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**Ultrasonic Examination of Double-Shell
Tank 241-SY-101 Examination
Completed March 2004**

A.F. Pardini
G.J. Posakony

May 2004

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830



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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

COGEMA Engineering Corporation (COGEMA), under a contract from CH2M Hill Hanford Group (CH2M Hill), has performed an ultrasonic nondestructive examination of selected portions of Double-Shell Tank 241-SY-101. 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-SY-101 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-17750 (Jensen 2003) and summarized on page 1 of this document, are 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 disk and paper copies of all measurements are provided to PNNL for third-party evaluation. PNNL is responsible for preparing a report that describes the results of the COGEMA ultrasonic examinations.

Examination Results

The results of the examination of Tank 241-SY-101 have been evaluated by PNNL personnel. The ultrasonic examination consisted of two 15-in. wide scans over the entire height of the tank and the heat-affected zone (HAZ) of five vertical welds and one horizontal weld, and examination of the upper portion of the knuckle region. 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 shell courses #1, #2, #3, #4, and #5. The shell courses were examined for wall thinning, pitting, and cracks oriented vertically on the primary tank wall. There were 6 areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness. The areas were all located in shell course #1. No pitting or vertical crack-like indications were detected in shell courses #1, #2, #3, #4, or #5.

Primary Tank Wall Weld Scan Paths

The HAZ of vertical welds in shell courses #1, #2, #3, #4, and #5 were examined for wall thinning, pitting, and cracks oriented either perpendicular or parallel to the weld. There were 3 areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness in the HAZ of the vertical weld in shell course #1. There were 2 areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness in the HAZ of the vertical weld in shell course #2. No pitting or crack-like indications were detected in the weld HAZ areas in shell courses #1, #2, #3, #4, and #5.

The HAZ of the horizontal weld between shell course #5 and the tank knuckle 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 areas on the shell course #5 side or on the knuckle side of the horizontal weld.

Primary Tank Wall Knuckle Scan Paths

The upper portion of the knuckle area was scanned utilizing the Y-arm scanner attached to the AWS-5D crawler. The Y-arm scanned the transducers down around the knuckle approximately 11-in. from a starting position 1-in. below the upper knuckle weld joining shell course #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.

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1.0 Introduction

COGEMA Engineering Corporation (COGEMA), under a contract from CH2M Hill Hanford Group (CH2M Hill), has performed an ultrasonic nondestructive examination (UT) of selected portions of Double-Shell Tank (DST) 241-SY-101. 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-SY-101 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-17750 (Jensen 2003), are 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 shell course plate.
- Pits with depths that exceed 25% of the nominal shell course plate thickness.
- Stress-corrosion cracks that exceed 0.10-in. (through-wall) that are detected in the inner wall of the tank, heat-affected zone (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 disk and paper copies of all measurements are provided to PNNL for third-party evaluation. PNNL is responsible for preparing a report that describes the results of the COGEMA UT.

2.0 Qualified Personnel, Equipment, and Procedure

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 by CH2M Hill. Personnel participating in the examinations are to be certified in accordance with the American Society for Nondestructive Testing (ASNT) Guideline SNT-TC-1A-92 and associated documentation is to be provided. The capability of the UT system is to be validated through a performance demonstration test (PDT) administered by PNNL on a mock-up simulating the actual DST. The current procedure for the UT is to be based on the Section V, Article 4, *Boiler and Pressure Vessel Code* defined by the American Society for Mechanical Engineers (ASME).

2.1 Personnel Qualifications

The following individuals were qualified and certified to perform UT of the Hanford DST 241-SY-101:

- **Mr. Wesley H. Nelson**, ASNT Level III (#LM-1874) in UT, has been identified as COGEMA's UT Level III authority for this project. Mr. Nelson has been certified by COGEMA as a UT Level III in accordance with COGEMA procedure COGEMA-SVCP-PRC-014, latest revision. Further documentation has been provided to establish his qualifications. Reference: Letter from PNNL to C.E. Jensen dated August 22, 2000, "Report on Performance Demonstration Test – PDT, May 2000."
- **Mr. James B. Elder**, ASNT Level III (#JM-1891) in UT, has been contracted by COGEMA 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. Reference: PNNL-11971, *Final Report - Ultrasonic Examination of Double-Shell Tank 241-AN-107*.
- **Mr. William D. Purdy**, COGEMA UT Level II limited (for P-Scan data acquisition only). Mr. Purdy has been certified in accordance with COGEMA procedure COGEMA-SVCP-PRC-014, latest revision. Further documentation has been provided to establish his qualifications. Reference: Letter from PNNL to C.E. Jensen dated October 5, 2001, "Purdy Performance Demonstration Test (PDT) Report."

