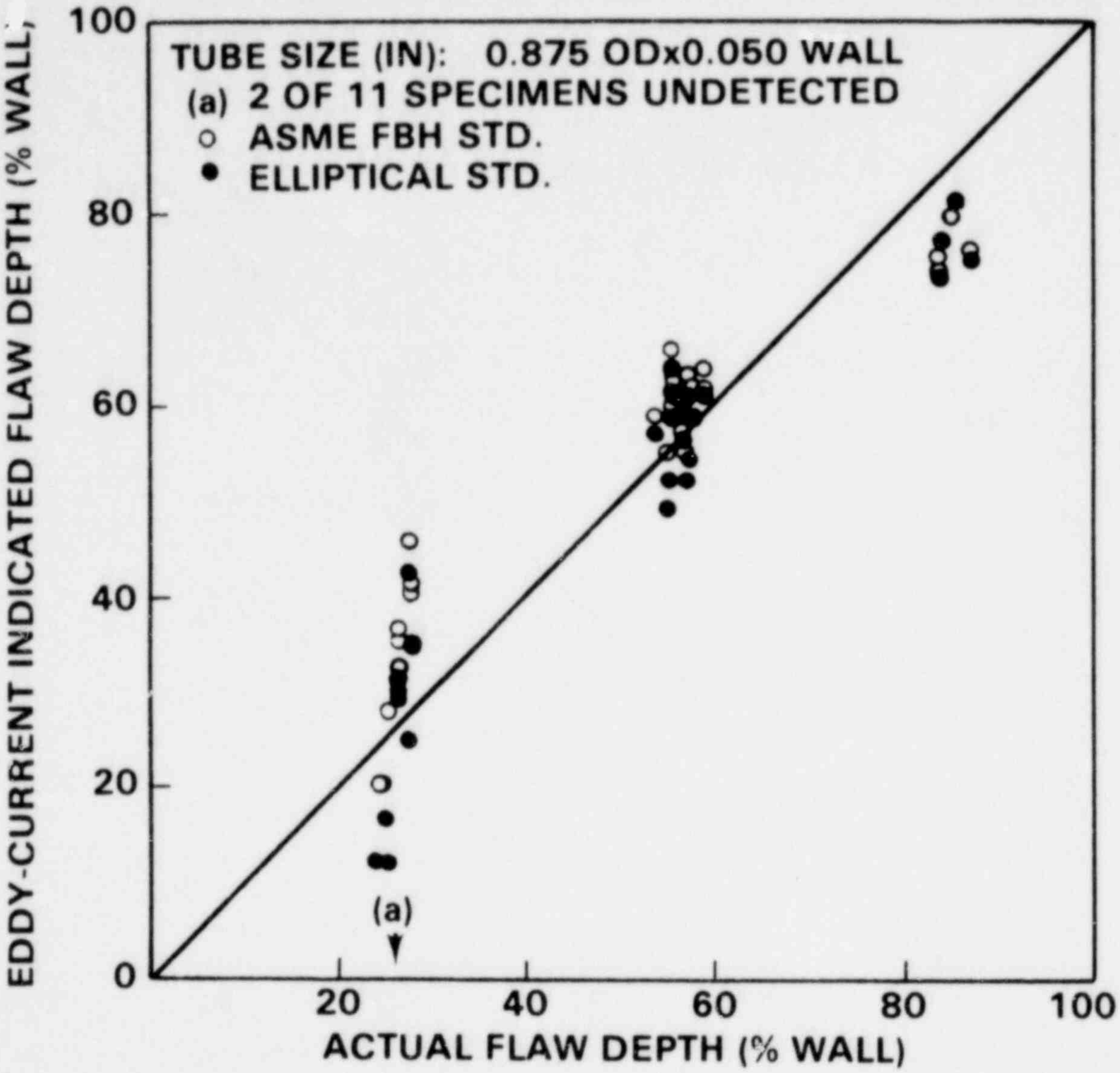

FIGURE 4. Elliptical Wastage Specimen Eddy-Current Depth Sizing Results Achieved Using ASME Flat-Bottom Hole and Elliptical Wastage Standards

