

# Performance Demonstration Update – New Phased Array Procedures

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# Use of New PDI-UT-14 Manual Phased Array UT Procedure for RPV Welds

## PDI-UT-14 Manual PA RPV Procedure – Recent OE

- Stacked indications detected during the PDI-UT-6 conventional flaw detection scans of a nozzle-toshell RPV weld at a BWR
- Separating indications from one another and the inside surface was not possible when using the PDI-UT-7 conventional UT sizing scans were challenged
- Probes and wedges for the new manual phased array PDI-UT-14 examination procedure for detection and sizing of flaws within nuclear pressure vessel welds were sent to the site
  - Onsite examiners had qualified to this procedure just a couple of weeks prior to the refueling outage
- Phased array UT scans revealed a large excavation weld repair area containing embedded weld fabrication reflectors along the fusion line
  - 6db focal spots are ~24% to ~40% of the PDI-UT-6 detection probe focal spot
  - 6dB focal spots are ~21% to ~35% of the PDI-UT-7 sizing probe focal spot

Manual phased array examination of the Midland Unit #2 reactor vessel closure head—to—flange weld at Framatome



## Height Versus Length Focal Spots (New PDI-UT-14)

- New manual phased array procedure for detection, length sizing, and through-wall sizing in nuclear pressure vessels
  - Focal spots essentially the same for the inner 50%-t
    - RPV thickness within focal range of search unit
  - 94%-t focal spot still provides separation from inside surface





# Height Versus Length Focal Spots (Old PDI-UT-6)

- Previous conventional UT procedure for flaw detection in **RPV** welds
  - Focal spots increase in size as RPV thickness is beyond focal range of search unit





# Height Versus Length Focal Spots (Old PDI-UT-7)

- Previous conventional UT procedure for flaw length sizing and depth sizing in RPV welds
  - Focal spots increase in size as RPV thickness is beyond focal range of search unit





# **Current Status of PDI-UT-14**

- Inspection vendors interested in personnel qualifications using new RPV remains
- Procedure has been used with great results for welds in which inspection challenges are present
  - Procedure has been used successfully when fabrication flaws are present
- Procedure offers a wider range of examination angles for claiming inspection coverage
  - Reduces scan time
  - Reduces the amount of RPV insulation which must be removed prior to UT
- Procedure eliminated amplitude-based threshold for recording indications
  - Indications are recorded if they image measurable through-wall extent
  - Reduces scan time spent on the RPV

# **Continuing Work on PDI-UT-14**

- Procedure is available for Licensee and inspection vendor personnel qualifications
- Currently evaluating the included supplemental guidance for using a phased array 0° probe to provide additional response characterization
  - Current guidance based on UT beam simulations, now exercising this guidance on flawed RPV mockups
- 2025 BWRVIP NDE Project: Create guidance for interrogating regions surrounding internal RPV attachment welds for cracking which propagate into the low-alloy RPV material
  - Recently obtained canceled RPV sections containing welded attachments
- EPRI NDE Program Project: Expand UT Simulator to PDI-UT-14
  - Allows for examiner practice and/or training without hands-on time on actual specimens at EPRI







# Update on New Manual Phased Array UT Procedure For the Examination of DM Welds

## **Background Information**

- The EPRI NDE Program is developing a new manual phased array procedure for the examination of DMWs
  - Will be an Appendix VIII-qualified "industry procedure" available to all EPRI NDE Program members
    - Qualified for detection, length sizing, and depth sizing
- Existing industry procedure is ~15 years old; 15 years of technology advancements and OE have identified areas for improvement
  - Areas seen needing improvement are:
    - Reduce the contact area of the wedge
    - Reduce time/dose spent performing exams
    - Use current technology to increase inspection coverage
    - Make it easier to use/deploy
  - The existing procedure will remain available for use, EPRI will likely cease all further development to instead focus on the new procedure

#### Improvements

- Several probe and wedge configurations
  - Probe size and configuration are now optimized for specific weld configurations to increase coverage and probe contact
  - Eliminate the need to perform separate scans using shear wave focal laws
- Probes and wedges optimized, designed, and ordered for a wide range of configurations
  - Thickness range: 0.2" to 6.5" [5.3mm to 165mm]
  - Diameter range: 1.5" to 52" [38mm to 1320mm]
  - Qualified equipment should cover nearly all DMW configurations across the fleet, and attempt to eliminate the need to design and qualify probe/wedge combinations for one-off configurations
- Probes contain captured Phillips<sup>®</sup> screws with metric threads
  - Captured screws so they stay in probe housing, no more hunting down tiny screws
  - Phillips<sup>®</sup> screws versus a socket head eliminates the need to find the correct Allen key
  - Metric threads make finding replacement inserts easier for non-U.S. users

#### **Axial Scan Probes**

- Axial scan probes are short and wide
  - Array length/width ratio is optimized for sizing performance and help achieve greater inspection coverage
    - Shortest contact surface is across hoop-shrinkage
- Probe flange and fasteners are along side and front of array
  - Chamfer included on front of wedge to reduce contact area





