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Getting Phased Array Approvals and Certifications

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Abstract

This paper describes the processes required to approve new inspection techniques for ASME Section V and other codes, specifically Olympus NDT's OmniScan unit, and for developing phased array certification. The rationale and processes required for Section V, both Article 4 and the new Article 14 for novel techniques, are described. The various processes can be applied to encoded electronic scanning (i.e. fixed angle raster scanning); encoded sectorial scans (S-scans) where the beam is swept through a range of angles, and manual S-scans.

A variety of techniques, procedures and reporting documents have been developed. The processes required for developing a certification program are based on experiences in North America, with the Canadian General Standards Board, the American Society of NonDestructive Testing, and external certifications. More recently, Performance Demonstration Qualifications have come to the fore in North America.

Keywords: Phased arrays, approvals, certifications, ASME Code

1. Introduction

Phased arrays offer major advantages over conventional radiographic inspection of welds: no radiation hazard, chemical disposal or licensing requirements; no disruption of production; near real-time inspection results, plus vertical defect sizing for Engineering Critical Assessment. In comparison with conventional ultrasonics, phased arrays are significantly faster, more flexible, reproducible, and can be tailored to the application. Overall, there is a strong interest in phased arrays, especially now that units are competitively priced, software is robust and inspections are often cost-effective [1].

However, the codes and approvals are not as advanced as the technology, as expected. In general, the various codes accept phased arrays as a valid technology, but say little on the technique or procedures. This paper describes a typical process required to approve new inspection techniques for ASME Section V, specifically Olympus NDT's OmniScan unit, plus some of the processes with other codes.

NDT is described in ASME B&PV Code Section V [2]. The rationale and processes required for Section V, both Article 4 and the new Article 14 for novel techniques, are described. When a part or component is not typical and/or if a new technology is introduced, some of the ASME Code Sections additionally require that the process be "qualified". Examples of where the qualification process has been a requirement include ASME Section VIII Code Case 2235-6 [3] and ASME Section XI [4].

1.1 Qualification

Qualification is a process whereby evaluation of technical, general and performance-based evidence is presented to verify that the examination technique, equipment and written procedure conform to the requirements of the Code, Standard or Specification. In the 2003 revision of Section V, Article 14 was added. This is entitled "Examination System Qualification" and provides ASME users a guideline on the methods and rigor involved in qualification.

1.2 Certification

In North America, certification refers to approval of the operator. In other jurisdictions, the certification process requires the operator to pass a defined exam with an industry organization; this applies to EN, ISO, PCN and CSWIP for example. Phased array courses for these qualifications require a blind exam at the end – to prove operator capability. However, ASNT in North America doesn't have a specific phased array course yet, nor any exam at the end. The manufacturers and training companies run phased array training courses, but it is possible to attend these and finish without any real knowledge of phased arrays. End-users in North America are becoming acutely aware of this deficiency.

The solution currently being investigated is "Performance Demonstration Qualification", and a few of these have been organized in North America at the date of writing. Performance Demonstrations can be organized into many different categories, for example: manual vs. encoded; carbon vs. stainless steels; nozzles vs. plates; small vs. large diameter pipes. In general, it is considered not a good plan to have too many categories since people will end up qualified only for very limited applications.

These Performance Demonstrations should be run blind, and this requires good security and control. The samples need to be made up according to established principles, i.e. a certain number of reflectors of specific size range, a variety of defects, and also an approved distribution thereof. Fortunately, other organizations such as ASME and API have specified the requirements for test blocks.

Hopefully, countries not using ASNT will not have to undergo this additional expense and inconvenience of requiring Performance Demonstrations. However, if training courses and certifications prove inadequate, the main option is Performance Demonstrations.

2. A Review of Examination Requirements

Early in 2004 R/D Tech (now Olympus NDT) asked Materials Research Institute and Eclipse Scientific Products to assess the suitability of using a portable phased array instrument, OmniScan (Olympus NDT, 2004), on weld inspections. The biggest concern was how users could rationalize deviation from the “tried-and-true” techniques prescribed by the various codes.

After a code review it was concluded that, in North America, ASME Section V was the most extensively used NDT regulatory document. A program was developed to demonstrate examination techniques using the portable ultrasonic phased array apparatus. A set of Standard Practices and Techniques (i.e. a full working Procedure) was developed that, when used, demonstrated conformance to the requirements of the ASME Code.

2.1 ASME Code Specifications

ASME Section V Article 1 T-150 explains how Procedures may be developed that deviate from those described in Section V for special configurations or materials. It also states that these special configurations may require modified techniques that are proved by demonstration to be equivalent or superior to those described in Section V.

