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## Qualification of Manual Phased Array Ultrasonic Techniques for Pipe Weld Inspection in Nuclear Power Plants

Jerome POIRIER and Robert WARD

GE Inspection Technologies

50 Industrial Park Road, Lewistown, PA 17044, USA

Tel: +1.866.243.2638, Fax: +1.717.242.2606

Email [jerome.poirier@ge.com](mailto:jerome.poirier@ge.com), [robert\\_ward@ge.com](mailto:robert_ward@ge.com)

Web: [www.geinspectiontechnologies.com](http://www.geinspectiontechnologies.com)

### **Abstract**

The Electric Power Research Institute (EPRI) is tasked with insuring that qualified techniques for inspections are uniformly applied at their constituent utility power plants, and have instituted the Performance Demonstration Initiative (PDI) to help carry out this task. PDI is a process where a technique and technician is verified to be capable of finding and characterizing target defects with a very small margin of error.

General Electric Inspection Technologies has worked with EPRI to develop and qualify a manual phased ultrasonic technique to inspect pipe welds in nuclear power plants. When a technician is trained in the techniques it is anticipated that phased array technology and advanced imaging will insure a significantly higher pass rate for the test than the current +/- 50% rate for manual methods.

The methods have been developed to use the best of available technology in hardware, software and probes, but be very easily learned by a typical manual ultrasound technician.

**Keywords:** Phased Array, Manual Inspection, Nuclear, Weld, PDI, UT.

## **Introduction**

The Electric Power Research Institute (henceforth EPRI<sup>[1]</sup>) has the charter to help insure member utilities that their plants are run safely and efficiently. Member utilities share the costs of developing the techniques and technologies to achieve this goal by funding EPRI for very specific technical areas; and one of these areas is nondestructive testing (NDT).

In the past, EPRI was limited to United States based utilities. In the past decade, EPRI influence has spread to Asia and Europe, and the concerns and issues are raised from all parts of the world.

The industry is acutely aware that there are manpower shortages for performing NDT tests and at the same time more tests with greater reliability are required. One answer to this difficult situation is for EPRI to validate test methods, NDT equipment, and NDT technicians to specific tasks within the plant. When technicians with a proven skill set perform specific tests in the plant, it can be assumed that the quality of the test results from site to site within a plant will be uniform, and that the Probability of Detection (POD) of the defects of interest will be as high as reasonably achievable.

Uniformity can lead to a monopoly on who and how tests are performed, a situation that is not in the best interests of the member utilities.

The Performance Demonstration Initiative addresses all these issues by:

1. Insuring qualified technicians are performing critical tasks,
2. Insuring the methods and systems used to perform tests reliably reveal the defects of interest, and
3. NDT service providers, member utilities and equipment vendors all can develop and qualify new techniques for a particular inspection question

In this paper, one such effort to qualify a new inspection procedure will be discussed. The candidate technique was developed by an NDT systems vendor, General Electric Sensing and Inspection Technologies (GE S&IT), and is made available to any customer purchasing the equipment needed to perform the test.

## **Qualification Materials**

The GE S&IT Phasor XS manual phased array system, probes and procedures were used to attempt a PDI<sup>[2]</sup> Qualification, a method defined in section XI of ASME code. The qualification is based trials over many tens of pipe weld samples of various materials, diameters, and thickness.

To date (May 05, 2008) Phasor XS is the only phased array equipment qualified for manual inspection of piping weld.

## Scope of Qualification

Manual inspection of piping welds

Materials: Ferritic (CS), Austenitic (SS), IGSCC

Minimum diameter: 2''

Maximum Thickness: 3/4'' for SS, 4.85'' for CS

Examination volume (according to ASME code)

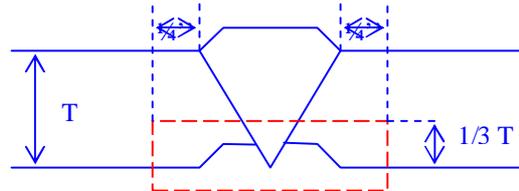


Figure 1. Examined Volume

Type of indications:

1. Axial & circumferential
2. ID connected

Single side & dual access of weld from pipe outer surface.

