
**Pacific Northwest
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Ultrasonic Examination of Double-Shell Tank 241-AN-107 Examination Completed March 2007

AF Pardini
DR Weier

April 2007



Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

AREVA NC Inc. (AREVA), under a contract from CH2M Hill Hanford Group (CH2M Hill), has performed an ultrasonic examination of selected portions of Double-Shell Tank 241-AN-107. The purpose of this examination was to provide information that could be used to evaluate the integrity of the wall of the primary tank. The requirements for the ultrasonic examination of Tank 241-AN-107 were to detect, characterize (identify, size, and locate), and record measurements made of any wall thinning, pitting, or cracks that might be present in the wall of the primary tank. Any measurements that exceed the requirements set forth in the Engineering Task Plan (ETP), RPP-Plan-27202 (Jensen 2005) and summarized on page 1 of this document, are to be reported to CH2M Hill and the Pacific Northwest National Laboratory (PNNL) for further evaluation. Under the contract with CH2M Hill, all data is to be recorded on electronic media and paper copies of all measurements are provided to PNNL for third-party evaluation. PNNL is responsible for preparing a report(s) that describes the results of the AREVA ultrasonic examinations.

Examination Results

The results of the examination of Tank 241-AN-107 have been evaluated by PNNL personnel. The ultrasonic examination consisted of two vertical 15-in.-wide scan paths over the entire height of the tank, the heat-affected zone (HAZ) of four vertical welds and one horizontal weld, the upper portion of the knuckle region, four small areas of the lower portion of the knuckle region within the air slot entrances, and the lower portion of the knuckle utilizing a multiple V path technique qualified for the extended Y-arm scanner from Riser 26. The examination also included two vertical 15-in.-wide scan paths over the entire height of the tank from Riser 25. The examination was performed to detect any wall thinning, pitting, or cracking in the primary tank wall.

Primary Tank Wall Vertical Scan Paths

Two 15-in.-wide vertical scan paths were performed on Plates #1, #2, #3, #4, and #5 from Riser 25. The plates were examined for wall thinning, pitting, and cracks oriented vertically on the primary tank wall. There were no areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness. No pitting or vertical crack-like indications were detected in Plates #1, #2, #3, #4, or #5.

Two 15-in.-wide vertical scan paths were performed on Plates #1, #2, #3, #4, and #5 from Riser 26. The plates were examined for wall thinning, pitting, and cracks oriented vertically on the primary tank wall. There were no areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness. No pitting or vertical crack-like indications were detected in Plates #1, #2, #3, #4, or #5.

Primary Tank Wall Weld Scan Paths

The HAZ of vertical welds in Plates #2, #3, #4, and #5 from Riser 26 were examined for wall thinning, pitting, and cracks oriented either perpendicular or parallel to the weld. There were no areas of

wall thinning that exceeded the reportable level of 10% of the nominal thickness. No pitting or crack-like indications were detected in the weld HAZ areas in Plates #2, #3, #4, and #5.

The HAZ of the horizontal weld between Plate #5 and the tank knuckle from Riser 26 was examined for wall thinning, pitting and cracks oriented either perpendicular or parallel to the weld. There were no areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness. No pitting or crack-like indications were detected in the weld HAZ areas on Plate #5 side or on the knuckle side of the horizontal weld.

Primary Tank Wall Knuckle Scan Paths

The upper portion of the knuckle area from Riser 26 was scanned utilizing the Y-arm scanner attached to the AWS-5D crawler. The Y-arm scanned the transducers down around the knuckle approximately 12-in. (from a starting position 2-in. down) from the upper knuckle weld joining Plate #5 to the knuckle. The knuckle was examined for wall thinning, pitting, and cracks oriented circumferentially around the primary tank. There were no areas that exceeded the reportable level of 10% of the nominal thickness. No pitting or circumferentially oriented crack-like indications were detected in the upper portion of the knuckle area.

Four small areas on the lower portion of the knuckle area from Riser 26 were examined for wall thinning only utilizing the Y-arm scanner in areas accessible through selected air slots. The four areas examined were in air slots designated as Slot 1, Slot 2, Slot 3, and Slot 4. There were no areas that exceeded the reportable level of 10% of the nominal thickness.

The lower portion of the knuckle area from Riser 26 was interrogated utilizing a multiple V path technique qualified for the extended Y-arm scanner. This technique has only been qualified for detection of cracks oriented circumferentially around the primary tank in the lower knuckle region. No circumferentially oriented crack-like indications were detected in the lower portion of the primary tank knuckle area.

Extreme Value Analysis

Extreme value measured wall thickness losses were estimated. Since current remaining wall thickness typically still exceeds drawing nominal, thereby generating negative losses, UT image maximum values were instead used to determine estimated nominal wall thickness per plate/riser combination. These thicknesses tended to run about 0.035-in. greater than drawing nominal. They in turn were used with each UT image minimum value to determine estimated wall thickness losses which were then combined for a plate course over the two risers, two UT measurement paths per riser.

Three parameter Weibull distributions were fit to the plate course measurements as well as to the measurements combined over all plates. The latter case leads to a proposed worst case measured wall thickness loss of 0.066-in. that might be expected if the entire surface area of the tank wall were UT inspected. A 95% confidence bound is computed based on the uncertainty in the Weibull parameters caused by the relatively minimal amounts of data for distribution fitting and the quality of the Weibull fit;

this 95% bound on measured wall thickness loss is 0.074-in. Note that such losses should be considered relative to the larger “estimated” nominal wall thicknesses and not the drawing nominal.

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1.0 Introduction

AREVA NC Inc. (AREVA), under a contract from CH2M Hill Hanford Group (CH2M Hill), has performed an ultrasonic examination (UT) of selected portions of Double-Shell Tank (DST) 241-AN-107. The purpose of this examination was to provide information that could be used to evaluate the integrity of the DST. The requirements for the UT of Tank 241-AN-107 were to detect, characterize (identify, size, and locate), and record measurements made of any wall thinning, pitting, or cracks that might be present in the wall of the primary tank. Any measurements that exceed the requirements set forth in the Engineering Task Plan (ETP), RPP-Plan-27202 (Jensen 2005), are to be reported to CH2M Hill and the Pacific Northwest National Laboratory (PNNL) for further evaluation. Specific measurements that are reported include the following:

- Wall thinning that exceeds 10% of the nominal thickness of the plate.
- Pits with depths that exceed 25% of the nominal plate thickness.
- Stress-corrosion cracks that exceed 0.10 in. (through-wall) and are detected in the inner wall of the tank, HAZ of welds, or in the tank knuckle.

The accuracy requirements for ultrasonic measurements for the different types of defects are as follows:

- Wall thinning – measure thickness within ± 0.020 in.
- Pits – size depths within ± 0.050 in.
- Cracks – size the depth of cracks on the inner wall surfaces within ± 0.1 in.
- Location – locate all reportable indications within ± 1.0 in.

Under the contract with CH2M Hill, all data is to be recorded on electronic media and paper copies of all measurements are provided to PNNL for third-party evaluation. PNNL is responsible for preparing a report(s) that describes the results of the AREVA UT.

2.0 Qualified Personnel, Procedures, and Equipment

Under contract from CH2M Hill, qualification of personnel participating in the DST inspection program, the UT equipment (instrument and mechanical scanning fixture), and the UT procedure that will be used in the examination of the current DST is required. Personnel participating in the examinations are to be certified in accordance with American Society for Nondestructive Testing (ASNT) Recommended Practice SNT-TC-1A, 1992 Edition, and associated documentation is to be provided. The capability of the UT system is to be validated through a performance demonstration test (PDT) on a mock-up simulating the actual DST. The current procedure for the UT is to be based on requirements listed in the American Society for Mechanical Engineers (ASME), Boiler and Pressure Vessel Code Section V, Article 4, *Ultrasonic Examination Methods for Inservice Inspection*.

2.1 Personnel Qualifications

The following individuals were qualified and certified to perform UT of the Hanford DST 241-AN-107:

- **Mr. Wesley Nelson**, ASNT Level III (#LM-1874) in UT, has been identified as AREVA's UT Level III authority for this project. Mr. Nelson has been certified by AREVA as a UT Level III in accordance with AREVA procedure COGEMA-SVCP-PRC-014, latest revision which conforms to the requirements of ASNT SNT-TC-1A, 1992. Further documentation has been provided to establish his qualifications (Pardini 2000) (Pardini 2005).
- **Mr. James B. Elder**, ASNT Level III (#JM-1891) in UT, has been contracted by AREVA to provide peer review of all DST UT data. Mr. Elder has been certified by JBNDT as a UT Level III in accordance with JBNDT written practice JBNDT-WP-1, latest revision. Further documentation has been provided to establish his qualifications (Posakony and Pardini 1998).
- **Mr. William D. Purdy**, AREVA UT Level II limited (for P-Scan data acquisition only). Mr. Purdy has been certified in accordance with AREVA procedure COGEMA-SVCP-PRC-014, latest revision. Further documentation has been provided to establish his qualifications (Posakony 2001).

The following individuals participated in this examination and are trainees and are not qualified or certified to perform independent UT of the Hanford DST 241-AN-107:

- **Mr. Jeffery S. Pintler**, AREVA UT trainee in accordance with AREVA procedure COGEMA-SVCP-PRC-014, latest revision.
- **Ms. Laura A. Sepich**, AREVA UT trainee in accordance with AREVA procedure COGEMA-SVCP-PRC-014, latest revision.

2.2 Ultrasonic Examination Equipment

CH2M Hill has provided the UT equipment for the examination of Tank 241-AN-107. This equipment consists of a Force Institute P-Scan ultrasonic test instrument and Force Institute AWS-5D and AGS-2 remote-controlled, magnetic-wheel crawlers for examining the primary tank wall. Ultrasonic transducers used for the examinations are commercially available. The P-Scan ultrasonic system and Y-arm scanner attachment have been qualified through a PDT administered by PNNL. (Posakony and Pardini 1998) (Pardini 2001)

2.3 Ultrasonic Examination Procedure

AREVA has provided the UT procedure for the examination of Tank 241-AN-107. This procedure, COGEMA-SVUT-INS-007.3, Revision 3, outlines the type of UT and mechanical equipment that are to be used as well as the types of transducers. Both straight-beam and angle-beam transducers are used for the examination of the primary tank wall. The examination procedures include full documentation on methods for calibration, examination, and reporting. Hard copies of the T-Scan (thickness) and P-Scan (projection or angle beam) views of all areas scanned are made available for analysis. The UT procedure requires the use of specific UT transducers for the different examinations. A calibration performed before and after the examinations identifies the specific transducers used and the sensitivity adjustments needed to perform the inspection. The AREVA UT procedure has been qualified through a PDT (Posakony and Pardini 1998).