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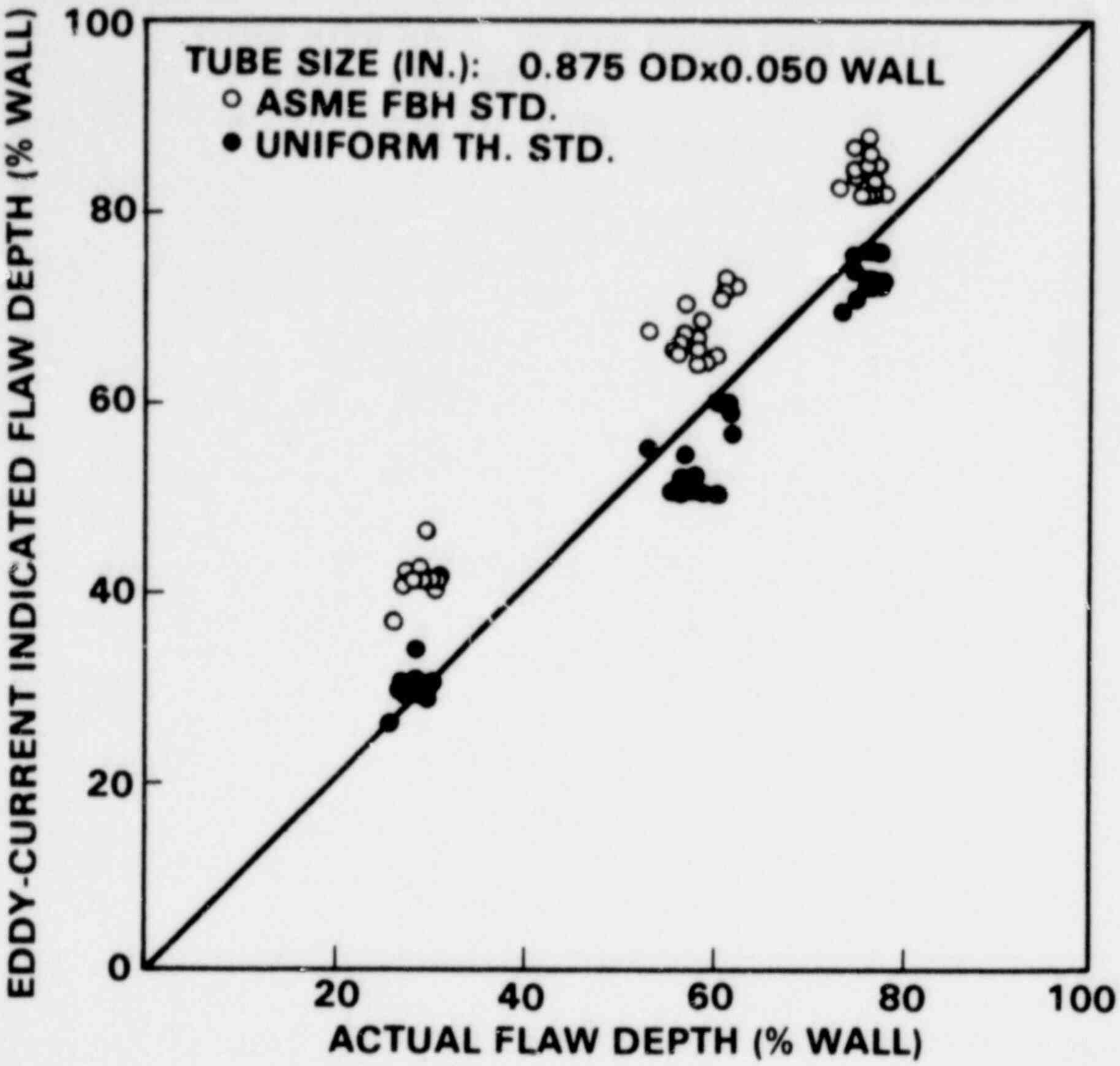

FIGURE 5. Uniform Thinning Wastage Specimen Eddy-Current Depth Sizing Results Achieved Using ASME Flat-Bottom Hole and Uniform Thinning Wastage Standards

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where: $\overline{X}$ is the mean error in percent of tube wall thickness,

X_i is the error for the i^{th} eddy-current measurement, and

N is the number of data points in the set.

The standard deviation of the measurements (a measure of the dispersion around the mean) is calculated as follows:

$$S = \sqrt{\sum_{i=1}^{N} (X_i - \overline{X})^2/(N - 1)} \qquad (3)$$

where: S is the standard deviation of the eddy-current measurements,

$\overline{X}$ is the mean error in percent of tube wall thickness,

X_i is the error for the i^{th} measurement, and

N is the number of data points in the set.