## **Circumferential Scan Probes**

- Circumferential scan probes are long and narrow
  - Shortest distance across hoop-shrinkage to increase probe contact and maximalize inspection coverage when scanning up against obstructions, like nozzles
    - Arrays are one-half as wide as they are long
- Probe flanges and fasteners are along front and back of arrays, minimizing probe width as much as possible
- Wedges are chamfered along the sides to increase inspection coverage when scanning up against an obstruction



#### Improvements

- Probes are 4x8 matrix arrays instead of 1D linear arrays
  - Allows for electronic adjustment of roof angle
    - One wedge per contour with electronic adjustment for thickness
    - Allows for electronic skewing up to ~20° to account for scanning on tapers or increasing inspection coverage
- The need to perform shear wave scans has been eliminated
  - This will reduce time spent at the nozzle





#### Improvements

- Current procedure draft no longer requires "cal check" after loading new examination set-up
  - If material noise and inside surface responses image on the sector scan as expected, then no need for calibration check
    - This reduces time spent at the nozzle and enhances safety by eliminating the need to bring heavy calibration blocks to each nozzle
- Eliminated amplitude-based recording of indications
  - No longer use a standard reference reflector in ASME Section V basic calibration blocks
  - Procedure images through-wall extent of flaws, so recording threshold may include only indications which contain measurable through-wall extent; there is minimal benefit to manually plot indications after the phased array UT examination
    - This reduces time spent at the nozzle

## **Current Status**

- Qualifying multiple instruments
  - Olympus OmniScan X3 and Zetec Topaz 32 instruments are currently being qualified
- Sensor Networks probes and wedges currently being qualified
  - Alternative search units and wedges from Evident and other manufacturers under consideration
- Qualification sessions are underway to assist with procedure qualification
  - EPRI offering inspection vendors and utilities limited opportunities to no-cost qualification sessions
    - GEH sent 3 examiners, all 3 passed detection and sizing on the first attempt
  - Qualification requirements have been met for detection, length sizing, and depth sizing



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Main Navigation – Home	Performance Demonstration Initiative (PDI)					
Contacts Meetings	The Performance Demonstration Initiative (PDI) is an organization comprised of all U.S. nuclear utilities that was formed to provide an efficient, cost-effective, and technically sound implementation of Appendix VIII performance demonstration requirements. The PDI Focus Group is responsible for reviewing the test protocols and providing the Interface between the Nuclear Regulatory Commission and the ASME Boller and Pressure Vessel Code and providing technical oversight.					
PD Program	The EPRI NDE Center is the Performance Demonstration Administrator (PDA) for the program. Under the guidance of the PDI and in compliance with the EPRI Quality Program and Procedure Manual, the PDA provides technical and legal support, and administrator (PDA) for the program. Under the guidance of the PDI and in compliance with the EPRI Quality Program and Procedure Manual, the PDA provides technical and legal support, and administrator (PDA) for the program. Under the guidance of the PDI and in compliance with the EPRI Quality Program and Procedure Manual, the PDA provides technical and legal support, and administrator (PDA) for the program. Under the guidance of the PDI and in compliance with the EPRI Quality Program and Procedure Manual, the PDA provides technical and legal support, and administrator (PDA) for the program. Under the guidance of the PDI and in compliance with the EPRI Quality Program and Procedure Manual, the PDA provides technical and legal support, and administrator (PDA) for the program.	Jualification testing, and m	aintaining regis	tries.		
Guidelines Generic Correspondence	The PDA also performs other support activities such as participation in NUPIC and EPRI internal QA audits, coordinating ANII(S) involvement in the PDI program, and maintaining generic procedures for manual ultrasonic examinations.					
Inquiries NRC Correspondences IGSCC History	Home – This page     Contacts – Contains contact information for EPRI PD staff Focus group meeting agendas and action items     Meetings – Contains guidelines, energice PD and agenda     PD Program – Contains guidelines, energice PD and NRC correspondence, generic inquiries, and IGSCC history					
Technical Documents EPRI Qualified Procedures	Technical Documents – Contains technical drawings and other documents.     EPRI Qualified Procedures – Includes ANII Acceptance letters, Phased Array and Conventional procedure documents     Eresting – Information, cost, and a scheduling of PD tests     UT Simulator – Loan Agreement and VNDE Equipment Request forms					
ANII-Acceptance Letters Conventional Procedures	PD Implementation Tool – Tool that allows for selecting specific Procedure / Instrument and Probes and generate a custom Table 1 and Table 2 document     Procedure PDQS – Lists all and/or search for Procedure PDQS documents     Personnel PDQS – Alls personnel PDQS listed by individual					
Phased Array Proceedures	For contact information, visit the <u>Contacts</u> page. Charlotte Area					
PA Piping Table 1 Documents	Calvinformation     Cambra Medi					
PA Piping Table 2 Documents PA RPV Table 1 & 2 Documents	EPRI Charlotte Location					
Table 3 Documents						
Testing 📴						
PDI Pricing Information PDI Demonstration Registration						
UT Simulator						
PD Implementation Tool						
Procedure PDQS Personnel PDQS						