3.0 Ultrasonic Examination Configuration

AREVA is required to inspect selected portions of the DSTs which may include the primary and secondary tank walls, the HAZ of the primary tank vertical and horizontal welds, and the tank knuckle and bottoms. The P-Scan system has been configured to perform these examinations and has been performance tested. The examination of Tank 241-AN-107 included UT of the primary tank wall and the HAZ of selected welds in the primary tank wall.

3.1 Primary Tank Wall Transducer Configuration

Figure 3.1 provides an example of the scanning configuration generally used during an examination of the primary tank wall. However, other configurations can be used at the discretion of the AREVA UT Level III (i.e., 45-degree transducers can be removed for simple wall thickness measurements). The functional diagram in Figure 3.1 shows one straight-beam and two angle-beam transducers ganged together for examining the primary tank wall. The straight beam is designed to detect and record wall thinning and pits, and the angle beams are designed to detect and record any cracking that may be present. These transducers are attached to the scanning bridge and they all move together. Information is captured every 0.035-in. (or as set by the UT inspector) as the assembly is scanned across a line. At the end of each scan line the fixture is indexed 0.035-in. (or as set by the UT inspector) and the scan is repeated. The mechanical scanning fixture is designed to scan a maximum of approximately 15-in. and then index for the next scan. The hard copy provides a permanent record that is used for the subsequent analysis.

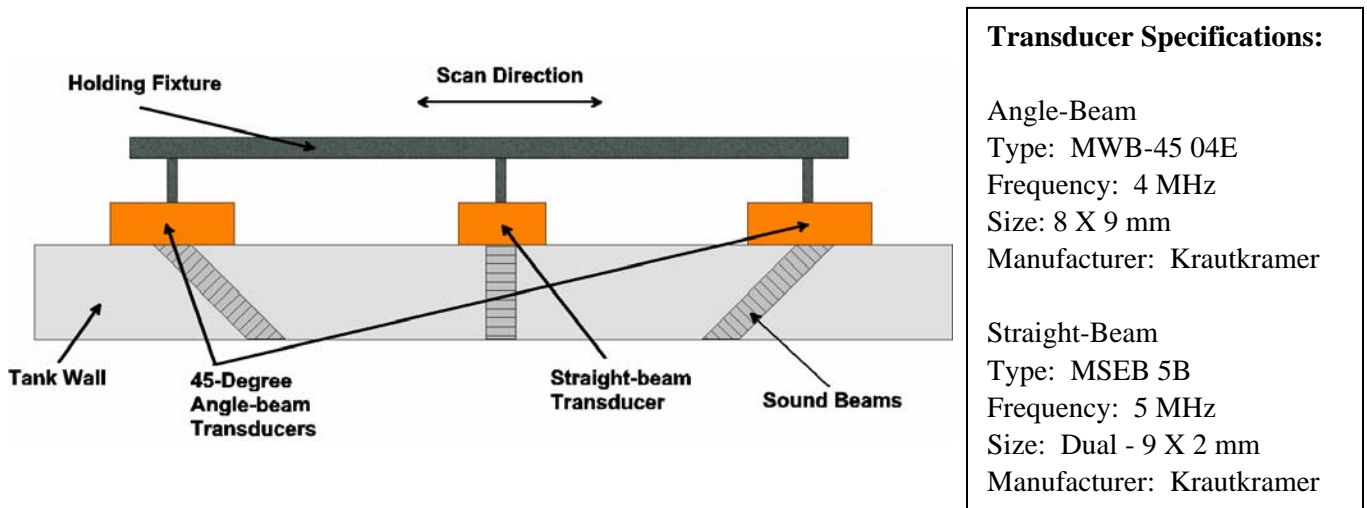
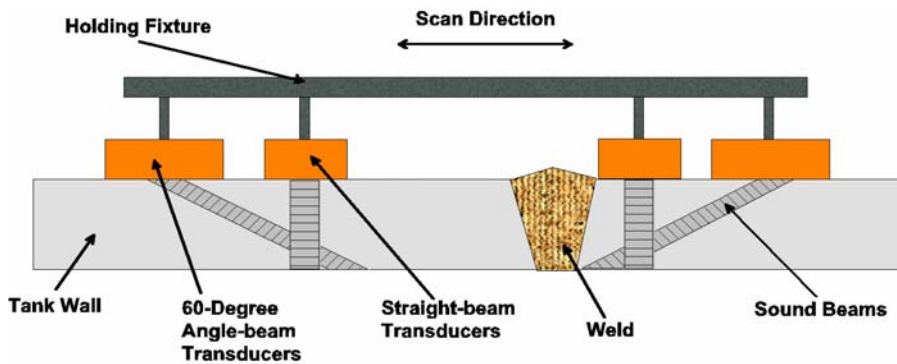


Figure 3.1. Transducer Configuration for Examining the Primary Tank Wall

3.2 Weld Zone Transducer Configuration

Figure 3.2 is a functional sketch that shows the configurations for examination of the weld zone. The area of interest (HAZ of the weld) is shown as lying adjacent to the weld. Both cracks and pitting may occur in this region. The “A” portion of this sketch shows the 60-degree angle-beam transducers used for detecting cracks parallel to the weld. The straight-beam transducers in this sketch are used for detecting and recording any pitting or wall thinning that may be present. All transducers are ganged together. The scanning distance traveled is limited to a total of approximately 5.0-in. The sketch titled “B” shows the arrangement for detecting cracks that may lie perpendicular to the weld. Four 45-degree, angle-beam transducers are used for this inspection. Again the transducers are ganged together but the scan is limited to a total of approximately 4.0-in. The weld zone requirements are shown in Figure 3.3. The scan protocol, data capture, and index parameters are the same for examining other weld areas in the tank.

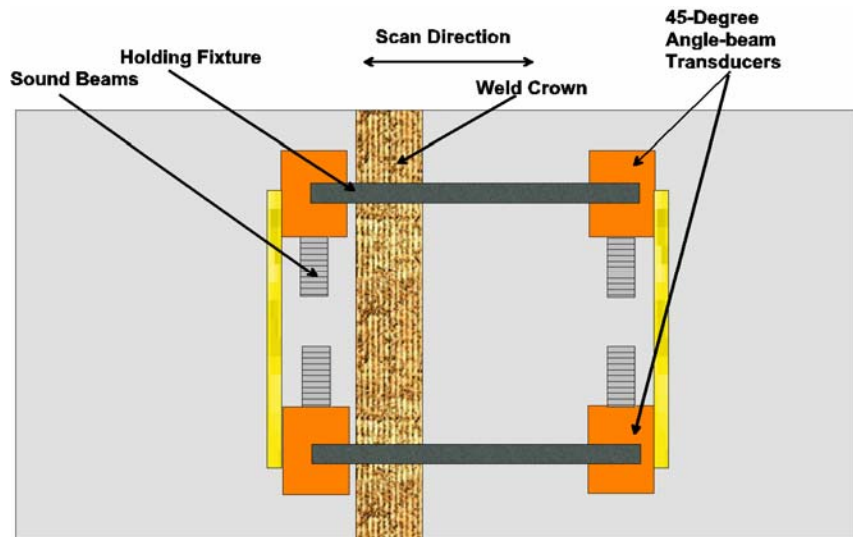


A. Configuration for pitting and cracks parallel to weld

Transducer Specifications:

Angle-Beam
Type: MWB-60 04E
Frequency: 4 MHz
Size: 8 X 9 mm
Manufacturer: Krautkramer

Straight-Beam
Type: MSEB 5B
Frequency: 5 MHz
Size: Dual - 9 X 2 mm
Manufacturer: Krautkramer



B. Configuration for cracks perpendicular to weld

Transducer Specifications:

Angle-Beam
Type: MWB-45 04E
Frequency: 4 MHz
Size: 8 X 9 mm
Manufacturer: Krautkramer

Figure 3.2. Transducer Configurations for Examination of Weld Zone in the Primary Tank Wall

In the HAZ, the requirement for characterizing cracks that lie perpendicular or parallel to welds in the primary tank wall is described in Figure 3.3. The HAZs are located on either side of the weld and defined as being within 1-in. of the toe of the weld and on the inner three-quarters of the thickness ($3/4T$) of the plate. These zones are considered most likely to experience stress-corrosion cracking.

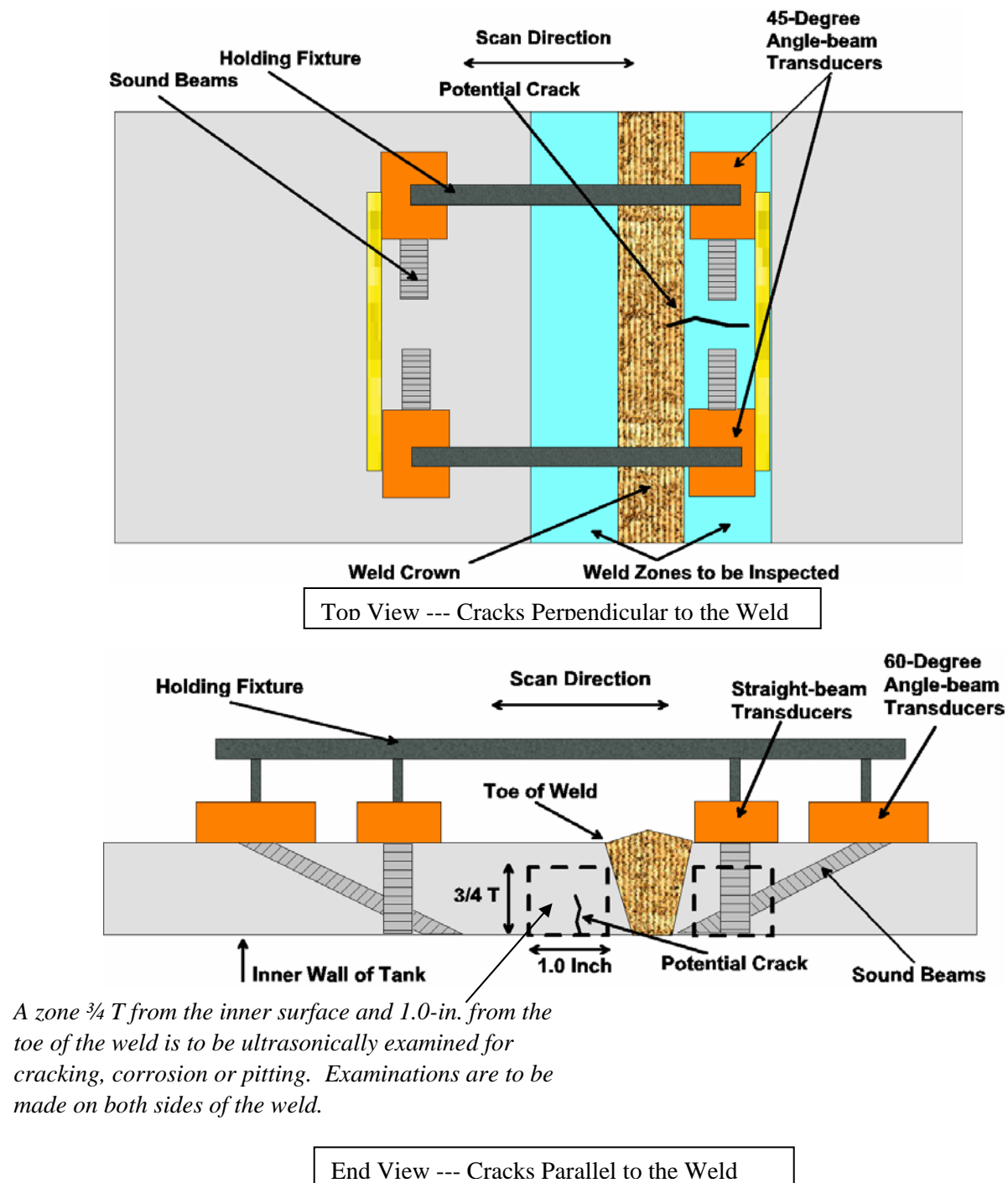


Figure 3.3. Views of the Weld Zone to be Ultrasonically Examined in the Primary Tank Wall