The following individual is a trainee and is not qualified or certified to perform independent UT of the Hanford DST 241-SY-101:

- **Mr. Jeffery S. Pintler**, COGEMA UT trainee in accordance with COGEMA 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-SY-101. This equipment consists of a Force Institute P-Scan ultrasonic test instrument and a Force Institute AWS-5D remote-controlled, magnetic-wheel crawler for examining the primary tank wall. The examination of Tank 241-SY-101 also included utilization of the Y-arm scanning bridge. Ultrasonic transducers used for the examinations are commercial off the shelf. The P-Scan ultrasonic system and Y-arm scanner attachment have been qualified through a PDT administered by PNNL. Reference: PNNL-11971, *Final Report- Ultrasonic Examination of Double-Shell Tank 241-AN-107* and letter from PNNL to C.E. Jensen dated September 21, 2001, "Qualification of the Y-Arm Attachment".

2.3 Ultrasonic Examination Procedure

COGEMA has provided the UT procedure for the examination of Tank 241-SY-101. This procedure, COGEMA-SVUT-INS-007.3, Revision 2, 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 and the HAZ of selected primary tank vertical and horizontal welds. 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 insures that each transducer used in the inspection is adjusted and that the entire system is performing correctly. The COGEMA UT procedure has been qualified through a PDT. Revisions to the procedure are reviewed to determine if a further PDT is required. Reference: PNNL-11971, *Final Report - Ultrasonic Examination of Double-Shell Tank 241-AN-107*.

3.0 Ultrasonic Examination Configuration

COGEMA 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-SY-101 included UT of the primary tank wall, the HAZ of selected welds in the primary tank wall, and the upper portion of the knuckle extending axially downward from the upper knuckle weld approximately 11-in.

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 COGEMA 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 pitting, 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 NDE 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 NDE inspector) and the scan is repeated. The mechanical scanning fixture is designed to scan a maximum of 15-in. and then index for the next scan line. The hard copy provides a permanent record that is used for the subsequent analysis.

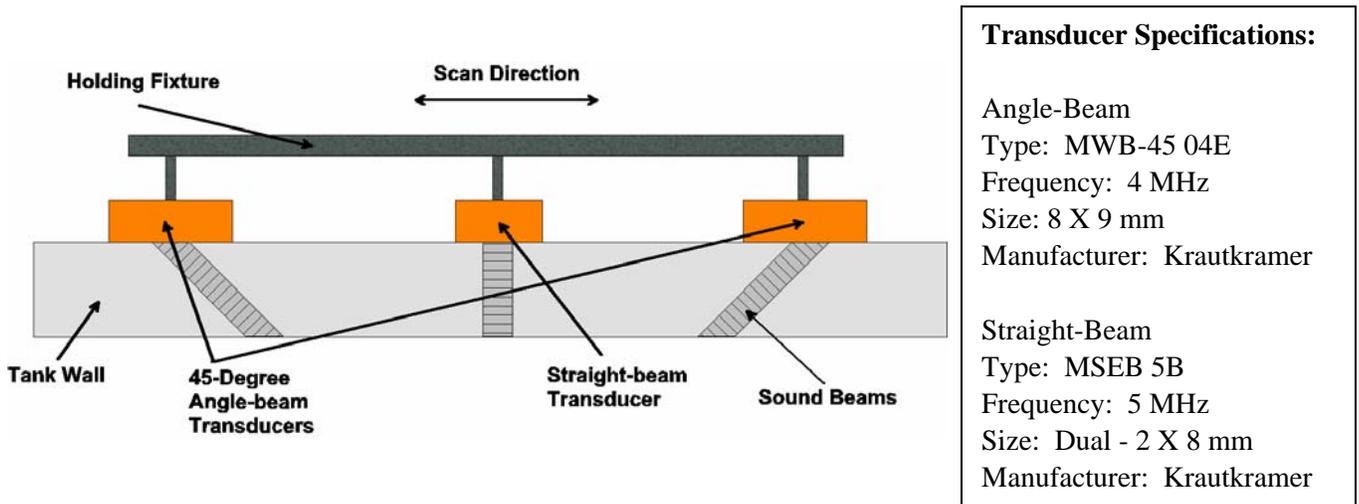
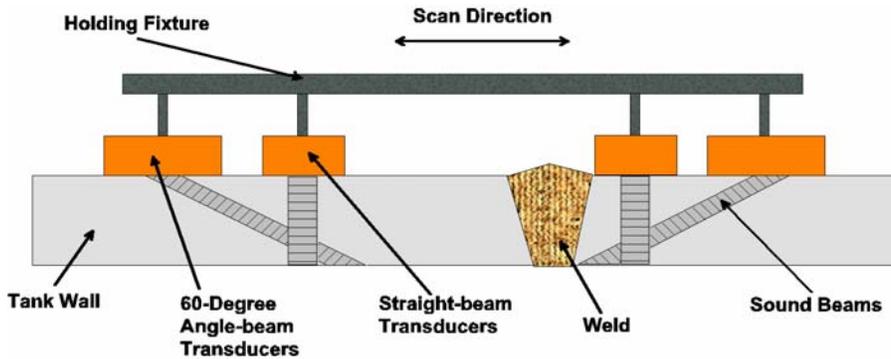