Table 1 shows the flaw type, flaw depth range, number of specimens in the data set (N), mean error ($\overline{X}$), 2 standard deviations of the mean (2S), and interpretation curve used to determine flaw depth.

Table 1 shows that EDM slots 25% to 30% of wall thickness in depth were difficult to detect. Of 23 slots, 22 were not detected. Slots 50% to 60% of wall in depth produced overestimated results using the EDM slot curve with a mean error of 11.60% of wall, whereas the ASME FBH curve gave an overestimated result of only 2.36% of wall. Slots 78% to 90% of wall in depth produced slightly underestimated results using the EDM slot curve with a mean error of -0.63% of wall, whereas the ASME FBH curve gave an underestimated result of -10.95% of wall.

The EDM slot results show improved accuracy in depth sizing for slots 78% to 90% of wall in depth. However, slots 50% to 60% of wall were better sized for depth using the ASME FBH curve. EDM slots less than 40% of wall in depth are difficult to detect. Only one slot 25% of wall in depth was detected. Both the ASME FBH curve and EDM slot curve greatly overestimated the depth of this slot (see Appendix A, Table A.1, Tube B-38-3).

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TABLE 1. Statistical Data for EDM Slot, Elliptical Wastage, Uniform Thinning Wastage and Flat-Bottom Hole Standards[a]

Flaw Type	Flaw Depth (% wall)	No. Specimens (N)	Mean Error (% wall)	2 Standard Deviation (% wall)	Interpretation Curve (re: Figure 3)
EDM Slot	25 - 30	23	(b)	--	--
	50 - 60	25	2.36	10.41	ASME
	50 - 60	25	11.60	12.01	EDM
	78 - 90	33	-10.95	11.23	ASME
	78 - 90	33	-0.63	13.82	EDM
Elliptical Wastage	25 - 28	9	6.18	16.58	ASME
	25 - 28	9	-1.03	20.58	ELLIPTICAL
	53 - 57	18	4.69	7.23	ASME
	53 - 57	18	2.8	8.41	ELLIPTICAL
	82 - 86	4	-6.75	3.98	ASME
	82 - 86	4	-5.73	6.03	ELLIPTICAL
Uniform Thinning Wastage	25 - 28	14	13.66	4.27	ASME
	25 - 28	14	1.77	4.35	UNIFORM
	51 - 60	18	9.75	5.14	ASME
	51 - 60	18	-4.02	6.00	UNIFORM
	72 - 76	16	7.88	4.35	ASME
	72 - 76	16	-1.97	3.53	UNIFORM

(a) Tube size (in.): 0.875 OD x 0.050 wall thickness.
(b) 22 of 23 EDM slots undetected.

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Table 1 data showed that the standard deviation of the measurements essentially remained constant for each standard.

Elliptical wastage flaws with depths ranging from 25% to 28%, 53% to 57%, and 82% to 86% of wall produced over- and underestimated mean error results of -1.03%, 2.80%, and -5.73% of wall thickness, respectively. Correspondingly the mean errors were 6.18%, 4.69%, and -6.75% of wall, respectively, for the ASME FBH curve. The elliptical wastage results showed improved accuracy in flaw depth sizing with the use of the elliptical wastage standard. Table 1 data show that the standard deviation of the measurements essentially remained constant for each standard.

Uniform thinning wastage with depths ranging from 25% to 28%, 51% to 60%, and 72% to 76% of wall produced slightly over- and underestimated mean error results of 1.77%, -4.02% and -1.97% of wall thickness, respectively. Correspondingly, the ASME FBH curve produced overestimated mean error results of 13.66%, 9.75%, and 7.88% of wall thickness. The uniform thinning wastage results show that there is a dramatic improvement in measurement accuracy for the depth sizing of uniform thinning wastage specimens with the use of uniform thinning wastage standards. Table 1 data show that the standard deviation of the measurements essentially remained constant for each standard.

SUMMARY

This study has shown that alternate tube standards with machine induced elliptical wastage and uniform thinning wastage flaws resulted in a more accurate determination of depth for elliptical wastage and uniform thinning wastage specimens compared to the ASME flat-bottom hole standards. However, the improved accuracy in measuring flaw depth has not decreased the standard deviation (increased the precision).