3.3 Knuckle Area Transducer Configuration

Examination of the knuckle utilizes a modified scanning bridge known as the Y-arm scanner. The Y-arm provides scanning of the transducers directly on the knuckle region. The Y-arm is a special fixture that attaches to the AWS-5D magnetic wheel crawler. Its purpose is to extend the reach of the transducer assembly. This extension allows the transducer assembly to follow the curve of the upper portion of the knuckle below the transition Plate #5 to upper knuckle weld. It is designed to hold the dual 0-degree or two 45-degree transducers in the same configuration as used for the examination of the tank wall. The transducer configuration used for crack detection in this examination was two opposing 45-degree angle-beam transducers that were rotated 90-degrees from the orientation used for the wall crack inspection. This configuration is designed to detect cracks that are in a circumferential direction with respect to the axis of the tank. Figure 3.4 is a sketch showing the area of the section of the knuckle examined using the Y-arm fixture. With the transducer positioned 2-in. below the transition Plate #5 to upper knuckle weld, the scanning bridge was set to scan the transducer downward an additional distance of approximately 12-in. in 0.035-in steps (or as set by the operator). Upon completion of the scan, the bridge was indexed circumferentially 0.035-in. (or as set by the operator) and the scan downward is repeated to obtain a pixel size 0.035-in. by 0.035-in. (or as set by the operator).

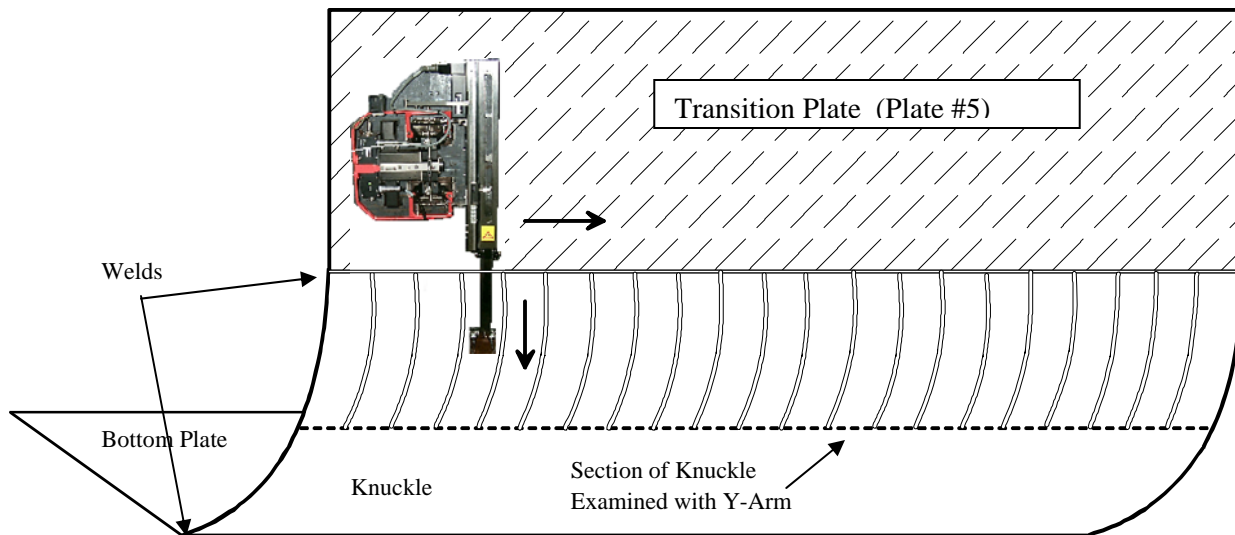


Figure 3.4. Sketch of a Section of the Knuckle Examined with the Y-Arm Scanner

Additional Y-arm scanning was done on areas that were accessible in the air slots that extend under the tank in the concrete support foundation. Figure 3.5 provides an end view (looking down the air slot) and Figure 3.6 provides a side view (looking along the circumference of the tank) of the examination of the lower knuckle in the region of the air slots.

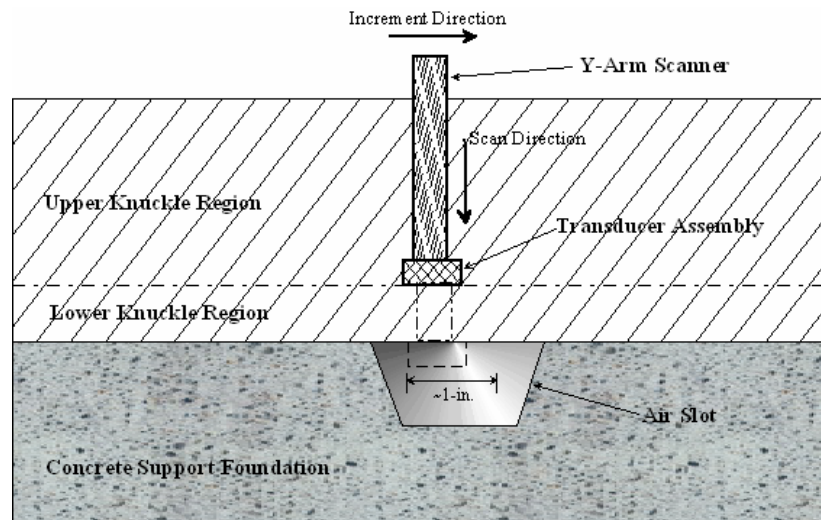


Figure 3.5. Lower Knuckle Examination in Air Slot Regions (End View)

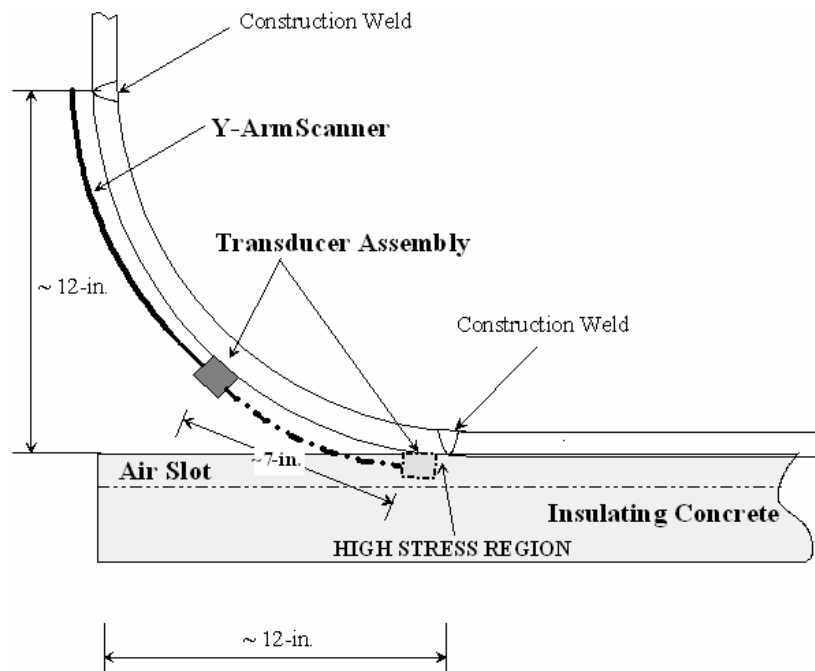


Figure 3.6. Lower Knuckle Examination in Air Slot Regions (Side View)

Also covered in this examination was additional Y-arm scanning using a single 45-degree angle-beam transducer oriented in the axial direction to detect cracks that are in the circumferential direction with respect to the axis of the tank in the lower knuckle region. Figure 3.7 is a sketch showing the section of the knuckle examined using the Y-arm fixture. With the transducer positioned 2-in. below the transition Plate #5 to upper knuckle weld, the scanning bridge was set to scan the transducer downward an additional distance of approximately 8-in. in 0.035-in steps (or as set by the UT inspector). The remaining distance between the transducer and the lower knuckle weld joining the bottom plate is interrogated utilizing a multiple V path technique qualified for the extended Y-arm scanner. (Pardini 2005)

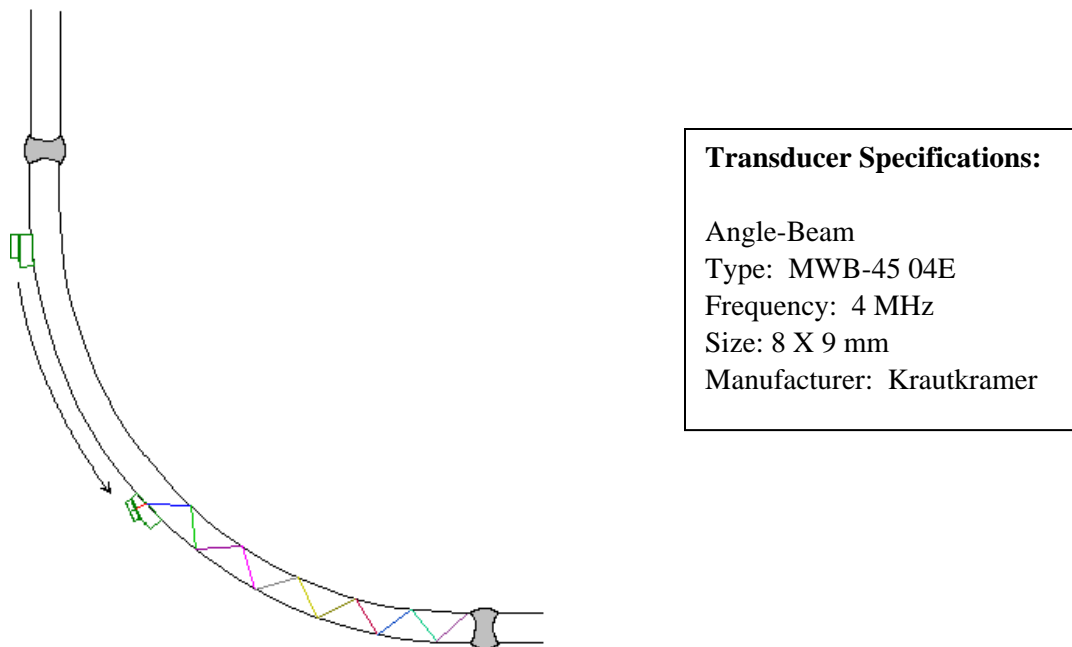


Figure 3.7. Lower Section of the Knuckle Examined

Upon completion of the single line scan, the bridge was indexed circumferentially 0.035-in. (or as set by the UT inspector) and the scan downward is repeated to obtain a pixel size 0.035-in. x 0.035-in. This scan pattern continued for approximately 20-ft. circumferentially as shown in Figure 3.8.