Figure 3.1. Transducer Configuration for Examining the Primary Tank Wall

3.2 Weld Zone Transducer Configuration

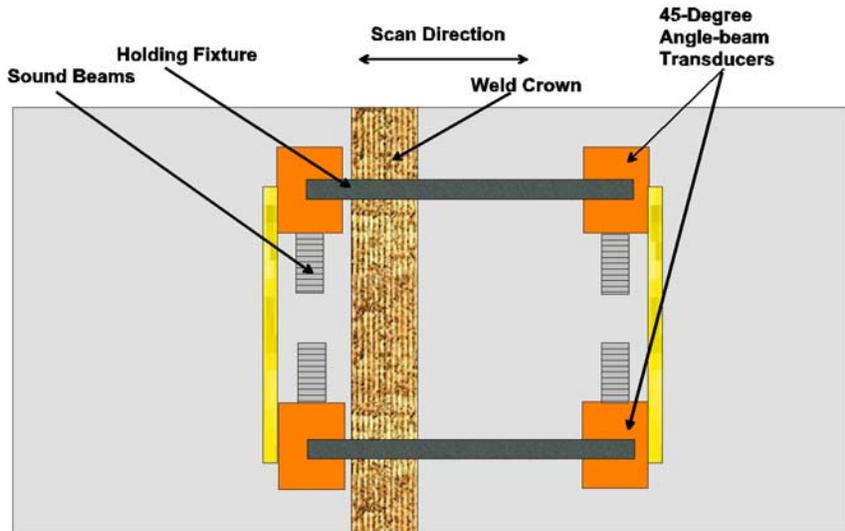
Figure 3.2 is a functional sketch that shows the configurations for examination of the weld zone. The area of interest (HAZ of the weld) is adjacent to the weld. Both cracks and pitting may occur in this region. The “A” portion of this sketch shows the 60-degree angle-beam transducers used for detecting 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 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 - 2 X 8 mm
 Manufacturer: Krautkramer

