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UNDERSTANDING CODE COMPLIANT ULTRASONIC TESTING

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INTRODUCTION

In today's industrial setting, accurate inspection data is critical. The accuracy of this data depends on several factors, including the complexity of the equipment used. Ultrasonic equipment has significant capabilities to detect a variety of internal defects, but they are often very complex and highly dependent on the operator. This has effects on both individual inspections and the market as a whole. A Frost & Sullivan (June 2014) report stated that "the biggest growth driver for non-destructive testing (NDT) training services globally is a lack of qualified technicians."

As the industry looks for alternative NDT methods to radiography, ultrasonic testing has gained popularity. The development of ultrasonic phased array images is important because they allow for a variety of structures to be inspected without radiation or taking equipment out of service. Large area B-scan and C-scan images have become commonplace. Codes are now being developed which allow phased array systems as an acceptable inspection technique for many procedures.

However, the complexity of these systems has led to several challenges for the market. The setup of phased array systems involves many complicated steps, each of which must be done correctly. Different inspections can require multiple costly probes to fully interrogate the target. However, the most challenging aspect of employing phased array systems is the dependence on the operator using the equipment. Training for these systems takes many weeks and requires in-depth knowledge of complicated UT focal laws and probe performance. This often limits repeatability and results in a high false call rate. If there is a time gap in using phased array, inspectors must be retrained. The most talented of phased array inspectors can generate accurate data. These inspectors are in high demand. This results in a high turnover rate as many inspectors jump from company to company leaving some many NDT service providers without adequate resources to run the UT equipment.

NEW TECHNOLOGY

Different from phased array UT, real-time ultrasound cameras for NDT usage are now available in the marketplace to address some of these issues. Some of the more advanced units available are essentially camcorders for ultrasound and have widespread applications. They can generate real-time C-scan imagery along with a quantitative A-scan reading, which is identical to a conventional flaw detector. **Figure 1** shows our handheld system consisting of a handheld probe and touchscreen controller.

Highlights of this new technology include:

- IP 66 – splash proof and dust proof
- Certification training in less time

Figure 1. Acoustocam i700

Figure 2. Worker inspecting weldments on piping

- Versatile design –Same system can be used for multiple frequencies and inspections
- 00 to 700 adjustable shear angle
- Compliant with AWS and ASME UT codes
- 2D encoders for either automated or freehand mapping
- Any curved surface from 4" diameter to flat
- Reduced time to setup, calibrate, and scan a 12" x 12" area in under 4 minutes
- Up to 6" metal thickness
- Penetrates paints and many coatings
- Higher resolution than phased array
- Battery powered
- All results reviewed and reported on offline analysis tool

To generate images, these systems use a separate source from its receiver. The source transducer emits sound waves which

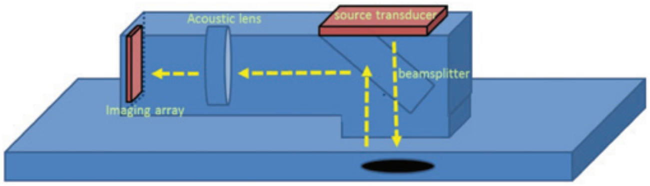

Figure 3. Internal view of source transducer, beamsplitter, lens, and array

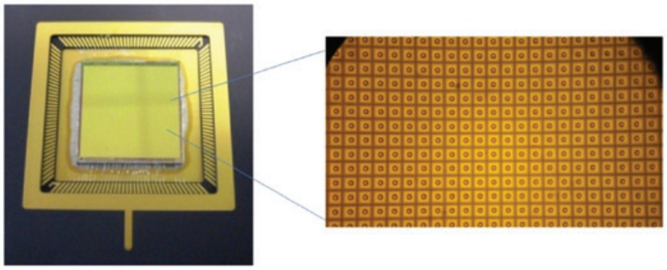

Figure 4. 14,400 element imaging array of 100 micron pixels

transmit through an acoustic beam splitter onto the target. The sound waves are reflected through the acoustic beam splitter, a water-filled tube, and an acoustic lens that focuses them on a microelectronic ultrasound-sensitive detector array that produces a digital acoustic image (**Figure 3**).

The detector array, shown in **Figure 4**, is highly sensitive—it is made up of 120 x 120 pixel elements (i.e., 14,400 pixels)—and can generate and record C-scan images at specific depths within a target object at the rate of 30 frames per second.

To select different frequencies the user replaces the source transducer from the camera head with a more suitable one, but the rest of the hardware is common to all inspections.