The EDM slot standard produced results that were more accurate in determining the depth of EDM slots 78% to 90% of wall thickness. However, EDM slots 50% to 60% of the wall thickness were better sized in depth using the ASME flat-bottom hole standard. Axial EDM slots of depth less than 40% of the wall thickness, are difficult to detect. For depths less than 40% of the wall thickness, slots that are wider at the surface (larger volume slots) will be required in order to produce a detectable eddy-current signal indication.

The reader should note that the results reported in this study were based upon curves generated from a single one of a kind standard. The interpretation curves were drawn giving a best fit curve to the data points generated from each standard. This approach is not unique and is the same method used to construct interpretation curves using ASME flat-bottom hole standards.

Future work on this program will require the development and eddy-current testing of alternate standards for flaw depth measurement determination with different size tubing. The tube sizes (in.) scheduled for testing are: 0.750 OD x 0.043 wall, 0.750 OD x 0.050 wall, and 0.625 OD x 0.034 wall.

The investigators recognize that key to the use and application of alternate standards requires the ability to correctly classify and accurately interpret (pattern phase angle) each eddy-current indication. If flaws are incorrectly classified as to type, the wrong interpretation curve would be chosen to determine flaw depth. The interpretation curves of Figure 2 show that if an EDM slot flaw (known depth at 80% wall) with a pattern phase angle of 120 degrees, is incorrectly classified as a uniform thinning wastage flaw, the slot depth would be assessed using the uniform thinning curve, at 55% of the wall thickness. Whereas, the EDM slot curve would have sized the slot to be 75% of the wall in depth. The incorrect classification of the flaw has inadvertantly resulted in a substantial flaw depth measurement error of 25% of the wall thickness.

REFERENCES

1. ASME Boiler and Pressure Vessel Code, Appendix IV, of the 1975 Winter Addenda of Section XI, American Society of Mechanical Engineers, New York, NY.

2. J. M. Alzheimer, R. A. Clark, C. J. Morris, and M. Vagins, Steam-Generator Tube Integrity Program Phase I Report, NUREG/CR-0718, PNL-2937, Pacific Northwest Laboratory, Richland, WA 99352, 1979.

APPENDICES A, B, AND C

PHASE I - SGTI PROGRAM EDDY-CURRENT DATA
(Single Frequency Eddy-Current Data for
EDM Slot, Elliptical Wastage, and
Uniform Thinning Wastage Specimens)

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TABLE A.1. Phase I - SGTI Program Eddy-Current Data

EDM Slot (Heats B, E, and F)

Specimen Number	Defect Length (in.)	Actual Flaw Depth (% wall)	Eddy-Current Indicated Flaw Depth: ASME FBH Curve (% wall)	Eddy-Current Indicated Flaw Depth: EDM Slot Curve (% wall)	Measurement Error[b]: ASME FBH Curve (% wall)	Measurement Error[b]: EDM Slot Curve (% wall)
B-38-3	0.250	25.0	48	55	23.0	30.0
B-06-9	0.496	25.3	(a)	(a)	--	--
B-22-1	0.255	25.9	(a)	(a)	--	--
B-21-9	1.480	26.6	(a)	(a)	--	--
B-07-3	1.485	29.8	(a)	(a)	--	--
B-13-9	0.255	30.2	(a)	(a)	--	--
B-16-1	0.500	30.7	(a)	(a)	--	--
B-25-9	1.493	52.5	43	49	-9.5	-3.5
B-37-5	1.498	53.6	57	65	3.4	11.4
B-37-0	0.255	55.6	56	63	0.6	7.4
B-04-1	0.502	57.9	55	62	-2.9	4.1
B-03-3	0.500	58.7	57	65	-1.7	6.3
B-37-7	0.500	78.5	63	73	-15.5	-5.5
B-40-9	0.495	82.0	72	83	-10.0	1.0
B-33-5	1.505	83.7	90	100[c]	6.3	16.3
B-70-1	0.999	84.0	76	88	-8.0	4.0
B-41-1	1.505	84.9	87	98	2.1	15.1
B-37-9	0.250	86.2	66	76	-20.2	-10.2
B-13-5	0.253	91.4	81	94	-10.4	0.6
F-06-7	0.501	57.3	52	64	-5.3	6.7
F-10-3	0.500	57.5	55	63	-2.5	5.5
E-05-7	0.495	58.7	63	74	4.3	15.3
E-06-1	0.495	58.7	65	76	6.3	17.3
F-06-1	0.504	85.0	68	79	-17.0	-6.0
E-04-1	0.505	89.1	77	88	-12.1	-1.1
F-03-9	0.499	89.6	77	88	-12.6	-1.6
E-04-9	0.505	91.1	75	86	-16.1	-5.1

(a) Undetectable.
(b) Measurement error (% wall) = [Eddy-current indicated depth (% wall)] - [actual flaw depth (% wall)].
(c) Interpretation based upon extrapolated curve.