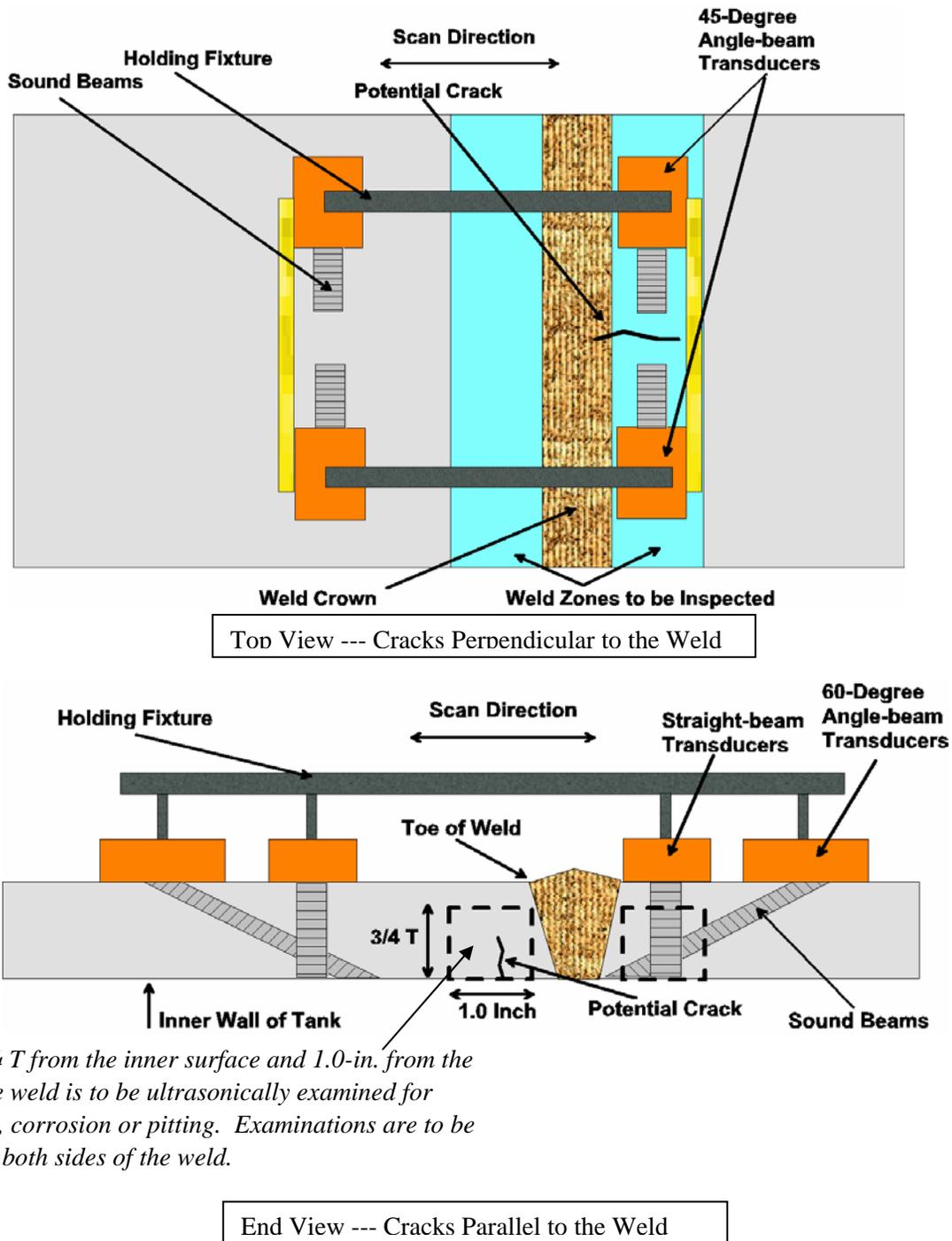


B. Configuration for cracks perpendicular to weld

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 shell course plate. These zones are considered most likely to experience stress-corrosion cracking.



A zone $3/4 T$ from the inner surface and 1.0-in. from the toe of the weld is to be ultrasonically examined for cracking, corrosion or pitting. Examinations are to be made on both sides of the weld.

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 shell course #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 1-in. below the transition shell course #5 to upper knuckle weld, the scanning bridge was set to scan the transducer downward an additional distance of approximately 11-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. x 0.035-in. (or as set by the operator).

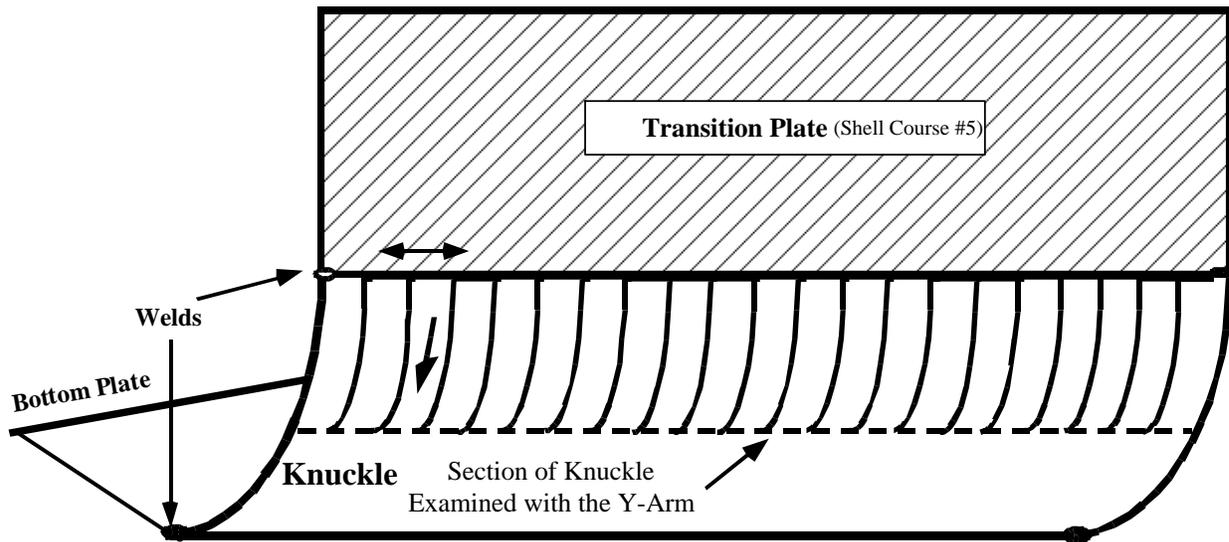


Figure 3.4. Sketch of a Section of the Knuckle Examined with the Y-Arm Scanner

4.0 Ultrasonic Examination Location

Tank 241-SY-101 is located in the Hanford 200 West area in SY Tank Farm. The crawler and associated scanner that hold the transducers were lowered into the 24-in. riser located on the east side of 241-SY-101 and designated as Riser 26. Figure 4.1 provides a graphic of the location of this riser.