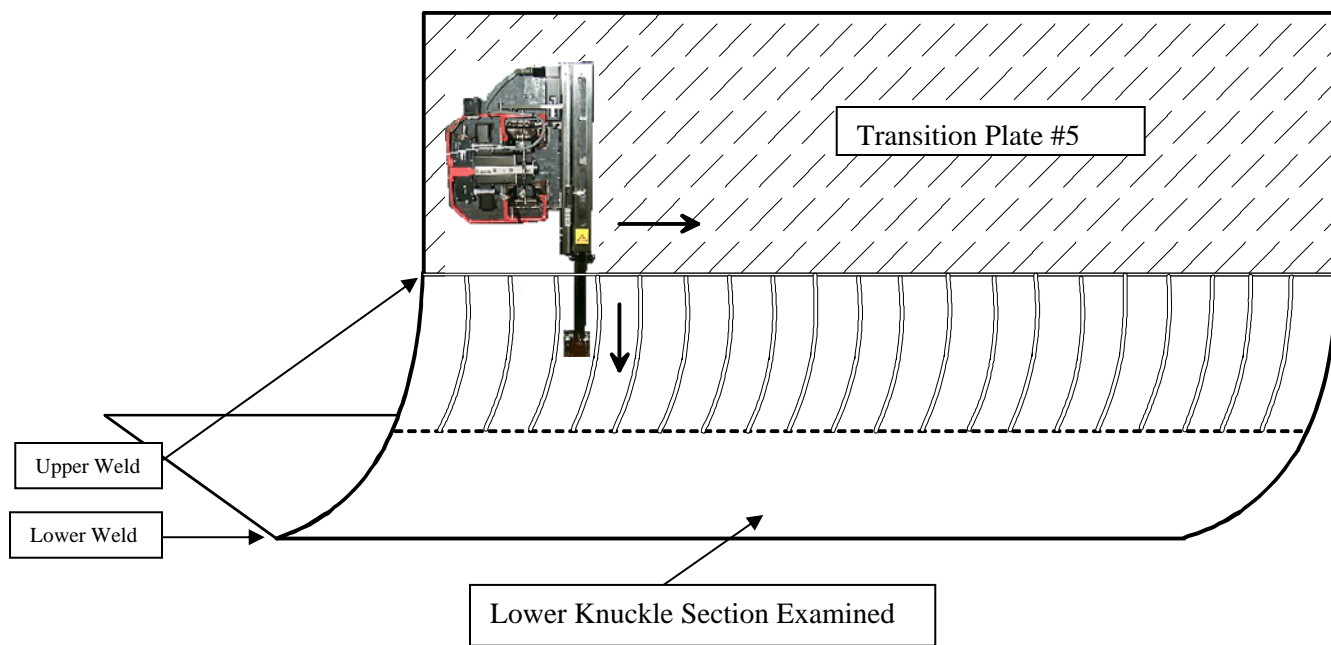


Figure 3.8. Sketch of the Lower Section of the Knuckle Examined with the Y-Arm Scanner

4.0 Ultrasonic Examination Location

Tank 241-AN-107 is located in the Hanford 200 East area in AN Tank Farm. The crawler and associated scanner that hold the transducers were lowered into the 24-in. risers located on the north side (Riser 25) and on the south side (Riser 26) of 241-AN-107. Figure 4.1 provides a graphic of the location of the risers.

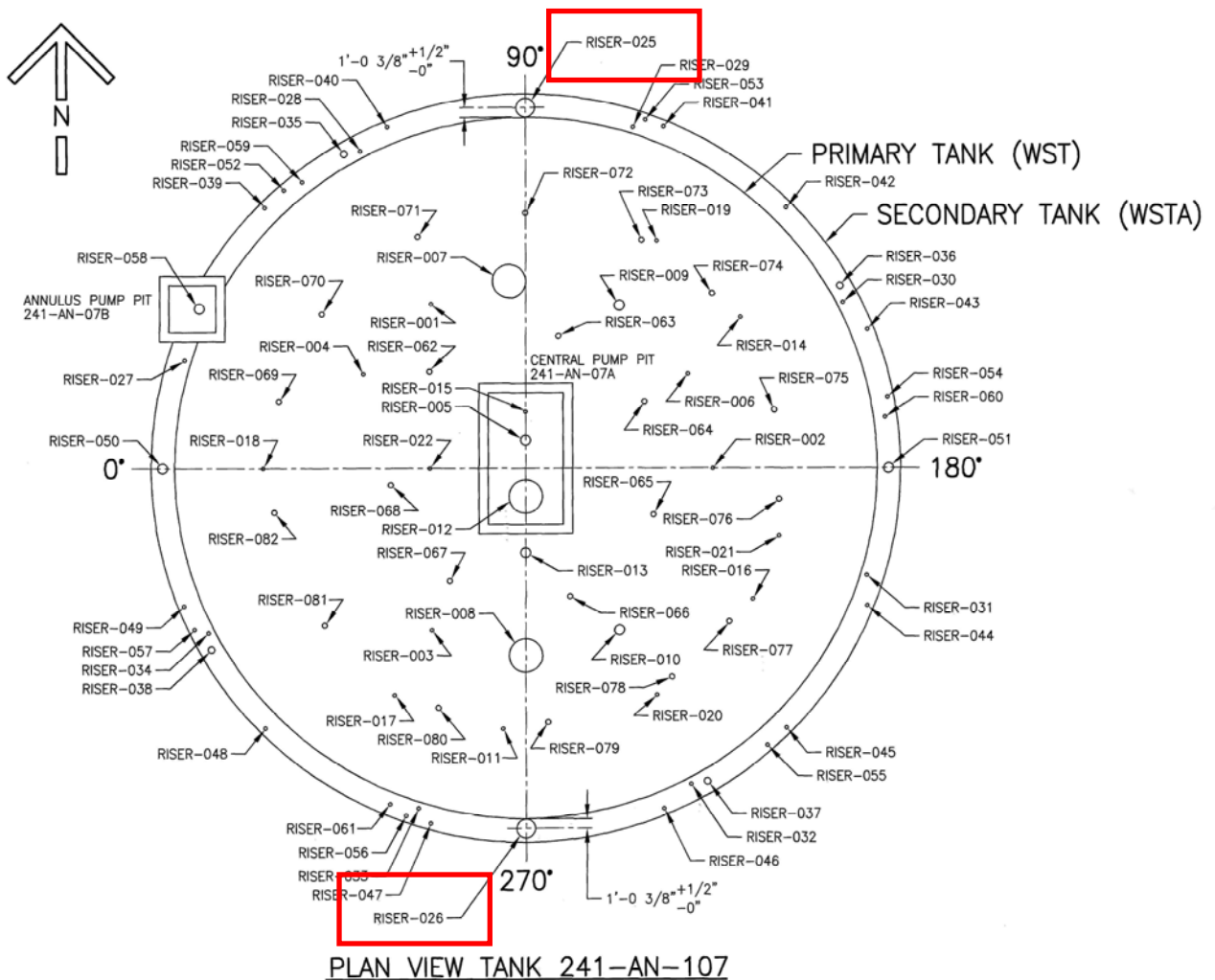


Figure 4.1. UT of Tank 241-AN-107 Riser 25 and Riser 26

Figure 4.2 describes the areas on the primary wall of Tank 241-AN-107 that were ultrasonically examined from Riser 25 located on the north side of the tank. Two 15-in.-wide vertical scan paths were performed on Plates #1, #2, #3, #4, and #5 below the entrance to Riser 25.

