ASME CODES AND STANDARDS FOR BOILER INSPECTIONS

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ABSTRACT
ASME (the American Society for Mechanical Engineers) recently published a full series of Mandatory AUT (Automated Ultrasonic Testing) and Phased Array (PA) Appendices to Section V (NDE). These now cover most aspects of advanced ultrasonic inspection (adding in TOFD), and are specifically aimed at boiler and piping inspections. The three new AUT Appendices essentially replace the old Code Case 2235, but are significantly easier to read and understand; however, they do not include acceptance criteria as these will be developed in other ASME reference Sections. The two new PA Appendices are re-packaged versions of the initial five Code Cases, and cover the same technical ground. This presentation will briefly describe the five new Mandatory Appendices, and their implications. While ASME was (originally) for the USA, it is now a globally used Code, and Section V is often referenced for in-service inspections as well. As such, ASME Boiler and Pressure Vessel Code is significantly more important than just for construction welding.

Keywords: American Society of Mechanical Engineers, Automated Ultrasonic Testing, Phased arrays, Time-of-Flight Diffraction, Boiler and piping inspections, Mandatory Appendices.

INTRODUCTION
ASME as an organization recently celebrated their 125th anniversary. ASME was founded after too many boilers burst in the USA, so something needed to be done to minimize the death and destruction of people and factories. ASME came up with the well-known ASME Boiler & Pressure Vessel Code (1), which has become globally accepted. This code covers all aspects of pressure vessel manufacture, including design, welding, and inspection. The Code itself is divided into 12 Sections, with NonDestructive Examination (NDE) labelled Section V (2). Typically, the NDE portion does not write acceptance criteria for defects; that is the domain of other (referencing) sections, which tend to be more structures-based.

ASME NDE HISTORY
The ASME NDE Section has developed quite rapidly over the years, mirroring the rise of NDE. It is now quite substantial in volume, with a progressive outlook. Specifically, in ultrasonics, the ASME Section V Working Group decided that it was time to introduce new techniques, specifically AUT, phased arrays and Time-Of-Flight Diffraction into the Code. As such, they started back in the early 2000’s to write up a TOFD Code (3), along with a TOFD Interpretation Manual (4) and TOFD guidelines (5). Subsequently, ASME started working on phased array Code Cases (eventually published five), and modifying Code Case 2235 for AUT (6). Code Case 2235 was not published by Section V, but by other Referencing Sections, so it included accept-reject criteria.

THE ASME TOFD CODE
ASME was somewhat late in producing a TOFD code, as these were prepared in Europe first (see ref 7 for example). However, there are some differences between the ASME Code and European one’s. For example, ASME’s primary reference block is the standard ASME Calibration block with side-drilled holes. In contrast, the European codes typically allow one to calibrate on all kinds of different reflectors: lateral wave, standard reference notches, grass level reflections, even a “known” crack.

The other major difference is ASME’s requirement to use ultrasonics to inspect the root and cap areas – traditionally un-inspectable using TOFD due to the presence of dead zones. Note that this is a reasonable requirement for new construction welds (which ASME is primarily targeting in Section V).

ASME PHASED ARRAY CODES
In the 2003-4, phased arrays were essentially “new” to ASME – just as they were to the other active code bodies. ASME was quite active in preparing codes, and recommended Code Cases as an intermediate step. ASME started with the simplest application – manual phased arrays with a single beam (8). This was subsequently followed by two other manual phased array codes, S-scans and E-scans (9, 10). However, encoded scanning (linear scanning) proved more challenging.

While it was obvious that phased arrays could cover welds (both well and quickly), it was not so obvious how to do it.
After considerable work and effort, it was determined that modeling with some experimental backup was the best route (11). Figure 1 shows an example of modeling S-scans on a weld. Basically, if one wants to hit a simple V-weld at ± ten degrees bevel incidence angle, one needs to use at least two separate S-scan angles, but the results are scalable. For five degree tolerance, three S-scans would be needed.

The last two phased array code cases were published for encoded S-scans and E-scans (12, 13). These five Code Cases were later amalgamated into two Mandatory Appendices (14, 15). Other factors, such as scanning speed, weld coverage, step size, were all either already covered in Section V Article 4, or were fairly “common sense”.

**CODE CASE 2235**

This AUT Code Case was a major step forward by ASME when it was first published in 1996 as it used Fracture Mechanics accept-reject criteria. As such, defect allowance was significantly more tolerant than traditional workmanship criteria. However, the Case itself was re-written a few times, and was not written by NDE personnel. It came from ASME Sections I and VIII. As such, a re-write was definitely needed – as well as putting the Code Case into the Code itself. In particular, the phraseology of the Code Case left something to be desired.

ASME finally published all three AUT Codes (16-18) and two phased array codes in July 2010, so we are now “legal”. There will still be fine-tuning, but the essence of the codes is there. These three Mandatory Appendices are similar to the original CC 2235, but are much clearer. Specifically, they are written in English, so hopefully there will be fewer questions on them. One Mandatory Appendix is for workmanship criteria, one for Fracture Mechanics (or Engineering Critical Assessment), and one for procedure qualification. Essentially, the procedure qualification Appendix requires a non-blind test for operators,

Fig. 1 : Top, 5 degree tolerance; requires three S-scans per side. Middle: 10 degree tolerance; requires two S-scans per side. Bottom: 10 degree tolerance; scalable.
while for new construction, EDM notches or similar can be used. Overall, the new Mandatory Appendices (particularly Appendix VIII) are similar to Code Case 2235.

SO WHAT DO PUBLISHED PHASED ARRAY MANDATORY APPENDICES REQUIRE?

With phased arrays, much is common sense. However, there are a few details that should be highlighted:

*Calibrate all waveforms:* This is independent of angle or path length, and is mandatory. For OmniScan, this is not a major problem as Olympus has set up the Auto-TCG function for calibrating. Figure 2 shows an example of the calibration approach, and Figure 3 some typical results.

*Scan Plans:* For encoded scanning a Scan Plan is both essential and mandatory. While a scan plan can be drawn on the back of an envelope, it is a lot quicker and easier to use a computer program, as shown in Figure 4. These are practical and easy to use – and economical.

*Scanning speed, step size etc:* These rules are basically common sense. If you scan too fast, there will be data drop-outs, and ASME has defined what is tolerable – accepting that there are also commercial factors in play. Step size is fairly logical too; the thicker components require less coverage, due to beam spread amongst other factors.

GLOBAL IMPLICATIONS

The ASME Code is now a global reference, with all kinds of makers from all kinds of countries using it. In addition to manufacturers, the ASME Code is referenced by in-service inspection companies (which tend to have much looser inspection criteria). This is primarily for calibration and set-up, which is all-important. Thus, while ASME is nominally for new construction in the USA, in practice it is distinctly global, and also applies to in-service inspections.

CONCLUSIONS

1. The ASME Code has adapted to new NDE techniques, primarily TOFD, phased array and AUT.
2. These Codes have been published and are ready for use. The ASME TOFD Code is behind the Europeans and ISO, while the ASME phased array codes are significantly ahead.
3. Specifically, the new phased array Codes require full waveform calibration, a scan plan and controlled scanning.

REFERENCES

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16. Mandatory Appendix VI, \emph{idem}, “Ultrasonic Examination Requirements for Workmanship Based Acceptance Criteria”, July 2010
17. Mandatory Appendix VII, \emph{idem}, “Ultrasonic Examination Requirements for Fracture Mechanics Based Acceptance Criteria”, July 2010
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