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TABLE A.2. Phase I - SGTI Program Eddy-Current Data

EDM Slot (Heats B, E, and F)

Specimen Number	Defect Length (in.)	Actual Flaw Depth (% wall)	Eddy-Current Indicated Flaw Depth: ASME FBH Curve (% wall)	Eddy-Current Indicated Flaw Depth: EDM Slot Curve (% wall)	Measurement Error(b): ASME FBH Curve (% wall)	Measurement Error(b): EDM Slot Curve (% wall)
E-04-5	0.500	26.3	(a)	(a)	--	--
F-09-3	0.496	27.7	(a)	(a)	--	--
F-09-9	0.498	27.7	(a)	(a)	--	--
E-03-7	0.496	28.3	(a)	(a)	--	--
B-29-7	1.510	24.1	(a)	(a)	--	--
B-42-5	1.504	26.8	(a)	(a)	--	--
B-38-5	0.502	27.2	(a)	(a)	--	--
B-48-9	0.501	28.0	(a)	(a)	--	--
B-75-3	1.503	53.1	61	70	7.9	16.9
B-43-5	0.505	56.4	63	73	6.6	16.6
B-60-3	0.503	58.9	61	70	2.1	11.1
F-06-7	0.501	57.3	52	64	-5.3	6.7
F-10-3	0.500	57.5	55	63	-2.5	5.5
E-05-7	0.495	58.7	63	74	4.3	15.3
E-06-1	0.495	58.7	65	76	6.3	17.3
B-27-7	1.502	81.1	71	82	-10.1	0.9
B-13-1	0.499	81.7	70	81	-11.7	-0.7
B-21-5	1.490	82.7	67	77	-15.7	-5.7
B-11-9	0.503	83.0	73	85	-10.0	2.0
B-32-1	0.249	85.2	73	85	-12.2	0.2
B-75-5	0.260	90.7	76	88	-14.7	-2.7
F-06-1	0.504	85.0	68	79	-17.0	-6.0
E-04-1	0.505	89.1	77	88	-12.1	-1.1
F-03-9	0.499	89.6	77	88	-12.6	-1.6
E-04-9	0.505	91.1	75	86	-16.1	-5.1

(a) Undetectable.
(b) Measurement error (% wall) = [Eddy-current indicated depth (% wall)] - [actual flaw depth (% wall)].

TABLE A.3. Phase I - SGTI Program Eddy-Current Data

EDM Slot (Heats E and F)

Specimen Number	Defect Length (in.)	Actual Flaw Depth (% wall)	Eddy-Current Indicated Flaw Depth		Measurement Error[b]	
			ASME FBH Curve (% wall)	EDM Slot Curve (% wall)	ASME FBH Curve (% wall)	EDM Slot Curve (% wall)
E-05-1	0.500	25.3	(a)	(a)	--	--
E-03-5	0.490	25.3	(a)	(a)	--	--
E-04-7	1.493	26.3	(a)	(a)	--	--
E-02-3	1.495	26.3	(a)	(a)	--	--
F-08-9	1.490	26.7	(a)	(a)	--	--
F-04-9	0.496	26.9	(a)	(a)	--	--
F-01-5	1.525	27.3	(a)	(a)	--	--
F-01-7	0.498	28.0	(a)	(a)	--	--
F-06-5	1.488	53.8	60	68	6.2	14.2
F-10-9	0.504	55.6	57	65	1.4	9.4
F-03-5	0.499	55.8	65	75	9.2	19.2
F-01-3	1.525	56.5	62	72	5.5	15.5
E-14-6	0.503	56.7	56	63	-0.7	6.3
E-15-1	1.490	56.7	63	73	6.3	16.3
E-09-1	0.490	57.7	63	73	5.3	15.3
E-05-9	1.495	60.7	62	72	1.3	11.3
F-07-5	0.499	81.0	83	97[c]	2.0	16.0
F-03-3	1.505	83.7	74	79	-9.7	-4.7
F-08-1	1.498	85.0	74	79	-11.0	-6.0
E-15-3	0.503	85.0	77	89	-8.0	4.0
F-04-5	0.499	85.7	77	89	-8.7	3.3
F-09-5	0.246	87.0	75	80	-12.0	-7.0
F-07-3	0.248	87.0	75	80	-12.0	-7.0
E-03-3	1.506	87.0	82	96	-5.0	9.0
E-09-5	0.247	89.1	77	89	-12.1	-0.1
E-14-8	0.249	89.1	74	79	-15.1	-10.1
E-09-7	0.498	89.1	75	80	-14.1	-9.1
E-14-9	1.505	89.1	79	92	-10.1	2.9