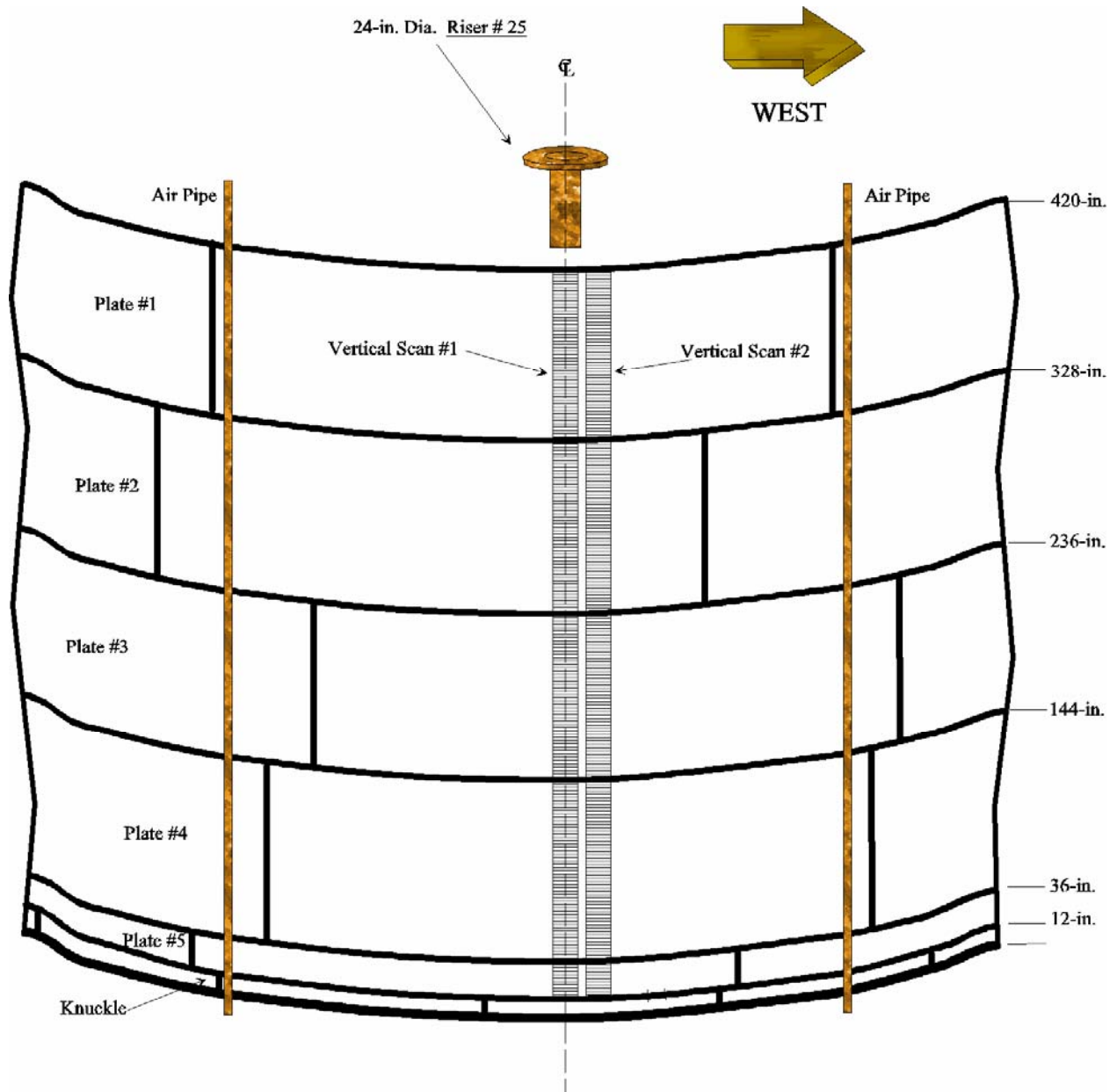


Figure 4.2. Sketch of Scan Paths on 241-AN-107 Primary Tank from Riser 25

Figure 4.3 describes the areas on the primary wall of Tank 241-AN-107 that were ultrasonically examined from Riser 26 located on the south side of the tank. Two 15-in.-wide vertical scan paths were performed on Plates #1, #2, #3, #4, and #5 below the entrance to Riser 26. Vertical weld HAZ examinations were done on Plates #2, #3, #4, and #5, and the horizontal weld HAZ examination was done on the transition Plate #5 to knuckle weld. Also, the examination included the upper portion of the knuckle region, four small areas of the lower portion of the knuckle in the air slots, and the lower portion of the knuckle utilizing a multiple V path technique qualified for the extended Y-arm scanner.

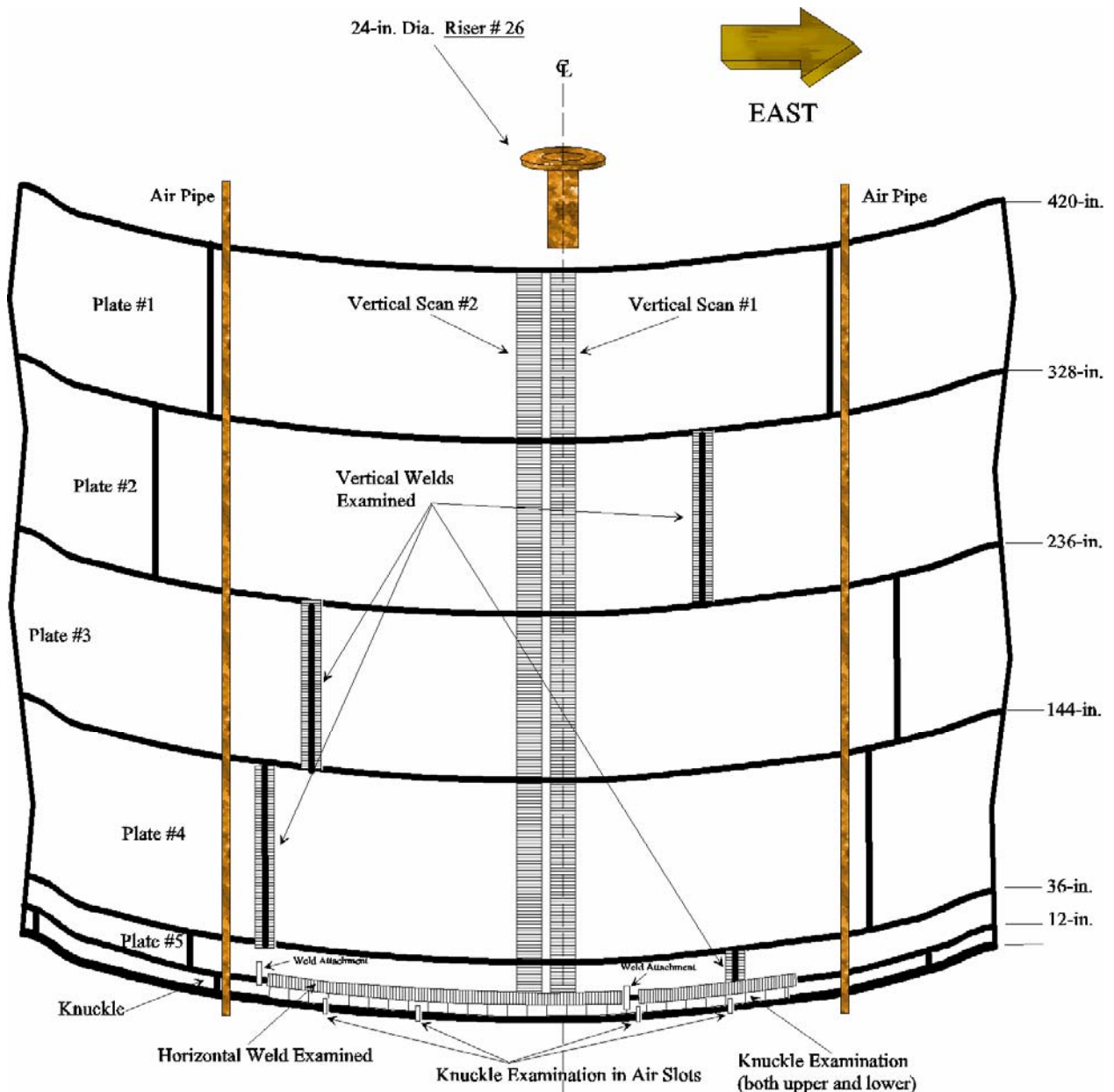


Figure 4.3. Sketch of Scan Paths on Tank 241-AN-107 Primary Tank from Riser 26

5.0 Ultrasonic Examination Results

AREVA has provided detailed reports including T-Scan and P-Scan hard copies of all areas that were ultrasonically examined to PNNL for third-party review. The data was analyzed by AREVA Level III Mr. Wes Nelson, and peer reviewed by JBNDT Level III Mr. Jim Elder. The results of the examination of Tank 241-AN-107 are presented in Figures 5.1, 5.2, 5.3, 5.4, and 5.5.

Figures 5.1 and 5.2 show the wall thickness examination results for the primary tank wall taken below Riser 25. The examination consisted of two vertical paths beneath the 24-in. diameter riser. Vertical scan #1 was 15-in.-wide on Plate #1, #2, #3, #4, and #5 near the centerline of the 24-in. riser. Vertical scan #2 was adjacent to vertical scan #1 and was also 15-in.-wide on Plates #1, #2, #3, #4, and #5. Vertical scans were conducted in the downward direction. Figures 5.1 and 5.2 display the minimum readings taken in each 15-in.-wide by 12-in.-long area of the scan.

Figures 5.3 and 5.4 show the wall thickness examination results for the primary tank wall and the HAZs of both vertical and horizontal welds taken below Riser 26. The examination consisted of two vertical paths beneath the 24-in. diameter riser. Vertical scan #1 was 15-in.-wide on Plate #1, #2, #3, #4, and #5 near the centerline of the 24-in. riser. Vertical scan #2 was adjacent to vertical scan #1 and was also 15-in.-wide on Plates #1, #2, #3, #4, and #5. Vertical scans were conducted in the downward direction. The HAZs of vertical welds in Plates #2, #3, #4, and #5 were examined and the HAZ in the horizontal weld between Plate #5 and the knuckle section was also examined. Weld area exams include approximately 5-in. on each side of the weld. Areas in the figures that show two measurements in the same box are the result of the vertical scan paths overlapping the horizontal scan paths. Figures 5.3 and 5.4 display the minimum readings taken in each 15-in.-wide by 12-in.-long area of the scan. In the overlapping areas, both minimum readings from each vertical and horizontal scan paths are given.

Figure 5.5 shows the examination performed on the knuckle of the primary tank wall below Riser 26. The readings distributed around the circumference of the tank knuckle represent the minimum reading in each 12-in. long by 12-in. wide portion extending down around the upper portion of the knuckle. The four areas denoted as Slot 1, Slot 2, Slot 3, and Slot 4, represent small areas that were scanned extending down to the lower portion of the knuckle in the air slots. These scan areas are approximately 1-in. long (increment direction around the circumference of the tank), and 7-in wide (scan direction is down around the knuckle and into the air slot) as shown previously in Section 3 of this report.