In addition to the C-scan video, these units contain two separate internal transducers which generate full waveform data. The first is a pulse echo receiver which is used during angle beam inspection, and the other is a dual element transducer meant for conducting thickness readings. Both transducers have three discrete sections which are each 1/3" in size. Either in real time or on the mapped image, this A-scan data is overlaid on top of the C-scan data. This provides 100% full waveform time of flight coverage. The A-scan output complies with ASTM E317: Standard Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Instruments and Systems without the Use of Electronic Measurement Instruments.

Since UT requires multiple angles to fully interrogate a structure, the system can be adjusted to different angles depending on the inspection. Using a 'tube within a tube' design, the system pictured below allows the incident angle to be adjusted from 0-degree straight beam for corrosion to 70-degree shear wave, thus covering all angles used for weld inspection.

To use these devices, ultrasonic couplant is applied to the target and the probe is placed against the pipe or plate. The user can then calibrate the system through an automated calibration routine. Thereafter, internal defects can be seen in real time mode or by mapping large areas using built in encoders with a pipe carriage. When large areas are mapped, all C-scan and A-scan data

Figure 5. Adjustable angle

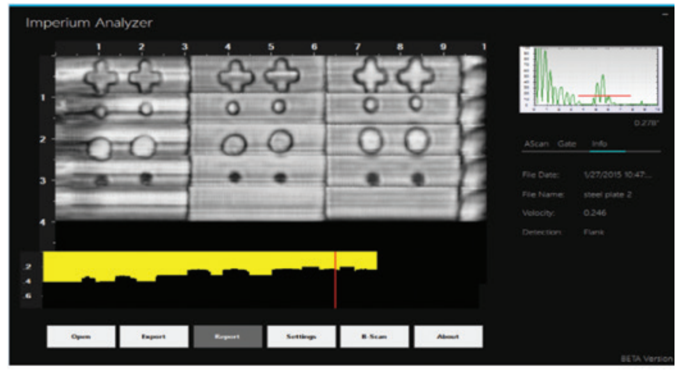

Figure 6. Analysis tool

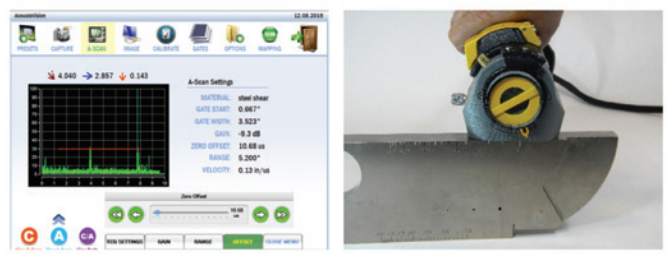

Figure 7. System Calibration

should be saved for later review(Data Analysis shown in **Figure 6**). It allows reviewing any area of interest with A-scan, B-scan, and C-scan reports.

WELD INSPECTION STUDY

Weld inspection is a primary application of ultrasonic testing. Through a series of tests performed with Central Piedmont Community College (CPCC), weld defects were investigated with the Acoustocam i700. A series of samples with internal cracks, lack of root penetration, and sidewall fusion were tested. All inspections were done with a 2.25 MHz transducer. The results below show the C-scan data, and all stored A-scan data can be used for quantitative analysis per existing codes.

The first step with any shear wave UT inspection is a calibration of the angle and screen range, which is shown below. In this case an IIW Type 2 block was used before the inspection was carried out.

The initial test was for a heat affected zone (HAZ) crack, as well as lack of root penetration. This experiment was carried out with a 45-degree shear wave transducer as recommended by