(a) Undetectable.
(b) Measurement error (% wall) = [Eddy-current indicated depth (% wall)] - [actual flaw depth (% wall)].
(c) Interpretation based upon extrapolated curve.

TABLE B.1. Phase I - SGTI Program Eddy-Current Data

Elliptical Wastage (Heat B)

Specimen Number	Cutter Radius (in.)	Wrap Angle (degrees)	Actual Flaw Depth (% wall)	Eddy-Current Indicated Flaw Depth: ASME FBH Curve (% wall)	Eddy-Current Indicated Flaw Depth: Elliptical Curve (% wall)	Measurement Error(b): ASME FBH Curve (% wall)	Measurement Error(b): Elliptical Curve (% wall)
B-48-3	24	0	26.1	(a)	(a)	--	--
B-48-7	24	0	26.1	(a)	(a)	--	--
B-36-1	24	45	26.3	27	16(c)	0.7	-10.3(c)
B-22-7	24	45	26.9	35	30	8.1	3.4
B-53-4	24	135	27.0	33	28	6.0	1.0
B-31-5	24	135	27.2	36	31	8.8	3.8
B-53-3	24	135	28.0	46	43	18.0	17.0
B-09-10	6	135	55.0	62	62	7.0	7.0
B-53-10	6	135	55.0	61	60	6.0	5.0
B-07-10	6	45	53.8	59	57	5.2	3.2
B-09-4	6	45	55.4	63	62	7.6	6.6
B-43-7	12	45	55.4	66	65	10.6	9.6
B-28-7	12	45	55.4	64	62	8.6	6.6
B-40-3	12	125	56.0	64	62	8.0	6.0
B-53-7	12	0	56.0	58	56	2.0	0.0
B-52-5	12	0	56.9	62	62	5.1	5.1
B-31-3	12	135	57.4	64	62	6.6	4.6
B-54-7	6	0	82.7	76	78	-6.7	-8.6
B-54-3	6	0	85.6	77	77	-8.6	-8.6

(a) Undetectable.
(b) Measurement error (% wall) = [Eddy-current indicated depth (% wall)] - [actual flaw depth (% wall)].
(c) Interpretation based upon extrapolated curve.

TABLE B.2. Phase I - SGTI Program Eddy-Current Data

Elliptical Wastage (Heats B, E, and F)

Specimen Number	Cutter Radius (in.)	Wrap Angle (degrees)	Actual Flaw Depth (% wall)	Eddy-Current Indicated Flaw Depth		Measurement Error[b]	
				ASME FBH Curve (% wall)	Elliptical Curve (% wall)	ASME FBH Curve (% wall)	Elliptical Curve (% wall)
B-36-5	24	0	25.3	20	12	-5.3	-13.5
B-27-1	24	0	26.1	20	12	-6.1	-14.1
B-06-3	24	135	28.2	40	25	11.8	-3.2
B-29-9	24	135	28.4	42	35	13.6	6.6
B-29-5	12	0	54.9	55	50	0.1	-4.9
B-39-3	12	0	55.0	62	60	7.0	5.0
B-40-7	12	135	56.0	62	60	6.0	4.0
B-39-9	12	135	57.4	63	59	5.6	1.6
E-14-3	12	0	54.7	55	53	0.3	-1.7
F-09-1	12	0	55.3	57	55	1.7	-0.3
F-08-5	12	0	56.3	55	53	-1.3	-3.3
E-06-9	12	0	56.7	55	53	-1.7	-3.7
B-35-5	6	0	82.7	75	75	-7.7	-7.7
B-53-1	6	0	84.0	80	82	-4.0	-2.0

(a) Measurement error (% wall) = [Eddy-current indicated depth (% wall)] - [actual flaw depth (% wall)].