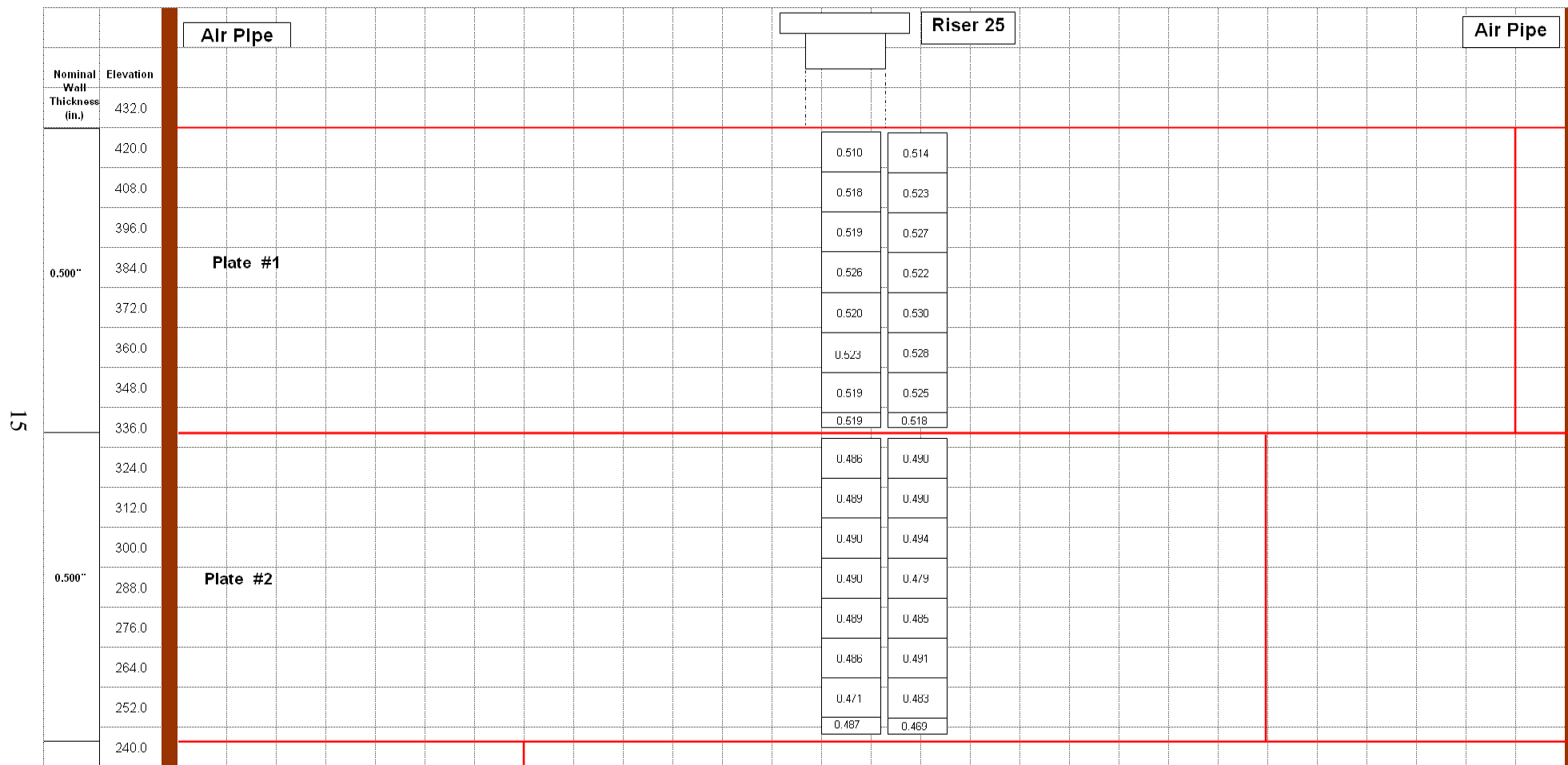


Figure 5.1. UT Data from Tank 241-AN-107 Riser 25

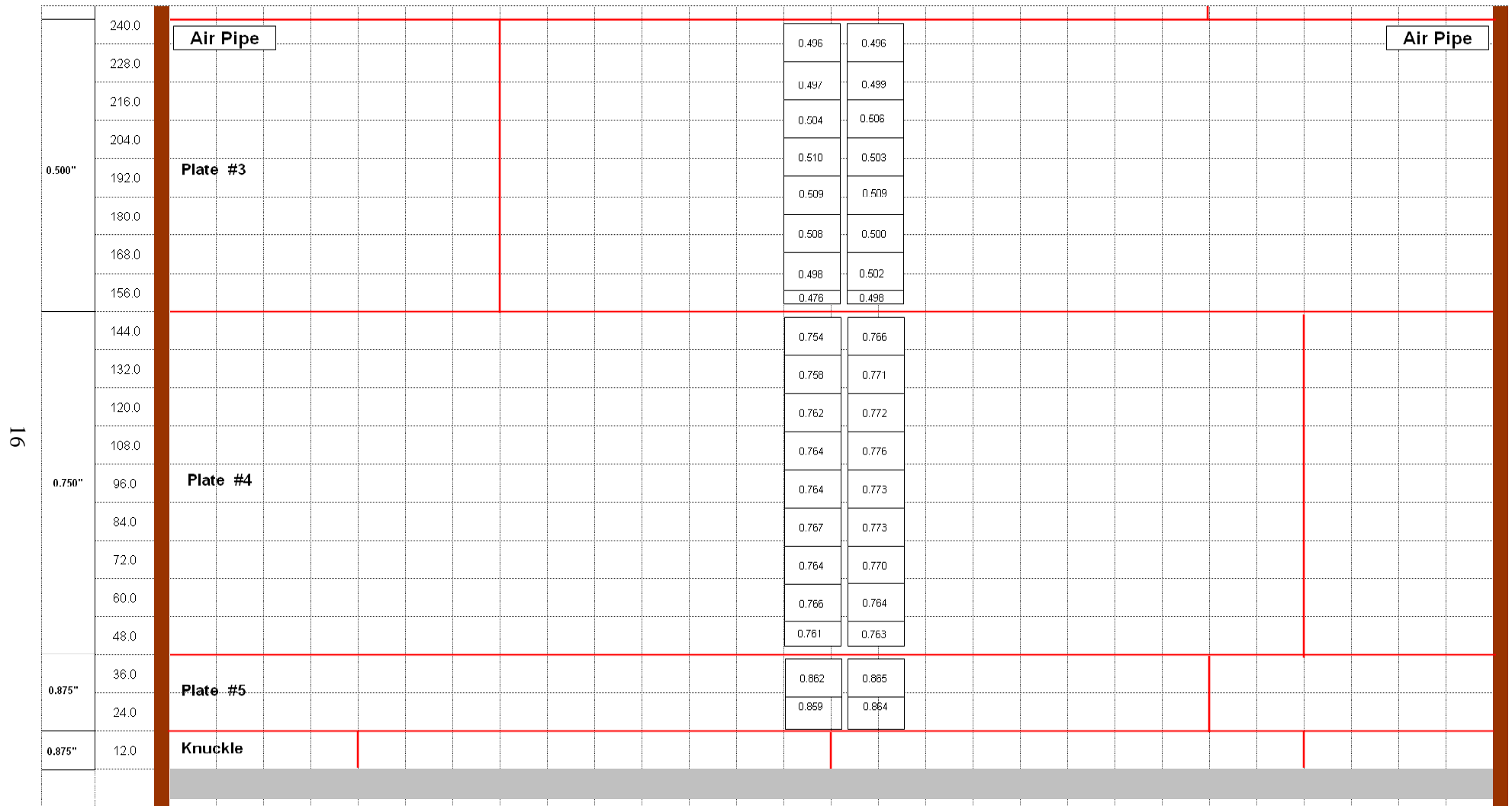


Figure 5.2. UT Data from Tank 241-AN-107 Riser 25 cont.