Qualification for detection and length sizing of defects

## Inspection method

Whole pipe range is inspected with 5 probes & 6 wedges.

4 linear phased probes for weld scanning in shear wave (different frequencies, different apertures).



Figure 2. Linear Phased Array probes

One TRL probe (Dual matrix probe) for scanning in compression wave. Custom datasets are provided to drive this dual matrix probes.



Figure 3. Dual Matrix Probe

Significant development research was carried out on wedge design in order to get the exit point to be very close to the front of the wedge. Footprint of the smaller wedge is “10mm x 10mm”.



Figure 4. Standard Wedge versus PDI Wedge

The target welds are scanned in “Raster Scan” by sectorial scanning, maximum range from 35° up to 80°.

Probe selection is defined in the procedure according to pipe diameter, pipe thickness and type of access (single or dual side).

The datasets for setting up the dual matrix probe are provided with the procedure.

### Advantages

In general, manual ultrasonic weld inspection methods are less costly than automated inspections, and can be performed by less experienced technicians. When performing automated or semi-automated (manual but using a mechanical scanner) NDT test, the scanner set up time can be as great or greater than actual data acquisition time. In many cases manual is the better choice, and it is the purpose of this effort to add the power of Phased Array Ultrasonic weld testing and data imaging to the manual weld examination, thereby increasing POD and talent pool for qualified technicians.

Coverage using an electronic scan, as can be the case when applying Phased Array Ultrasonic techniques, is greater than with a conventional probe, significantly reducing the number of scan lines over conventional manual weld inspection methods using A Scan methods. This can save overall inspection time, reducing radiation dose acquired by technicians and allowing more flexibility in the maintenance schedule.

In addition, scanning using a phased array technique requires less time on the pipe for operators, reducing stress and eyestrain and therefore increasing POD. The best attributes of automated scanning are incorporated into the manual examination using Phased Array Ultrasonic methods.

Imaging is also a very significant factor for increasing POD over conventional A-Scan methods. The images color code and stack the A-Scans of the sweep angles. The human eye can much more reliably compare colors of amplitudes displayed in this manner than changes in amplitude of a rectified A Scan displayed in sequence.

One indication of the power of using Phased Array Ultrasonics in conjunction with imaging is that for this effort, qualification was performed in less time than equivalent qualification using conventional flaw detectors.

Experience shows that this inspection method:

**1. Improves POD**

The purpose of inspection pipe welds is to detect defects of interest that can be used to predict fitness for service. If the likelihood of finding the target defects is increased, and simultaneously less time is spent evaluating signals that are not defects, the quality and usefulness of the weld test is greatly enhanced.