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TABLE C.1. Phase I - SGTI Program Eddy-Current Data

Uniform Thinning (Heats B, E, and F)

Specimen Number	Defect Length (in.)	Actual Flaw Depth (% wall)	Eddy-Current Indicated Flaw Depth: ASME FBH Curve (% wall)	Eddy-Current Indicated Flaw Depth: Uniform Thin Curve (% wall)	Measurement Error[a]: ASME FBH Curve (% wall)	Measurement Error[a]: Uniform Thin Curve (% wall)
B-60-1	0.384	24.6	36	25	11.4	0.4
B-23-5	1.510	26.1	40	27.8	13.9	1.7
B-03-8	0.195	26.9	46	33.5	19.1	7.6
B-32-8	0.195	27.0	40	27	13.0	0.0
B-60-5	0.752	27.5	40	27.8	12.5	0.3
B-08-9	0.375	27.7	40	27	12.3	0.7
B-60-7	0.755	28.0	39	27	11.0	-1.0
B-35-3	1.581	28.2	40	27.8	11.8	0.6
B-25-1	0.380	51.0	66	54	15.0	3.0
B-19-7	0.760	54.5	64	49.5	9.5	-5.0
B-40-5	0.182	55.0	68	53.5	13.0	-1.5
B-60-9	0.380	55.6	65	52	9.4	-3.6
B-23-9	1.513	56	63	49	7.0	-7.0
B-16-5	0.755	56.5	64	48.8	7.5	-5.7
B-12-5	1.496	57.4	63	49	5.6	-8.4
B-08-3	0.187	58.0	69	58	11.0	0.0
F-06-9	0.375	57.3	67	51	9.7	-6.3
E-02-9	0.380	58.7	72	58	13.3	-0.7
E-06-5	0.380	58.7	71	57	12.3	-1.7
B-19-9	0.185	72.4	81	68.5	8.6	-3.9
B-35-7	0.182	73.0	82	69.5	9.0	-3.5
B-36-7	0.378	73.5	80	71	6.5	-2.5
B-09-5	0.750	73.9	80	71	6.1	-2.9
B-31-7	0.378	74.9	81	72	6.1	-2.9
B-18-3	0.750	74.9	80	72	5.1	-2.9
B-18-1	1.500	74.9	80	72	5.1	-2.9
B-21-3	1.495	75.7	80	72	4.3	-3.7

(a) Measurement error (% wall) = [Eddy-current indicated depth (% wall)] - [actual flaw depth (% wall)].

TABLE C.2. Phase I - SGTI Program Eddy-Current Data

Uniform Thinning (Heat B)

Specimen Number	Defect Length (in.)	Actual Flaw Depth (% wall)	Eddy-Current Indicated Flaw Depth: ASME FBH Curve (% wall)	Eddy-Current Indicated Flaw Depth: Uniform Thin Curve (% wall)	Measurement Error[a]: ASME FBH Curve (% wall)	Measurement Error[a]: Uniform Thin Curve (% wall)
B-39-7	1.580	25.1	41	29	15.90	3.9
B-56-3	0.370	25.3	40	28	14.70	3.3
B-03-7	0.370	26.9	40	28	13.10	1.1
B-32-7	0.765	27.0	42	29.8	15.00	2.8
B-28-3	0.755	27.2	40	28	12.80	0.8
B-56-9	1.550	27.2	42	29.8	14.80	2.6
B-75-9	0.375	54.1	64	50	9.90	-4.1
B-06-1	0.750	54.5	64	50	9.50	-4.5
B-29-3	0.370	54.9	66	52	11.10	-2.5
B-18-9	0.775	56.0	63	49	7.00	-7.0
B-23-7	1.580	56.0	64	50	8.00	-6.0
B-12-1	1.560	56.5	63	49	6.50	-7.5
B-70-1	0.755	73.4	83	74.5	9.60	1.1
B-70-5	0.875	73.4	85	73	11.60	-0.4
B-08-5	1.496	73.9	83	74.5	9.10	0.6
B-42-7	0.184	74.7	86	74	11.30	0.7
B-42-9	0.378	74.7	84	71.5	9.30	-3.2
B-40-1	1.500	75.0	83	74.5	8.00	-0.5
B-04-7	0.399	75.3	83	74.5	7.70	-0.8
B-48-5	0.760	75.3	84	71.5	8.70	-3.8

(a) Measurement error (% wall) = [Eddy-current indicated depth (% wall)] - [actual flaw depth (% wall)].