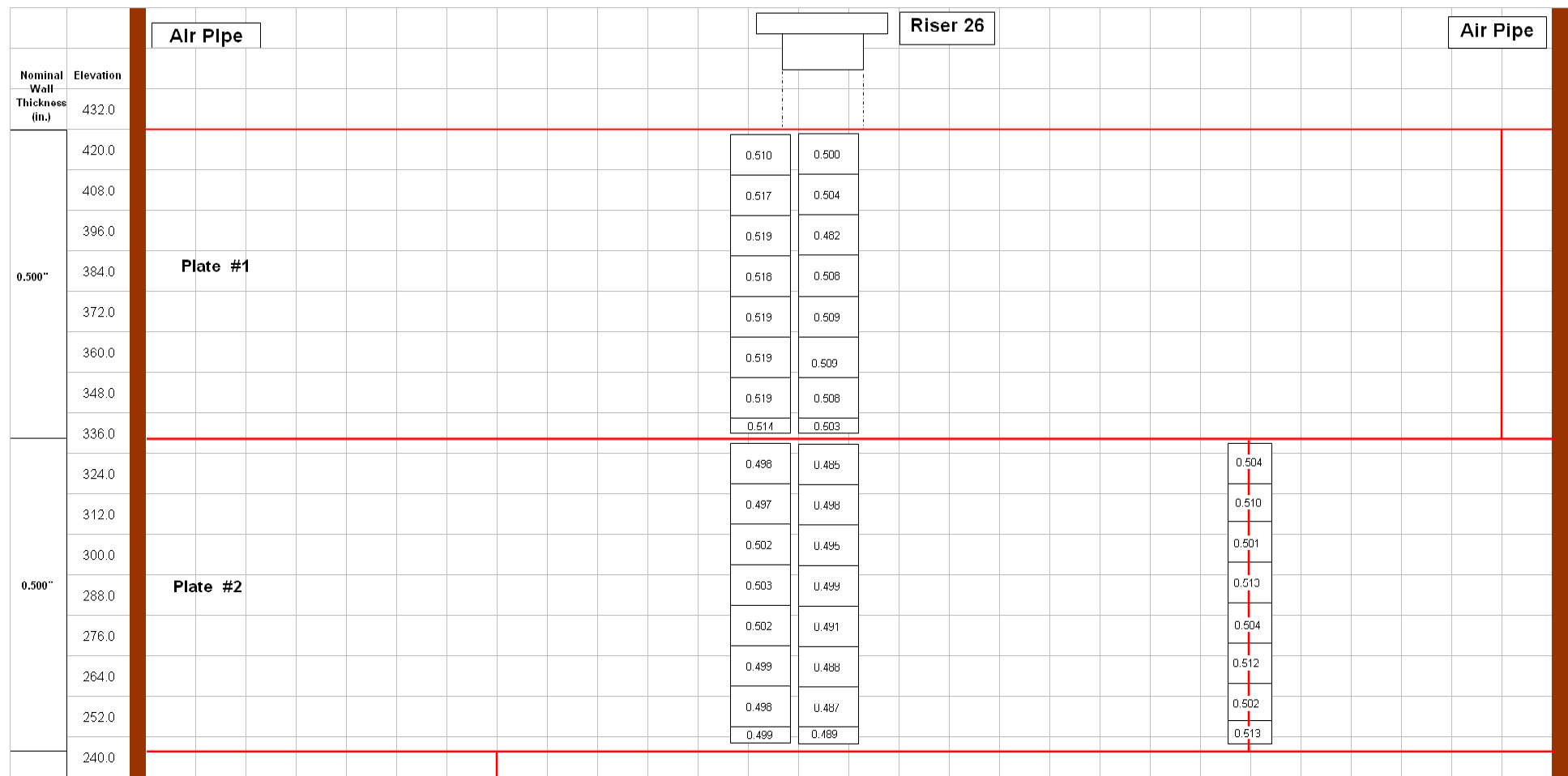


Figure 5.3. UT Data from Tank 241-AN-107 Riser 26

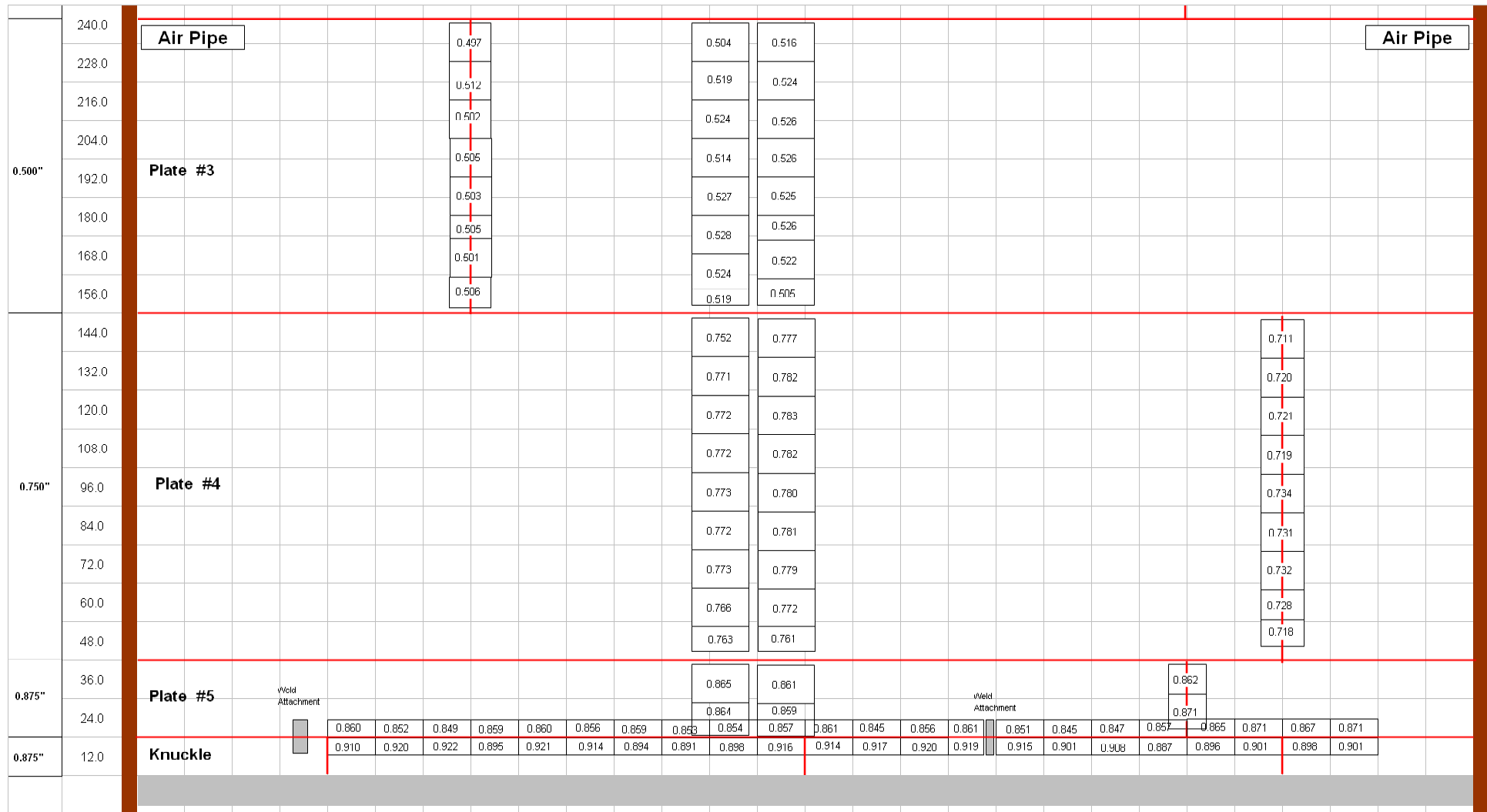


Figure 5.4. UT Data from Tank 241-AN-107 Riser 26 cont.

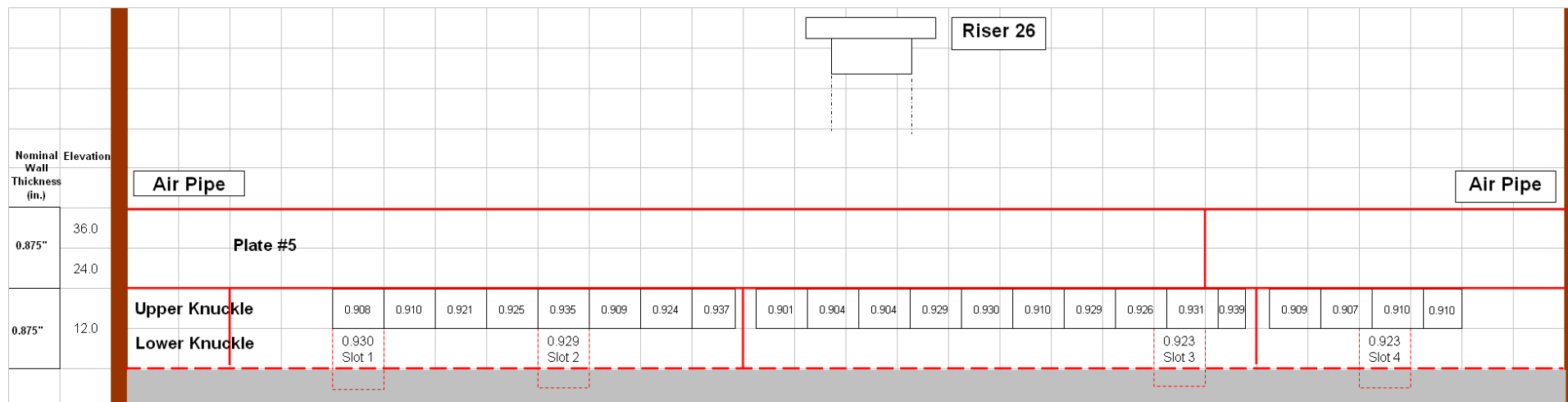


Figure 5.5. UT Data from Tank 241-AN-107 Riser 26 cont.

6.0 Extreme Value Analysis

The objective of this section is to estimate a worst case wall condition with respect to thinning (see Weier, Anderson, 2005, for a description of the methodology). If remaining wall thickness is used to estimate such a worst case condition, wall thickness measurements from plates with differing nominal thicknesses could not be combined to fit a common distribution. Extreme value distribution fitting will benefit from having more measurements to fit, so if results can be reasonably combined across plates, this approach is preferred. For this reason, extreme value plate loss is computed instead of using remaining wall thickness. However if the original nominal values for tank wall thicknesses of 0.500-in., 0.750-in., and 0.875-in. are used, negative losses are obtained since remaining wall thickness still exceeds drawing nominal. For this reason UT image maximum values were used to provide a better estimate of original wall thickness than the drawing nominal values. This assumes some areas of plates are in near pristine condition. But of course such maximum values would not be used if they were less than the original nominal thickness.

Note that measurement error and its variability has not been separated from the actual wall thickness variability here. Therefore when an extreme value is generated using the following methodologies, a worst case “measured wall thickness loss” is being estimated. That is, both the measurement variability and the actual wall thickness variability contribute to the uncertainty. When we obtain a worst case value, we are then deriving a worst case “measured result” that would be expected if the entire tank were inspected using UT methodology. This is a more extreme value than would be obtained by estimating only a worst case wall condition; to do that measurement error would have to be adequately characterized and removed from consideration. That has not yet been undertaken since appropriate data might not be available to do so, but it is a topic of ongoing analyses.

Two paths are available down each of two risers. For example, in a ~10-ft. plate (vertical dimension) for one riser, this generates about 18 maximum measured wall thickness values (it actually varies from plate to plate depending on plate dimensions). These values were considered for each riser/plate combination. The alternative “nominal thickness” selected in this manner then depended somewhat on the pattern of these maximum values, but generally it could be described as approximately the 80th percentile of such measurements. It was considered too extreme to use the largest of the 18 or so maximum values due to potential measurement error then grossly over-estimating the true nominal thickness. In this manner the Figure 6.1 maximum remaining thicknesses were obtained for Tank 241-AN-107.

AN-107	Plate Estimated Nominal				
	1	2	3	4	5
Riser 25	0.5425	0.5125	0.5300	0.7925	0.9000
Riser 26	0.5325	0.5325	0.5375	0.8025	0.9000

Figure 6.1. Table of Estimated Nominal Thickness from UT Maxima

Then the 18 individual UT image minimum values for a plate/riser combination were subtracted from

the estimated maximum value for that plate/riser from Figure 6.1. In this manner 18 estimated maximum wall thickness losses were obtained for a plate/riser combination, and then these were combined across the two risers, so about 36 such losses were available for the entire plate course. Note that since two risers are used, the riser variability within the tank does contribute to the overall variability in the results. For this reason an added one-sigma uncertainty, to accommodate riser variability if only a single riser were used, is not added here (see Weier, Anderson, Berman 2005).

The histograms in Figure 6.2 show such wall thickness loss data grouped by plate course. That is, the UT image maximum losses from the four paths, two per riser, within each plate course are combined. Three parameter Weibull distributions are fit to these histograms and are shown as the smooth curves. The total surface area of a plate course, and thus the number of 15-in. by 12-in. UT images needed to 100% inspect the plate course, is computed. The percentile of the distribution that then corresponds to the greatest expected loss among this many UT images, based on the distribution fit to the histogram, is considered as the estimated worst case loss. But the number of measurements available and the quality of the fit of the Weibull distribution affect the uncertainty in the estimated Weibull parameters, and in

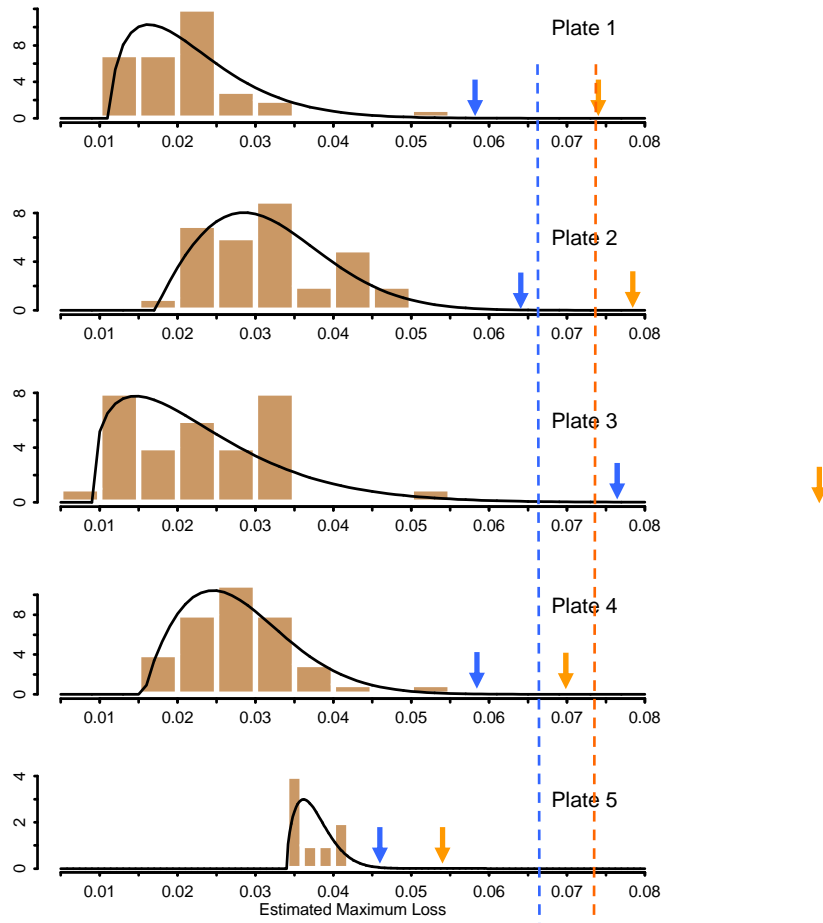


Figure 6.2. Weibull Distribution Fits to UT Maximum Wall Thickness Loss by Plate Course

turn, the uncertainty in the estimated worst case loss. Therefore 95% confidence bounds on the worst case values are also computed using these uncertainties.