Since the procedures developed for OmniScan were considered a “special configuration” as allowed for in T-150, it was then up to the “Code User” to specify what calibrations are required and when. Special consideration for the fact that the instrument is based on phased array technology has resulted in deviations from standard practices that might be used with single element pulse-echo probes and instrumentation. These are considered to be in accordance with the instructions of ASME V Article 1 T-160.

2.2 Equipment Approval and Calibration

ASME Section V Article 4 T-421.2 specifically states that Computer Imaging Techniques (CITs) may be used. Phased array systems are specifically included. (Similar phrases apply in API and AWS, and probably many other codes.) Essentially, the equipment is “approved”; however, the techniques and procedures are not inherently approved, and the operator is not necessarily certified.

Sensitivity settings for the “traditional” manual UT are based on responses set to a Distance Amplitude Correction curve using side drilled holes (or ID and OD notches) in the ASME “Basic Reference Block”. ASME Section V Article 4 Table T-422 identifies the “Requirements” of an ultrasonic procedure and identifies which are considered essential variables and which are considered nonessential variables. These are reproduced here in Table 1; in practice, most variables are considered “essential”.

Table 1 List of Essential and Nonessential Variables

Requirement	Essential variable	Nonessential variable
Weld configuration (thickness, product form)	X	
Personnel qualification requirements		X
Personnel performance when required	X	

Surface of examination	X	
Surface condition		X
Couplant brand		X
Technique (straight, angle, immersion, contact)	X	
Angles and wave modes in the test piece	X	
Probe type, frequency, size, shape	X	
Special wedges, adaptors, etc	X	
Ultrasonic instruments	X	
Calibration blocks and techniques	X	
Directions and extent of scanning	X	
Automatic alarm or recording when used		X
Scanning (manual vs. automatic)	X	
Method for discriminating flaw and geometry	X	
Method for sizing flaws	X	
Computer enhance acquisition when used	X	
Records (including minimum calibration data recorded)		X
Scan overlap (decrease only)	X	

The procedure developed for OmniScan identified all the items in the table above and described the extent to which they are applicable. Variables pertinent to ensure that all phased array software controls that could affect the amplitude response or data acquired (e.g. time base range, gated region, sampling, etc.) were identified on the technique information sheets developed for each configuration.

3. The Qualification Process

The "Qualification" for techniques and procedures was made using unique capabilities of phased array ultrasonic technology, specifically encoded E-scans. The qualification involved detection, length sizing, depth and location measurements of embedded flaws of known sizes. Expectations were defined as detection over the reference level of all relevant imbedded flaws. These were then compared against the responses seen using the manual techniques described in ASME Section V. A limited range of test piece thicknesses and geometries was used to establish the performance demonstration protocol (see Table 2).

Table 2: Thicknesses and Geometries used for Qualification

Thickness	**Form**
13mm	Plate
13mm	Pipe 4.5 inch diameter
18mm	Pipe 12 inch Diameter
25mm	Plate

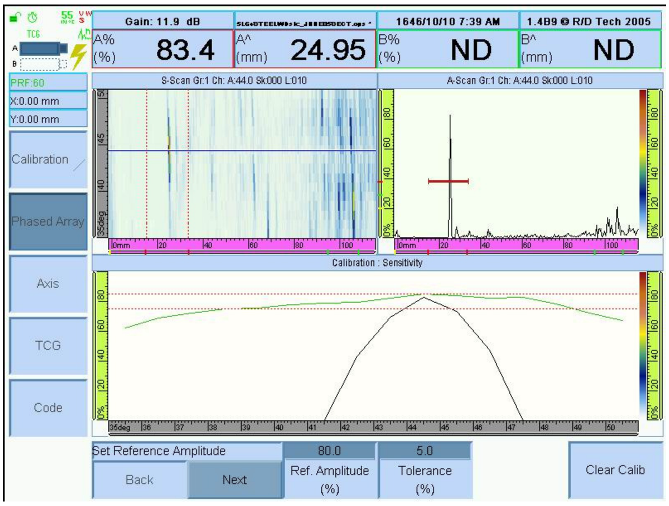
The inspection was performed using linear scanning (or one-line scanning) with an E-scan (electronic scan) running parallel to the weld. This is a standard inspection technique, and will be covered by an upcoming ASME code case and Mandatory Appendix (see below). Data were recorded using standard ASME procedures.

