PHASED ARRAYS FOR CONVENTIONAL MARKETS – THE EPOCH 1000*i*

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ABSTRACT

Ultrasonic phased arrays have become a popular inspection tool, providing advanced imaging, rapid scanning and volumetric reporting capabilities. An increasing number of end-users have specified this technology for common inspections and applications. As the market expands, costs have declined, convenience has improved, and the requirement for a comprehensive conventional flaw detector with phased array capabilities has become prevalent. The EPOCH 1000 Series Ultrasonic Flaw Detector is the latest development, and combines the highest level of performance of conventional portable flaw detection with the power of optional phased array imaging. Based on conventional flaw detector design philosophy, this instrument features a full VGA display, knob or navigation arrows for parameter adjustment, plus full EN12668-1 compliance. This manual phased array imaging offers improved Probability of Detection while maintaining conventional flaw detection techniques. Some typical display images will be shown.

INTRODUCTION

The commercial application of phased arrays has been available for nearly two decades, and has gained increasing momentum in the ultrasonic non-destructive testing community. The use of phased array instrumentation, formerly confined to an elite group of highly trained technicians and research facilities, has developed into a more mainstream inspection modality. This expansion can be attributed to many factors, including reduction in instrument/system costs, increased instrument portability, enhanced user interfaces, new training and education opportunities, and growing technology acceptance from governing inspection bodies and codes.

As phased array inspection techniques become more desirable, the ultrasonic NDT community has developed a requirement for instrumentation that allows competent conventional ultrasonic technicians to access the benefits of basic phased array imaging while maintaining a solid foundation in conventional techniques. The Olympus NDT EPOCH 1000*i* (Figure 1), introduced in December 2008, combines the highest performance in conventional, single channel flaw detection with these phased array imaging benefits in an intuitive and robust package, providing the solution to the needs of this developing market. This paper will highlight the requirements for such an instrument and provide key examples of the benefits of this level of instrumentation in the current NDT inspection environment.

Figure 1: The EPOCH 1000*i*

CONVENTIONAL MARKET

The core requirements of the conventional flaw detector market have remained largely static over several decades. While digital instrumentation has provided faster calibration methods, precise measurement capabilities, and more efficient implementations of sizing techniques such as Distance Amplitude Correction (DAC), Time Corrected Gain (TCG), Distance Gain Sizing (DGS), etc, the characterization of flaws remains largely rooted in the interpretation of A-scan signals. Indeed, the most significant advancements in portable flaw detectors in the last decade relate directly to increased fidelity of signal representation to promote higher confidence in A-scan interpretation. These enhancements are bolstered by increased pulser and receiver performance, allowing consistency of signal reproduction across a broader scope of applications.

The EPOCH 1000*i* flaw detector supports this fundamental instrument development trend, providing the highest quality pulser and receiver performance available in its form factor. Utilizing fully digital architecture, the EPOCH 1000*i* provides class leading technology addressing the core requirements of A-scan flaw detection:

- High dynamic range receiver with unprecedented signal stability
- Single shot pulser architecture allowing up to 6000 Hertz pulse repetition frequency
- Digitally controlled square wave pulser for efficient and powerful transducer performance
- Digital filtering capabilities incorporating latest signal processing technologies for exceptional and consistent noise reduction

These features combine to enhance the reproduction of the A-scan signal, which allows for confident interpretation of flaw reflections. This signal is reproduced on a full VGA display with minimal user interface obstructions, which dedicates the majority of the display area to the A-scan (see Figure 2).

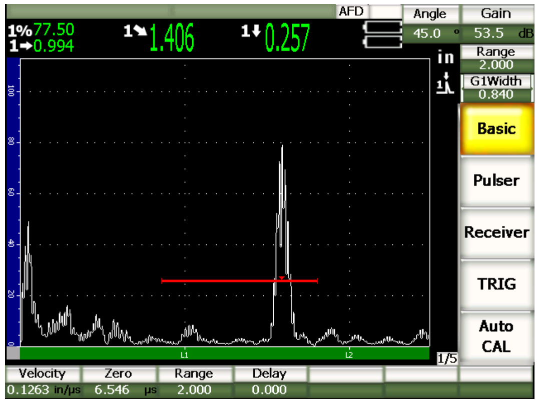

Figure 2: EPOCH 1000*i* A-scan screen shot

The design focus on conventional performance makes the EPOCH 1000*i* useful for the majority of flaw detector technicians working in the industry today, regardless of training or experience with phased arrays. The instrument user interface design focuses on intuitive use of these fundamental features and allows technicians with conventional experience to integrate the instrument immediately into existing inspection procedures.