The values indicated by the arrows on the histograms are the estimated worst case losses per plate course (blue) and their associated 95% confidence bounds (orange). The corresponding values are given in the table shown in Figure 6.3. Included in the table are: 1) the number of measurements, 2) the estimated extreme value loss expected for the plate course around the entire circumference of the tank, and 3) the 95% confidence bound for the extreme loss for each plate and for a combination of the plate data. This combination is represented in Figure 6.2 by the blue and gold vertical dotted lines.

<u>AN-107 Extreme Values</u>	Plates					
	Combined	1	2	3	4	5
Estimate	0.066	0.058	0.064	0.076	0.058	0.046
Bound	0.074	0.074	0.078	0.105	0.070	0.054
Measurements	140	32	32	32	36	8

Figure 6.3. Table of Tank 241-AN-107 Wall Thickness Extreme Value Loss Estimates and Bounds

Note that the Plate #3 distribution fit is considerably influenced by the “pile-up” of measurements at each end of the primary histogram and then the rather large outlier. These characteristics result in quite a conservative (large) maximum loss estimate and bound. These unusual cases can easily result from relatively minimal amounts of data available for distribution fitting; therefore we are motivated to group the wall thickness losses across plate courses as much as possible. Such grouping would also be based on the assumption that the corrosion mechanism for the tank wall interior is reasonably consistent throughout the tank. However, this assumption might be more reasonable in some tanks than others. Certainly the measurements should be also analyzed by plate course as above as part of the determination of the appropriateness of subsequent grouping.

While formal statistical tests would likely declare the plate wall thickness losses to be different from plate to plate, practically significant differences aren’t necessarily indicated, especially in the upper tail of the distributions which is the area of most interest in this extreme value estimation. Therefore the wall thickness losses are combined across all five plate courses for Tank 241-AN-107 and shown both in the table in Figure 6.3 above and in the histogram in Figure 6.4.

The extrapolation out to a tail percentile for the combined data has to accommodate the entire surface area of the tank across all five courses and therefore goes out to a higher percentile of the distribution. The estimate and bound in this combined case are shown by the arrows in Figure 6.4 and by the vertical dotted lines in Figure 6.2. These values are proposed as the most reasonable extreme value wall thickness loss estimates for Tank 241-AN-107.

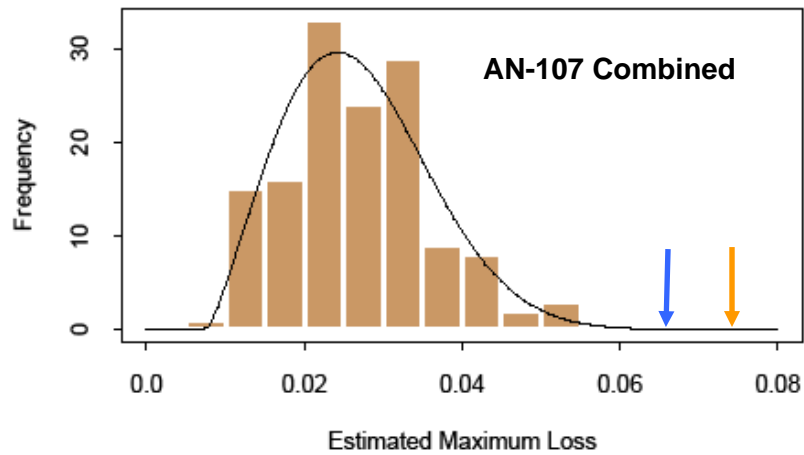


Figure 6.4. Weibull Distribution Fit to Maximum Wall Thickness Loss Combined over Plate Courses

Therefore 0.066-in. is proposed as a worse case measured wall thickness loss if the entire surface of the tank walls were UT measured. But the uncertainty on this estimate results in a 95% confidence bound on the true worse case measured loss as 0.074-in. It is important to note that if these loss values were applied to determine a worse case remaining thickness, drawing nominal thicknesses would not be used as the original tank wall thickness, but rather the estimated wall thicknesses given in the table in Figure 6.1. And note that for Tank 241-AN-107 these estimated nominal thicknesses from the UT maxima averaged about 0.035-in. greater than drawing nominal.

7.0 Conclusions

The results of the examination of Tank 241-AN-107 have been evaluated by PNNL personnel. The ultrasonic examination consisted of two vertical 15-in.-wide scan paths over the entire height of the tank, the heat-affected zone (HAZ) of four vertical welds and one horizontal weld, the upper portion of the knuckle region, four small areas of the lower portion of the knuckle region within the air slot entrances, and the lower portion of the knuckle utilizing a multiple V path technique qualified for the extended Y-arm scanner from Riser 26. The examination also included two vertical 15-in.-wide scan paths over the entire height of the tank from Riser 25. The examination was performed to detect any wall thinning, pitting, or cracking in the primary tank wall.

7.1 Primary Tank Wall Vertical Scan Paths

Two 15-in.-wide vertical scan paths was performed on Plates #1, #2, #3, #4, and #5 from Riser 26. The plates were examined for wall thinning, pitting, and cracks oriented vertically on the primary tank wall. The results indicated that the minimum thicknesses in the areas that were scanned with nominal thickness of 0.500-in. are as follows; Plate #1 was 0.482-in., Plate #2 was 0.485-in., and Plate #3 was 0.504-in. The nominal thickness in Plate #4 is 0.750-in. and the minimum thickness in this area was 0.752-in. The nominal thickness in Plate #5 is 0.875-in. and the minimum thickness in this area was 0.859-in. There were no areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness. No pitting or vertical crack-like indications were detected in Plates #1, #2, #3, #4, or #5.

Two 15-in.-wide vertical scan paths was performed on Plates #1, #2, #3, #4, and #5 from Riser 25. The plates were examined for wall thinning, pitting, and cracks oriented vertically on the primary tank wall. The results indicated that the minimum thicknesses in the areas that were scanned with nominal thickness of 0.500-in. are as follows; Plate #1 was 0.510-in., Plate #2 was 0.469-in., and Plate #3 was 0.476-in. The nominal thickness in Plate #4 is 0.750-in. and the minimum thickness in this area was 0.754-in. The nominal thickness in Plate #5 is 0.875-in. and the minimum thickness in this area was 0.859-in. There were no areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness. No pitting or vertical crack-like indications were detected in Plates #1, #2, #3, #4, or #5.

7.2 Primary Tank Wall Weld Scan Paths

The HAZ of vertical welds in Plates #2, #3, #4, and #5 from Riser 26 were examined for wall thinning, pitting and cracks oriented either perpendicular or parallel to the weld. The results indicated that the minimum thicknesses in the weld areas that were scanned are as follows: The nominal thickness of Plate #2 is 0.500-in. and the minimum thickness in this weld area was 0.501-in. The nominal thickness in Plate #3 is 0.500-in. and the minimum thickness in this weld area was 0.497-in. The nominal thickness in Plate #4 is 0.750-in. and the minimum thickness in this weld area was 0.711-in. The nominal thickness in Plate #5 is 0.875-in. and the minimum thickness in this weld area was 0.862-in. There were no areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness. No pitting or crack-like indications were detected in the weld areas in Plates #2, #3, #4, and #5.

The HAZ of the horizontal weld between Plate #5 and the tank knuckle from Riser 26 was examined for wall thinning, pitting and cracks oriented either perpendicular or parallel to the weld. The results indicated that the minimum thickness in the weld area with nominal thickness of 0.875-in. on Plate #5 was 0.845-in. The minimum thickness in the weld area with nominal thickness of 0.875-in. on the knuckle was 0.891-in. There were no areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness. No pitting or crack-like indications were detected in the weld areas on Plate #5 side or on the knuckle side of the horizontal weld.

7.3 Primary Tank Wall Knuckle Scan Paths

The upper portion of the knuckle area from Riser 26 was scanned utilizing the Y-arm scanner attached to the AWS-5D crawler. The Y-arm scanned the transducers down around the knuckle approximately 12-in. (from a starting position 2-in. down) from the upper knuckle weld joining Plate #5 to the knuckle. The knuckle was examined for wall thinning, pitting, and cracks oriented circumferentially around the primary tank. The results indicated that the minimum thickness in the approximately 20 circumferential feet of knuckle area examined with nominal thickness of 0.875-in. was 0.901-in. There were no areas that exceeded the reportable level of 10% of the nominal thickness. No pitting or circumferentially oriented crack-like indications were detected in the upper portion of the knuckle area.

Four small areas on the lower portion of the knuckle area from Riser 26 were examined for wall thinning only utilizing the Y-arm scanner in areas accessible through selected air slots. The four areas examined were in air slots designated as Slot 1, Slot 2, Slot 3, and Slot 4. The results indicated that the minimum thickness in the lower portion of the knuckle area, with nominal thickness of 0.875-in., in the selected air slots was 0.923-in. There were no areas that exceeded the reportable level of 10% of the nominal thickness.

The lower portion of the knuckle area from Riser 26 was interrogated utilizing a multiple V path technique qualified for the extended Y-arm scanner. This technique has only been qualified for detection of cracks oriented circumferentially around the primary tank in the lower knuckle region. No circumferentially oriented crack-like indications were detected in the lower portion of the primary tank knuckle area.

7.4 Extreme Value Analysis

Since current remaining wall thickness typically still exceeds drawing nominal, thereby generating negative losses, UT image maximum values were instead used to determine estimated nominal wall thickness per plate/riser combination. These thicknesses tended to run about 0.035-in. greater than drawing nominal. They in turn were used with each UT image minimum value to determine estimated wall thickness losses which were then combined for a plate course over the two risers, two UT measurement paths per riser.

Three parameter Weibull distributions were fit to the plate course measurements as well as to the

measurements combined over all plates. The latter case leads to a proposed worst case measured wall thickness loss of 0.066-in. that might be expected if the entire surface area of the tank wall were UT inspected. A 95% confidence bound is computed based on the uncertainty in the Weibull parameters caused by the relatively minimal amounts of data for distribution fitting and the quality of the Weibull fit; this 95% bound on measured wall thickness loss is 0.074-in. Note that such losses should be considered relative to the larger “estimated” nominal wall thicknesses and not the drawing nominal.

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