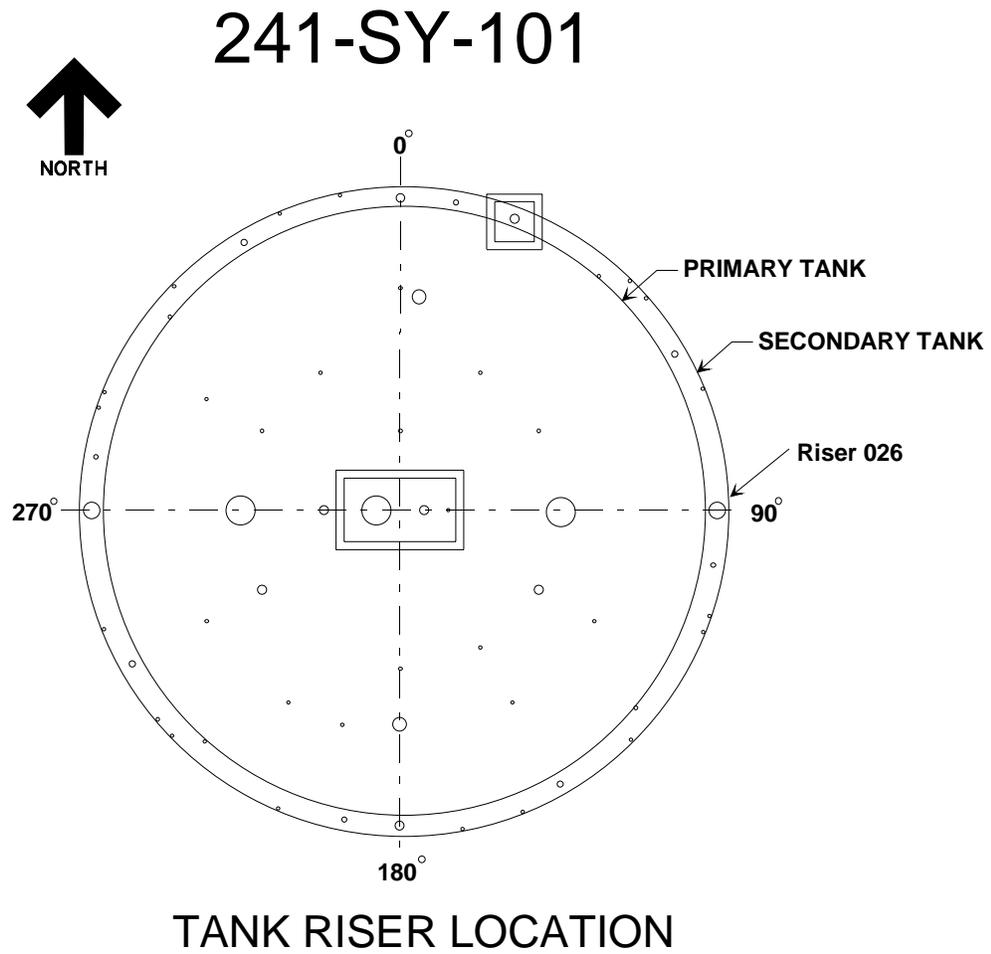


Figure 4.1. UT of 241-SY-101 from Riser 26

Figure 4.2 describes the areas on the primary wall of Tank 241-SY-101 that were ultrasonically examined. Two 15-in.-wide vertical scan paths were performed on shell courses #1, #2, #3, #4, and #5 below the entrance to Riser 26. Vertical weld HAZ examinations were done on shell courses #1, #2, #3, #4, and #5, and the horizontal weld HAZ examination was done on the transition shell course #5 to knuckle weld. Examination of the upper portion of the knuckle was also performed.