Although phased arrays have gained increasing acceptance in many core flaw detection applications, three main factors continue to inhibit the mainstream use of portable phased array instruments:

- Insufficient operator training
- Complications integrating phased array techniques into conventional codes
- Price

As the demand for NDT inspections to provide imaging data continues to increase and phased arrays gain further acceptance, the inspection industry requires the ability to overcome the three obstacles above. The EPOCH 1000*i* confronts these three issues directly, while maintaining the high level of performance required to perform standard conventional inspections.

CONVENTIONAL METHODS

A primary obstacle to overcome in the continued development of phased array instrumentation is the need for advanced operational training. In the last few years, this obstacle has been mitigated in part by a surge in training facilities and programs aimed at increasing the knowledge of technicians in the inspection community. These training courses are typically based on the operation of sophisticated equipment that provides both flaw detection and flaw sizing techniques based on interpretation of phased array images and, in many cases, encoded phased array scanning techniques.

While the rapid growth of training options has many obvious benefits to the NDT community, it illustrates the complexity of integrating phased array instrumentation into current inspections. For technicians that cannot invest in the time and cost of additional training, phased arrays have been less accessible as a practical inspection technology.

The EPOCH 1000*i* addresses this industry dilemma by implementing phased array imaging with the expectation that the technician still uses the A-scan presentation for flaw sizing and characterization. With this philosophy in mind, the EPOCH 1000*i* has been designed to produce a high fidelity A-scan from each focal law used to generate the phased array image, using technology that supports the performance of the conventional flaw detection mode of the instrument.

A typical inspection using the EPOCH 1000*i* utilizes its phased array technology for its primary benefit: increased probability of detection. The instrument allows technicians to more easily and confidently detect flaws across multiple angles in a single sectorial scan (S-scan) view (see Figure 3).

Figure 3: EPOCH 1000*i* S-scan

Once an indication is detected using phased array imaging, it is simple to select a single inspection angle, representing a A-scan which allows visibility to the potential defect, and switch to a full A-scan view, similar to the conventional mode of the instrument (see Figure 4). The technician is then able to use standard, conventional sizing techniques to characterize the flaw.

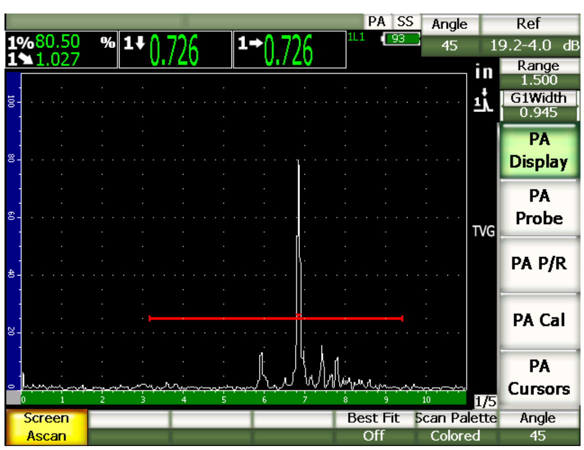

Figure 4: EPOCH 1000*i* full A-scan view

This inspection philosophy allows conventional ultrasonic technicians to quickly reap the benefits of phased array imaging while relying on well established sizing and characterization techniques. The training requirement for this methodology is considerably lower than for more advanced phased array instruments. Of course, this methodology also excludes the capabilities to use encoded, passive scanning, post-analysis and other powerful phased array techniques. But for many, the ability to quickly integrate an imaging instrument into an operator's established skill set without the need for significant training investments is a highly desirable benefit of the EPOCH 1000*i* instrument.