4. Weld Inspection with Phased Array UT

Part of the deviations from "normal" practice using single element techniques is the requirement to calibrate the phased array system for delay and attenuation differences due to different path lengths in the wedge that the various focal laws require. Figure 1 illustrates an example of the special screen feature used to ensure that the amplitude response from each focal law provides a uniform amplitude response to the calibration reflector. The operator calibrates by moving the probe back and forth; using a feature called Auto-TCG, the portable phased array unit automatically adjusts gain to the prescribed amplitude (80% is indicated on Figure 1).

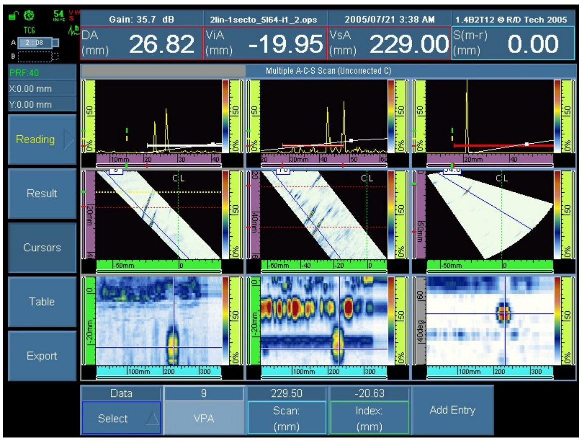
This process is called ACG (Angle Corrected Gain). The horizontal scale is the virtual probe aperture which defines the group of elements ("focal law") that is sequenced in the scan. These may be linear steps or angles, depending on whether E-scans or S-scans are being calibrated. Once the amplitude response is seen to be the same for all the virtual probe apertures, the operator enters the calibration as part of the configuration. The Auto-TCG process can be repeated on reflectors at different depths to give a combined TCG and ACG calibration. This calibration process inherently works best of Side Drilled Hole reflectors. Thus every point within the calibration range at every angle and position is calibrated.

Figure 1: Sample pane in calibration sequence of phased array system



For the thicknesses examined, a single encoded linear scan was required. The operator has the option to display several views simultaneously and in real time (see Figure 2).

Figure 2 Real time Data Display showing multiple scans simultaneously.



5. Qualification Results

The critical aspect of qualification is detection of all pertinent flaws; phased array E-scans did that. The qualification process used in this program specified that all flaws detected would need to exceed the reference level in order to qualify the technique. Various ASME acceptance criteria exist and not all use signals exceeding the reference level to assess acceptability.

In addition to simply detecting flaws over a threshold, several of the ASME Code Sections require flaw height assessment. The Procedure demonstrated used a tip diffraction sizing for flaw height assessment [5]. This is just one option that may be used; another standard solution is TOFD (Time-Of-Flight Diffraction).

6. Other Code Activities

6.1 ASME

Code Cases 2541, 2557 and 2558 for manual rastered phased arrays to cover single angle scanning have been published in ASME Section V. Two more code cases are being prepared to cover linear encoded E-scans, and encoded S-scans.

E-scanning is essentially the same ultrasonically as current automated scanning using conventional equipment. S-scans are less known, and there are issues such as number of passes, bevel incidence angle etc. These are being addressed separately. A comprehensive Mandatory Appendix for encoded phased arrays is in progress.

6.2 American Society for Testing and Materials

ASTM E-2491-06, a standard guide for phased array set-up, has been published [6]. This SG requires full angular gain compensation (ACG) and TCG over the side-drilled hole calibration range for S-scans. If full ACG and TCG are not possible, then the angular range must be reduced. This SG fulfils the spirit of ASME calibration, where all waveforms should be calibrated.

6.3 American Petroleum Institute

API can use QUTE UT 1 and UT 2 procedures for new technology/techniques. Manual API inspections are common now.

6.4 American Welding Society

The 2006 version of AWS D1.1 has codified new technology/techniques, but still requires the Engineer's approval – which is a limitation. An Annex for encoded scanning in AWS is in progress, but is likely to be some years from completion.

6.5 Canadian General Standards Board

The CGSB has introduced a one week AUT course and qualification for combined TOFD, AUT and phased array. Not surprisingly, this is a demanding course and exam, which implies that anybody passing it must know a lot about these techniques beforehand.

7. Conclusions

(1) The dominant code for weld inspections in North America is ASME, which conveniently offers several routes for qualification of advanced techniques and procedures.

(2) As with many other codes, ASME accepts phased arrays in principle, though the techniques and procedures require approval.

(3) ASME Article 14 was used to approve the procedures by comparing the results with established techniques. Not surprisingly, the portable phased array unit passed the test.

(4) Certification – in North America – is primarily for operators as no industry-approved examination is available. In other jurisdictions, exams are part of the approval process.

(5) There are standard approaches for Certification, based on established codes like ASME and API.

Acknowledgements

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