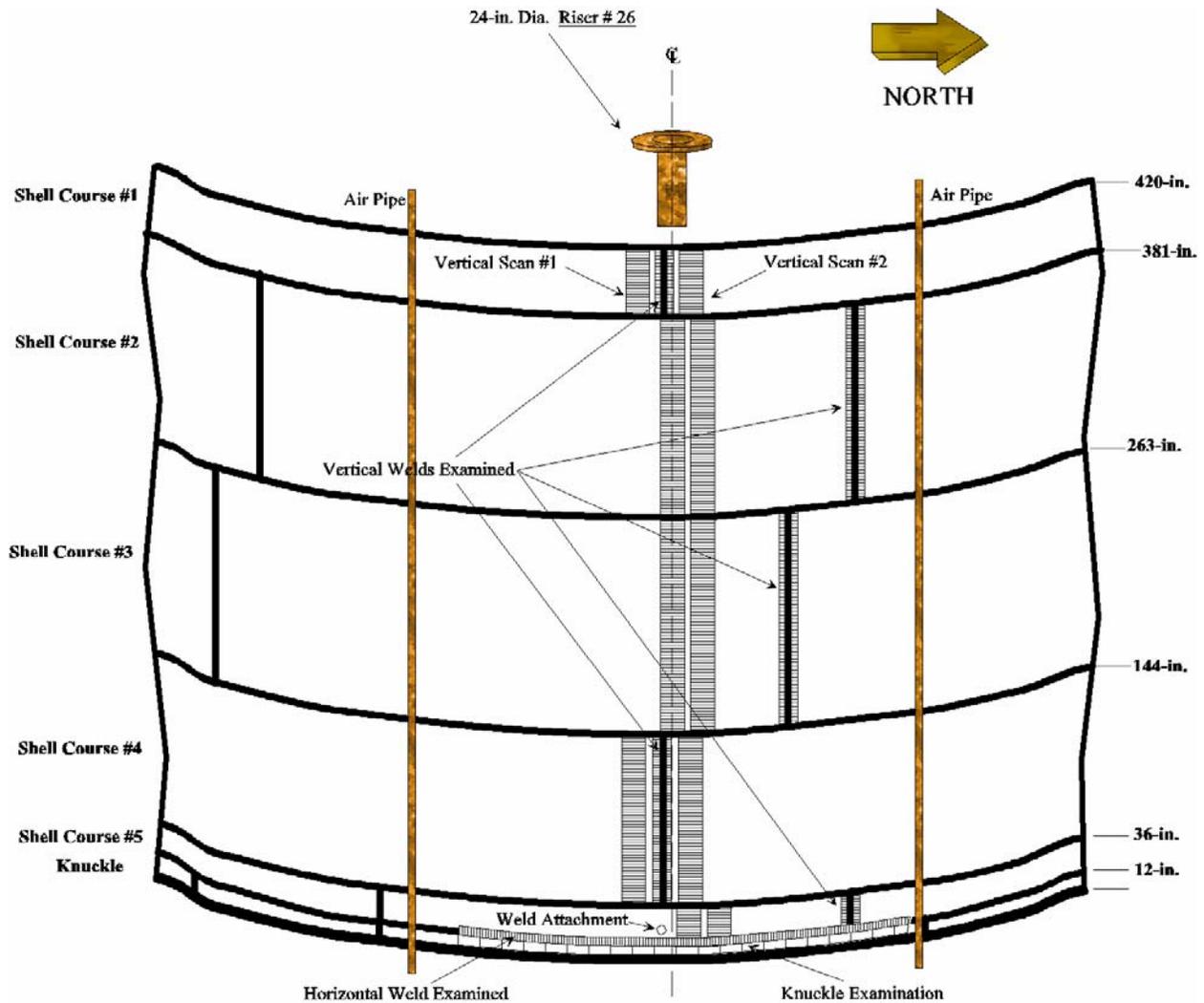


Figure 4.2. Sketch of Scan Paths on Tank 241-SY-101

5.0 Ultrasonic Examination Results

COGEMA 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 COGEMA Level III Mr. Wes Nelson and peer reviewed by JBNDT Level III Mr. Jim Elder. The results of the examination of Tank 241-SY-101 are presented in Figures 5.1, 5.2, and 5.3.

Figures 5.1 and 5.2 show the wall thickness examination results for the primary tank wall and the HAZs of both vertical and horizontal welds. The examination consisted of two vertical paths beneath the 24-in. diameter riser. Vertical path #1 was 15-in. wide on shell courses #1, #2, #3, #4, and #5 and started near the centerline of the 24-in. riser. Vertical path #2 was adjacent to vertical scan #1 (except in shell courses #1 and #4 where they were separated by a vertical weld) and was also 15-in. wide on shell courses #1, #2, #3, #4, and #5. The HAZs of vertical welds in shell courses #1, #2, #3, #4, and #5 were examined and the HAZ in the horizontal weld between shell course #5 and the knuckle section was also examined. Areas in the figures that show two measurements in the same box are the result of the vertical scan paths overlapping the horizontal HAZ scan paths. Figures 5.1 and 5.2 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 of vertical and horizontal scan paths are given. The highlighted areas in shell course #1 and #2 show minimum wall thickness exceeded the reportable level of 10% of the nominal thickness.

Figure 5.3 shows the examination performed on the knuckle of the primary tank wall. The readings distributed around the circumference of the tank knuckle represent the minimum reading in each 11-in. long by 12-in. wide portion extending down around the knuckle.