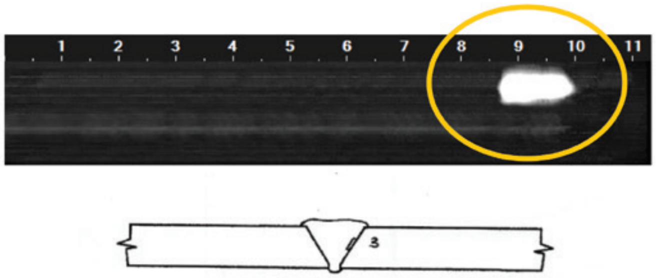

Figure 8. HAZ crack and lack of root penetration – 45 degree shear

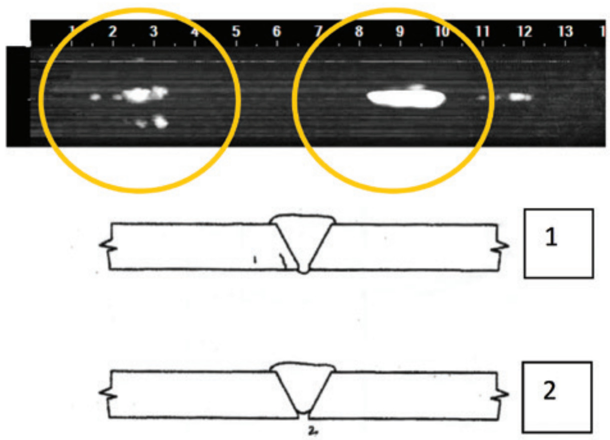

Figure 9. Toe Crack – 45 degree shear

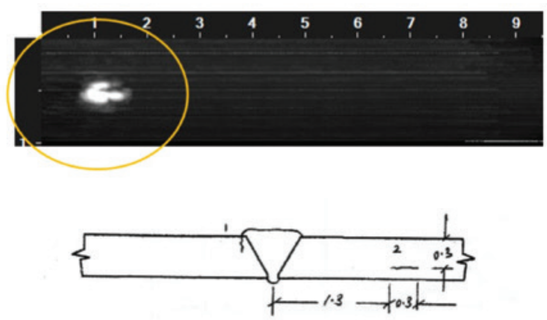

Figure 10. Lack of sidewall fusion - 60 degree shear

legacy inspection procedures. In **Figure 8**, the results of the scan show the HAZ root crack [1] and the lack of root penetration [2]. Both defects were on the same weld seam. The defects were then correctly sized and measured.

The next sample had a small toe crack. **Figure 9** shows the C-scan taken at a 45-degree shear. Again, the crack is easily identifiable.

Finally, we inspected for a lack of root penetration. This was done at a 60-degree shear wave angle. **Figure 10** shows the result of this inspection.

CORROSION MAPPING

Ensuring the integrity of pipelines and storage tanks is crucial for the continued success and reliability of O&G, petrochemical, and chemical processing operations. Unscheduled plant and pipeline shutdowns caused by corrosion costs U.S. oil & gas and petrochemical companies billions of dollars annually in product losses, production downtime, environmental cleanup efforts, and fines. Accordingly, the industry invests heavily in inspection personnel

Figure 11. Inspector performing corrosion mapping

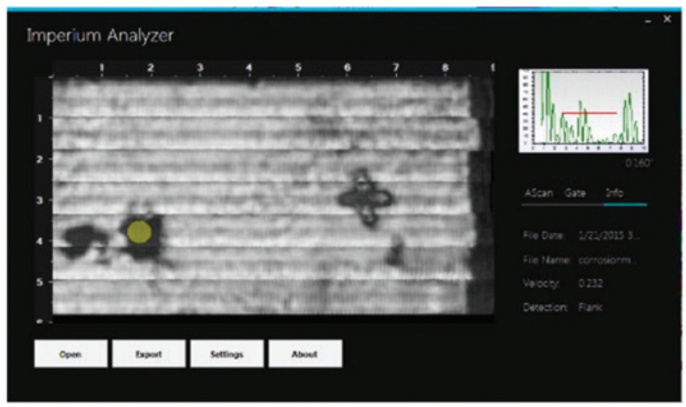

Figure 12. Typical corrosion mapping output with isolated pitting and thickness reading

and equipment to detect and monitor corrosion. Despite these efforts, the National Society of Corrosion Engineers (NACE) estimates that these costs can be reduced by up to 25 percent by implementing best practices and taking advantage of new technologies (Corrosion Costs and Preventative Strategies in the United States: Costs of Corrosion Study Revealed; 2002)

The ultrasonic method has been the most reliable method for the detection, measurement, and monitoring of ID corrosion in piping, pressure vessels and storage tanks. However, the ultrasonic method is still subject to miss calls and false calls due to the inherent limitations of the technology and human factors.

Figure 12 shows the typical output of a corrosion mapping scan. Note the high signal to noise ratio for identifying the area of pitting. Further note that the pitting has been highlighted and shows a remaining wall thickness at that spot.

HEAD TO HEAD: ACOUSTOCAM™ VS. PHASED ARRAY

To document the Acoustocam's results versus phased array, the following test was carried out. The Acoustocam and a popular PAUT device were used to inspect three steel pieces: a stepped standard, a corroded panel, and an 8" diameter pipe (see **Figure 13**).