**2. Reduces training time of operators**

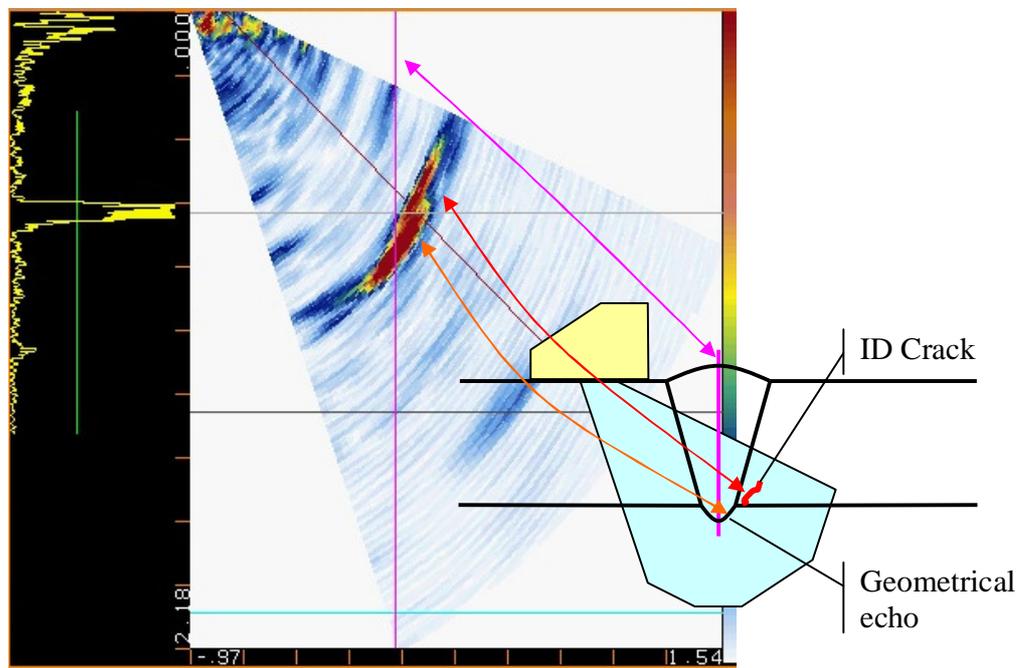
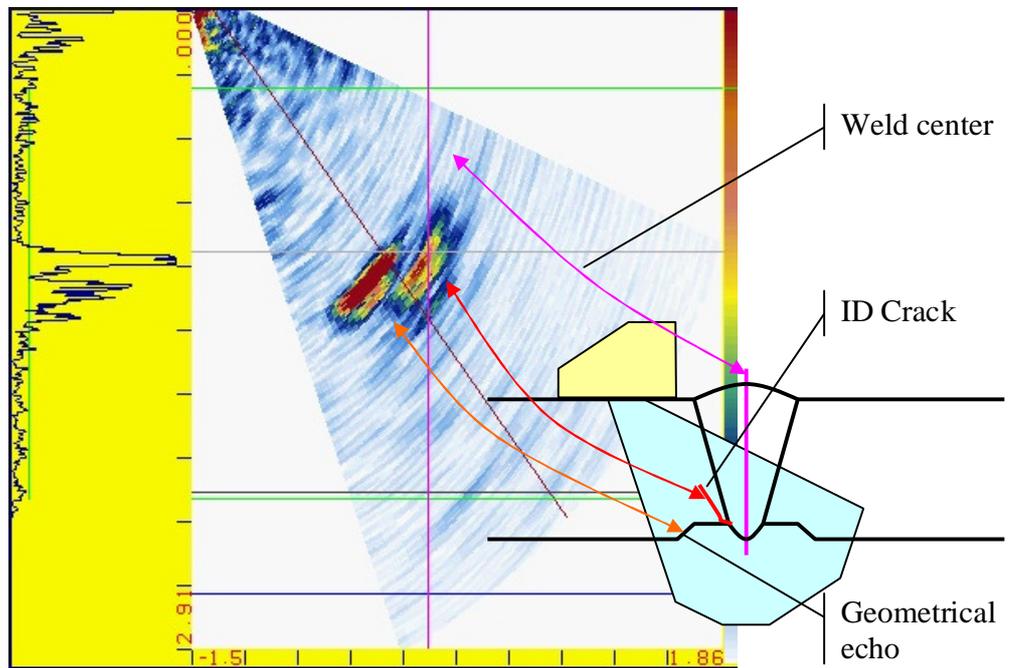
Manual weld examination training is much less time consuming and costly than automated training. Manual weld testing using imaging is much less time consuming than techniques using A Scans. The outcome is that in a short training period the likelihood of a positive qualification is greatly enhanced, and training times are reduced.

**3. Reduces inspection time**

Rastering of a conventional probe is time consuming and fraught with repeatability issues. The technique developed and qualified uses the power of Phased Array Ultrasonics to greatly reduce the Rastering requirement with two significant outcomes: quicker examinations and more repeatable results.

## Example of Scans

(Screen shoot performed on GE-IT samples)



## References

- [1] EPRI: Electrical Power Research Institute of Charlotte NC, USA
- [2] PDI: Performance Demonstration Initiative