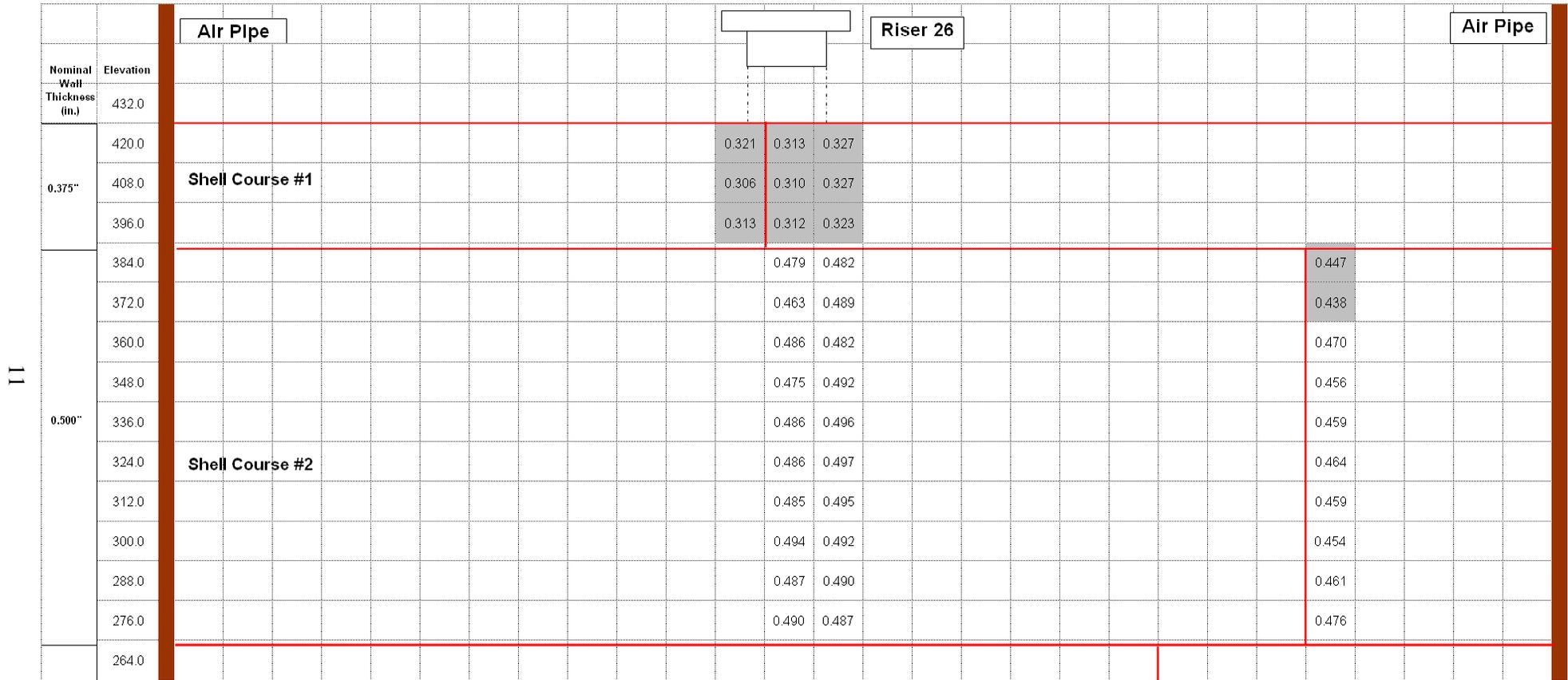


Figure 5.1. UT Data from Tank 241-SY-101

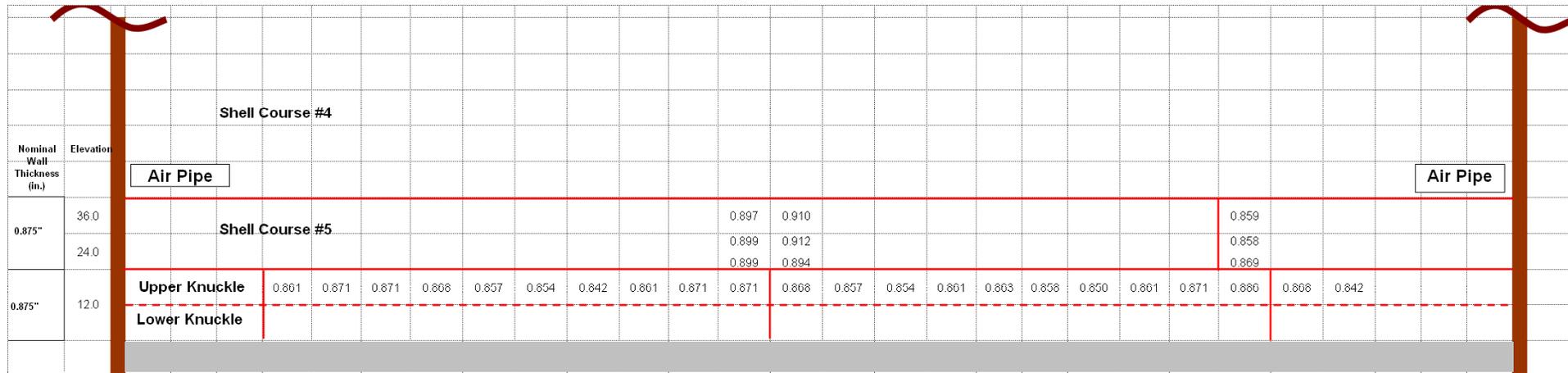


Figure 5.3 UT Data from Tank 241-SY-101 cont.

6.0 Conclusions

The results of the examination of Tank 241-SY-101 have been evaluated by PNNL personnel. The examination consisted of two 15-in. wide scans over the entire height of the tank and the HAZs of 5 vertical welds and 1 horizontal weld, and examination of the upper portion of the knuckle region. The examination was performed to detect any wall thinning, pitting, or cracking in the primary tank wall.

6.1 Primary Tank Wall Vertical Scan Paths

Two 15-in.-wide scan paths were performed on shell courses #1, #2, #3, #4, and #5. The shell courses were examined for wall thinning, pitting, and cracks oriented vertically on the primary tank wall. The results indicated that the nominal thickness in shell course #1 was 0.375-in. and the minimum measured thickness was 0.306-in. The minimum measured thicknesses in the areas scanned with nominal thickness of 0.500-in. were as follows; shell course #2 was 0.463-in. and shell course #3 was 0.485-in. The nominal thickness in shell course #4 is 0.750-in. and the minimum measured thickness in this area was 0.713-in. The nominal thickness in shell course #5 is 0.875-in. and the minimum measured thickness in this area was 0.897-in. There were 6 areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness. These areas were all located in shell course #1. No pitting or vertical crack-like indications were detected in shell courses #1, #2, #3, #4, or #5.

6.2 Primary Tank Wall Weld Scan Paths

The HAZ of vertical welds in shell courses #1, #2, #3, #4, and #5 were examined for wall thinning, pitting and cracks oriented either perpendicular or parallel to the weld. The results indicated that the minimum measured thicknesses in the weld areas scanned were as follows: The nominal thickness of shell course #1 is 0.375-in. and the minimum measured thickness in this weld area was 0.310-in. The nominal thickness of shell course #2 is 0.500-in. and the minimum measured thickness in this weld area was 0.438-in. The