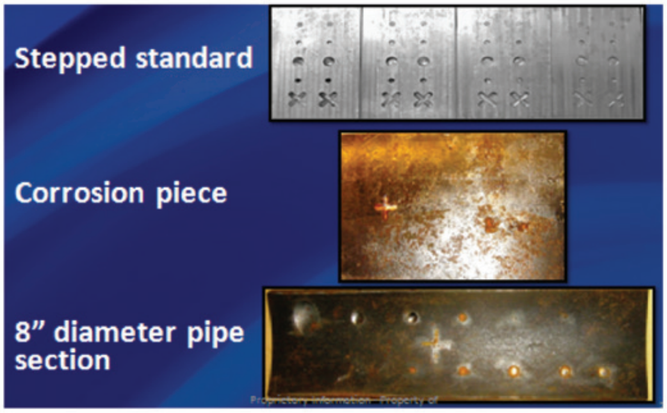

Figure 13. Targets studied in Acoustocam™ vs. Phased Array comparison

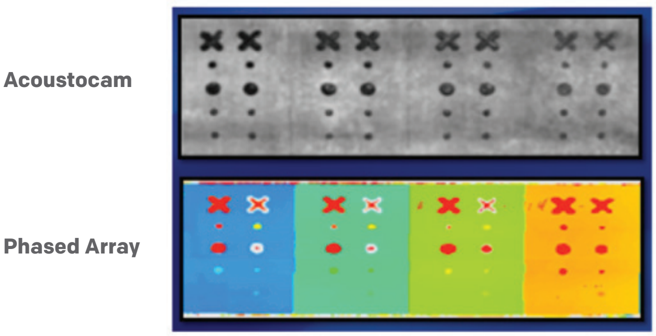

Figure 14. Results from stepped standard inspection

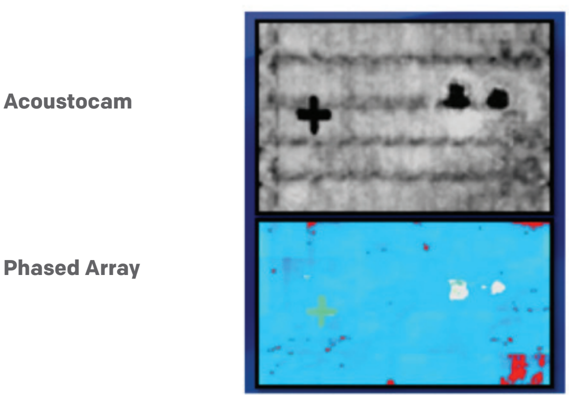

Figure 15. Results from inspection of corroded steel panel

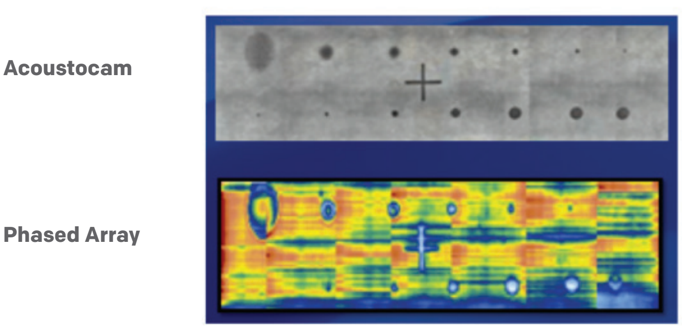

Figure 16. Results from inspection of 8” diameter pipe

In the test results illustrated in **Figure 14**, the Acoustocam produced a cleaner image, showing smaller holes more distinctly.

As shown in **Figure 15**, the the same system inspected the ¼”-thick corroded steel panel, showing crisp dark marks indicating damaged areas and produced fewer erroneous signals.

As shown in **Figure 16**, the system was also used to inspect the 8” diameter pipe, identifying the rear surface cross mark and holes with helpful contrast, as compared to that produced by the PAUT device.

CONCLUSION

Simple, real-time, and effective UT diagnostic tools exist on the market today and address many of the limitations of ultrasonic testing equipment. When used properly, they can reduce costly downtime and save operators significant time and money. By producing actual images of defects, these new systems arm inspectors with qualitative information together with easily interpreted quantitative data. Moreover, their intuitive design requires less training for technicians, without sacrificing data quality. ■

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Bob Lasser co-founded Imperium in 1996. He has published over 50 technical papers related to Imperium's technology and holds four U.S. patents for digital acoustic imaging. Mr. Lasser received his BS in Mathematics from the University of Michigan.