ATTACHMENT

ANALYSIS OF AN ULTRASONIC INDICATION IN A PRESSURE VESSEL PLATE H. B. ROBINSON UNIT NO. 2

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I. Introduction

The 10 Year Inservice Inspection of the H. B. Robinson plant disclosed an axially oriented ultrasonic indication in the lower vessel plate. The indication was detected by a 45° shear wave test performed from the inside of the vessel using the Westinghouse remote vessel inspection tool No. 2. The indication was detected in only one orientation of the 45° transducers, and was not detected by any other of the standard ASME Code directed tests. The following is an analysis of the extent, location and probable cause of the indication.

II. The Location of the Indication

A. The top of the indication is 1.3" below the girth weld between the intermediate and lower shell courses and is approximately 28 degrees circumferentially from vessel zero as located on the CE drawings. The location of the indication has been determined from tool data using nominal beam data in the calculation.

B. The indication in plan view extends 7 inches axially and 2.3 inches circumferentially at its maximum.

1. The length of the indication along the vessel was measured between points where the maximum amplitude of the ultrasonic response was equal or greater than that from a 0.375" side drilled hole in the calibration block.

2. The circumferential extent of the indication was measured at 1/2" intervals along its length, and is the distance between points showing a response equal to 50% of that obtained from the calibration hole.

3. Within this area the response varies from 50% of that of the calibration hole to 562% of the calibration hole.

III. Data Reduction Methods for Determining Discontinuity Depth

A. Location of the discontinuity within the plate (depth below surface) depends on calculations which are subject to error. The depth of the indication is calculated from the angle of entry of the ultrasonic beam, the ultrasonic velocity, and the time of travel of the sound in the metal.

III. B. The relation used in calculating the angle of the beam in the material is Snell's Law:

Beam Angle

$$= \text{Arc Sin} \left(\frac{(\text{Sin of Incident Angle}) \times \text{Refracted Velocity})}{(\text{Incident Velocity})} \right)$$

C. The relation used in calculating the metal distance to the indication is:

Metal Path = Travel Time x Ultrasonic Velocity

D. Errors in the calculations arise from the following conditions.

1. Ultrasonic velocity may be taken as a handbook value that may not be representitive of the part, or from an evaluation of the test block which is subject to operator and instrumentation error.

2. Travel time is measured to a sensitivity of one microsecond, the approximate equivalent of 1/8" metal path.

3. The incident velocity is the velocity of ultrasound in water, and this velocity is variable with the temperature of the water.

4. The calibration block and the vessel are clad with stainless steel on the entry surface. The effect of the clad, since the velocity in stainless steel is less than that of alloy steel, is to give the beam an offset.

5. The complex geometry associated with properly positioning the transducer requires extremely close operating tolerances. In the range of incident angles applicable to this problen, each .1° change in the incident angle results in approximately .25° change in the beam angle in the vessel.

IV. <u>The Depth of the Indication</u>

Plots of the indication made from the data without beam width correction show a shallow surface disruption very near and parallel to the outside surface of the plate which may be the result of a gouge, or a blended gouge. A typical plot has been tabulated (Table 1) and shows the maximum through wall

IV. height of the indication without beam width correction to be 0.91". The same plot shows the maximum width (circumferential dimension) to be 2.31". When beam width correction is applied the through wall height of the indication is much smaller.

A. The calculated shape of the indication is less affected by parameter uncertanties than is the calculated location because the shape is the result of delta measurements.

B. The various error possibilities outlined in II. result in a tolerance band for the calculations.

1. The velocity of sound in the vessel has been variously estimated or calculated to be from .118 to .126 inches per microsecond. This difference results in a change in the calculated depth of the indication of about .6 inches.

2. The velocity of sound in water varies according to the temperature of the water. This change affects the beam angle in metal. A change in water temperature of 1 degree at 100° F., the temperature of the examination, results in a change of 54.72 in/sec. in the ultrasonic velocity in water and a change of 0.04° in the beam angle in the part.

3. The effect of the clad is to offset the beam due to the slower velocity of ultrasound in the clad. There may also be a filtering effect in which the higher beam angles are filtered out of the test. In either case the effect of the clad is to reduce the calculated beam angle and to make the indication seem less deep than it really is.

V. Discontinuity Evaluation Examinations

A. The indication appeared on only one of five tests, the 45° beam in the CCW direction. The tests given were ±45°, ±60° and 0°.

B. Three 45° shear wave transducers were applied to the evaluation of the indication. It was determined that each transducer only disclosed the indication when it was beamed at it in the counter-clockwise circumferential direction in which the indication was first detected, and that each transducer produced a similar response from the indication.