nominal thickness in shell course #3 is 0.500-in. and the minimum measured thickness in this weld area was 0.478-in. The nominal thickness in shell course #4 is 0.750-in. and the minimum measured thickness in this weld area was 0.705-in. The nominal thickness in shell course #5 is 0.875-in. and the minimum measured thickness in this weld area was 0.858-in. There were 3 areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness in the HAZ of the vertical weld in shell course #1. There were 2 areas of wall thinning that exceeded the reportable level of 10% of the nominal thickness in the HAZ of the vertical weld in shell course #2. No pitting or crack-like indications were detected in the weld HAZ areas in shell courses #1, #2, #3, #4, and #5.

The HAZ of the horizontal weld between shell course #5 and the tank knuckle was examined for wall thinning, pitting and cracks oriented either perpendicular or parallel to the weld. The results indicated that the minimum measured thickness in the weld area with nominal thickness of 0.875-in. on shell course #5 was 0.855-in. The minimum measured thickness in the weld area with nominal thickness of 0.875-in. on the knuckle was 0.828-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 the shell course #5 side or on the knuckle side of the horizontal weld.

6.3 Primary Tank Wall Knuckle Scan Paths

The upper portion of the knuckle area was scanned utilizing the Y-arm scanner attached to the AWS-5D crawler. The Y-arm scanned the transducers down around the knuckle approximately 11-in. from a starting position 1-in. down from the upper knuckle weld joining shell course #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 measured thickness in the approximately 20 circumferential feet of knuckle area examined with nominal thickness of 0.875-in. was 0.842-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.

7.0 References

Jensen, C. E., 2003, *Engineering Task Plan for the Ultrasonic Inspection of Hanford Double-Shell Tanks FY2004*, RPP-17750, Rev 0, September 2003, CH2M Hill Hanford Group, Inc., Richland, Washington.

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