CODE COMPLIANCE

The issue of code compliance is an important one in the ultrasonic inspection industry, especially relating to the introduction of phased arrays. The integration of phased array techniques into such common code structures as ASME (American Society of Mechanical Engineers), ASTM (American Society for Testing and Materials), API (American Petroleum Institute) and AWS (American Welding Society) is well documented. Several code cases, including ASME 2541, ASME 2557, and ASTM E-2491-04 are well established in the industry for qualifying and using phased array techniques in common flaw detection applications.

Code acceptance of phased array techniques is still a concern that prevents many ultrasonic technicians from utilizing this technology in even the most well established applications, including weld inspection and crack detection and sizing, etc. While some inspectors can justify using code cases and performance demonstrations to implement full phased array inspection techniques, a requirement exists for a simpler method of utilizing phased array benefits without deviating from well established codes and procedures that deal only with conventional techniques.

The inspection philosophy detailed in the previous section of this paper and using the EPOCH 1000*i* provides a solution to this industry requirement. It can be seen that most established conventional codes dictate certain requirements for an ultrasonic flaw detector and transducer(s) to provide proper inspection coverage. Typically, the prescribed criteria include:

- Transducer frequency
- Transducer diameter
- Angle(s) of inspection (commonly 0°, 45°, 60° and/or 70°)
- Linearity verification of instrument
- Calibration for accurate distance measurements
- Method of defect sizing (6dB drop, DAC, DGS, etc)

Most widely recognized inspection codes are somewhat generic, allowing for multiple instrument and/or transducer manufacturers to comply with the requirement inspection techniques. Codes are simply designed to ensure proper detection and sizing of potential defects within required regions of a test piece by standard inspection methods.

It is relatively easy to comply with matching transducer frequency and dimensions when attempting code compliance while utilizing phased arrays. And by nature of phased array sectorial scans, all required angles of inspection are readily available with the proper transducer/wedge combination and calibration.

Calibration for accurate distance measurements can also be demonstrated using most commercially available phased array instrumentation. The calibration procedure varies from instrument to instrument, and it is important to recognize that a single phased array calibration must account for multiple angles of inspection. For instance, wedge delay will vary depending on the inspection angle. Most phased array instrument can calibrate for all wedge delay values to provide accurate measurements at any angle, but this factor must be considered before assuming proper measurements are possible.

Finally, the defect sizing method requirement often provides the greatest obstacle for phased array instrumentation to comply with established conventional codes. These conventional methods correspond to interpretation of a single A-scan at a fixed angle. Therefore, image sizing techniques using multiple angles of information do not apply, and would require code case acceptance or performance demonstration.

The EPOCH 1000*i* is capable of addressing each of these requirements, and therefore can be considered code compliant without the need for special case consideration. The instrument is designed to calibrate for proper measurements across every active angle using a simple calibration tool (see Figure 5). The accuracy of this calibration can be demonstrated to be equivalent to conventional instrument accuracy.

Figure 5: Wedge delay calibration tool

Additionally, the EPOCH 1000*i* is able to provide accurate defect sizing using single A-scan interpretation techniques, as described in the previous section of this paper. This is the key to allowing easy integration of the EPOCH 1000*i* phased array mode into well established code procedures. By continuing to use conventional techniques to size and characterize defects, the EPOCH 1000*i* is fully compliant with the requirements of conventional codes.

CONCLUSIONS

The ultrasonic inspection industry has matured to understand the benefits of phased arrays, but has a clear requirement to realize a subset of these benefits without significant training, performance demonstration and cost impacts. The EPOCH 1000*i* realizes this requirement by providing a high performance conventional flaw detector and a basic phased array imaging instrument in a single, intuitive package. This instrument supports the requirements of the industry by:

- Providing enhanced probability of detection through phased array imaging
- Maintaining conventional flaw sizing techniques via single A-scan view interpretation in imaging mode
- Allowing full code compliance with well established conventional codes
- Providing an intuitive user interface designed for conventional flaw detector users
- Allowing benefits of phased arrays without a significant training requirement for conventional operators
- Providing phased array imaging without compromise to conventional performance

REFERENCES

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3. AWS D1:1 2006, “Structural Welding Code – Steel”, American Welding Society, 2006.