V. C. A refracted longitudinal wave examination made shortly after the inspection confirmed the indication in the same orientation as the original examination.

VI. Evaluation Results

A. The examination has been evaluated using an ultrasonic velocity of .1197 in/μsec., and beam angles of 42, 43.4 and 45.8 for the trailing, three central, and leading rays respectively. The detailed results of the evaluation are in the attached Table 1.

B. The following conclusions may be drawn from the data:

1. The indication is not a "traveling indication;"

2. The indication is broad and laminar, rather than planar;

3. The indication does not appear to be a corner reflector;

4. Beam plots place it at or near the nominal outside plate surface.

VII. Conclusion

The indication is caused by a relatively shallow non-planar disruption on the outside surface. This could be handling damage, a blended gouge, or similar surface condition.

DATA FROM AN RPV PLATE INDICATION - Rev.2 - 5/4/82

TEST PLATE LOCATION DATA						FLAW DATA								
AZIMUTH (COUNTS/DEGREES)					VERTICAL	MTL PATH (µs.)/DPTH(IN)					MAX	FLAW		
50%	100%	MAX	100%	50%	(CT./IN)	50%	100%	MAX.	100%	50%	% DAC	HEIGHT	WIDTH	LENGTH
57497	57514	57528	57548	57559	46985	192	193	195	197	198				
49.87	50.04	50.18	50.38	50.49	265.87	8.88	8.76	8.85	8.94	8.73	111	.21	.94	0
57480	57489	57514	57547	57586	47065	186	188	191	195	203				
49.7	49.79	50.04	50.37	50.76	266.37	8.59	8.53	8.66	8.85	8.95	111	.36	1.60	.5
57483	57505	57505	57505	57571	47145	188	191	191	191	181*				
49.73	49.95	49.95	49.95	50.61	266.87	8.69	8.66	8.66	8.66	*	100	.03	1.34	1.0
57498	57561	57565	57574	57592	47225	192	195	195	195	203				
49.89	50.15	50.15	50.15	50.75	267.38	8.88	8.85	8.85	8.85	8.95	111	.07	1.31	1.51
57498	57561	57565	57574	57592	47308	191	209	204	204	205				
49.88	50.51	50.55	50.64	50.82	267.89	8.84	9.24	9.27	9.27	9.04	111	.2	1.43	2.02
57558	57579	57598	57683	57626	47385	196	199	202	203	204				
50.48	50.69	50.88	51.03	51.16	268.38	9.07	9.05	9.19	9.24	9.11	141	.24	1.03	2.51
57500	57530	57559	57625	57633	47465	192	197	201	207	207				
49.90	50.2	50.49	51.15	51.23	268.88	8.80	8.94	9.13	9.42	9.14	141	.56	2.02	3.01
57471	57478	57524	57604	57612	47545	184	185	181	202	204				
49.61	49.68	59.14	50.94	51.02	269.38	8.5	8.39	8.66	8.A9	9.0	281	.6	2.14	3.51
57464	57472	57526	57604	57621	47625	187	190	195	207	209				
51.02	49.62	50.16	50.94	51.11	269.89	8.64	8.62	8.85	9.42	9.23	562	.61	1.37	4.02
57458	57479	57540	57594	57610	47705	181	183	191	199	201				
49.48	49.69	50.3	50.84	51.00	270.39	8.36	8.20	8.66	9.05	9.09	125	.73	2.31	4.52
57488	57498	57515	57615	57639	47785	191	192	194	206	214				
49.78	49.88	50.05	51.05	51.29	270.89	8.84	8.85	8.55	9.37	9.46	200	.91	2.30	5.02
57478	57495	57582	57561	57569	47865	187	189	893	199	199				
49.68	49.85	50.29	50.51	50.59	271.39	8.64	8.57	8.76	9.05	8.77	200	.48	1.38	5.52
57480	57501	57527	57549	57560	47945	188	191	194	187	198				
49.7	49.91	50.17	50.39	50.5	271.90	8.69	8.66	8.55	8.94	8.73	125	.39	1.21	6.03
57502	57513	57535	57596	57623	48025	188	188	189	199	205				
49.92	50.03	50.25	50.86	51.83	272.40	8.69	8.53	8.57	9.05	9.04	200	.58	1.84	6.53
57496	57519	57546	57575	47484	48105	192	195	196	196	198				
49.86	50.09	50.36	60.65	50.74	272.90	8.88	8.85	8.9	8.94	8.73	200	.21	1.34	7.03

TABLE 1