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PCN CERTIFICATION OF PERSONNEL ENGAGED IN ULTRASONIC TESTING USING PHASED ARRAY TRANSDUCERS

ASSOCIATED DOCUMENTS:

Appendix Z1 to PCN/GEN (examination syllabus compendium)

Appendix Z2 to PCN/GEN (specimen examination questions compendium)

PSL/68 Acceptable certification for eligibility

CONTENTS:

SPECIFIC REQUIREMENTS AND ELIGIBILITY FOR THE CERTIFICATION OF PERSONNEL ENGAGED IN ULTRASONIC TESTING USING PHASED ARRAY TRANSDUCERS

1. SCOPE

This document prescribes the generic requirements and procedures by which personnel may be examined and, if successful, certified competent for Ultrasonic Testing using Phased Array transducers.

This certification is generic and does not apply to any specific proprietary equipment. Employers must satisfy themselves that individuals are sufficiently competent at using specific equipment types and versions of software in the appropriate product sector.

Each candidate is encouraged to bring his own equipment including probes, but examination centre equipment may be hired subject to availability. Additional familiarisation time will be allowed prior to the practical examination part for candidates hiring examination centre equipment.

Requirements contained in this document are supplementary to those contained in the current edition of the PCN General Requirements for Qualification and PCN Certification of NDT Personnel.

2. ELIGIBILITY

2.1 Certification.

Eligibility for PCN Certification covering Ultrasonic Testing using Phased Array (UTPA) transducers is conditional upon the possession of relevant certification as described below:

- Level 1 UTPA (welds) data collection: candidates will hold Level 1 or Level 2 certification for manual UT of welds issued by a certification body recognised by BINDT (see PSL/68).
- Level 2 UTPA (multi sector): candidates will hold valid certificates issued for any industry sector (aerospace, railway or In-Service Inspection) by a certification body recognised by BINDT (see PSL/68).
- Level 2 UTPA (single sector): candidates will hold a valid UT certificate issued for the sector(s) in which certification is sought by a certification body recognised by BINDT (see PSL/68).
- Level 2 UTPA interpreter: candidates will hold a Level 2 UT certificate issued for any product or industry sector (aerospace, railway, castings, welds or wrought products) covering the scope of UTPA interpretation certification sought by a certification body recognised BINDT (see PSL/68).
- Level 3 UTPA (multi sector): candidates will hold current valid Level 3 certification in Ultrasonic Testing issued by a certification body recognised by BINDT. Level 3 candidates who do not hold PCN Level 2 UTPA (multi sector) will be required to successfully complete the examination described in Clause 3.2.1.
- Level 3 UTPA (single sector): candidates will hold current valid Level 3 certification in Ultrasonic Testing issued by a certification body recognised by BINDT. Level 3 candidates who do not hold PCN Level 2 UTPA (single sector) will be required to successfully complete the examination described in Clause 3.2.1.
- Where a candidate has recently successfully passed a PCN UT examination relevant to the level and sector for which they wish to attempt but has not yet received the PCN certificate. A copy of the relevant PCN Results Notice that states the candidate has successfully passed the UT exam (in the relevant sector in which certification is sought) and is eligible for certification may also be accepted by the AQB.

2.2 Training

Candidates will be required to demonstrate that they meet the following minimum supplementary Training requirements before they will be allowed to take PCN examinations covering the use of ultrasonic phased array transducers.

Table 1 - Minimum Training Duration	
Level 1	Level 2 and 3
40 Hours covering the syllabus at Appendix E9.2	80 Hours covering the syllabus at Appendix E9.2

Training hours to be attained at a BINDT Accredited Training Centre, or a centre recognised by BINDT, for Ultrasonic Testing using Phased Array Transducers.

NOTE: A maximum of 40 hours previously obtained verifiable training in the use of phased array transducers (at non-accredited training establishments) by experienced candidates may be credited against the 80 hours in Table 1.

NOTE: Level 2 UTPA interpreter candidates will be required to complete an 80 Hour Level 2 UTPA training programme.

2.3 Experience

Industrial NDT experience may be acquired either prior to or following success in the qualification examination. In the event that experience is sought following successful examination, the results of the shall remain valid for up to two years from the date of examination.

Documentary evidence (in a form acceptable to the British Institute of NDT, e.g., using PCN form PSL/30) of experience satisfying the requirements detailed in Table 2 shall be confirmed by the employer and submitted to the British Institute of NDT prior to the award of PCN certification.

Table 2 – Minimum Experience Requirements		
Level 1	Level 2	Level 3
1 Month verifiable experience collecting and storing data using phased array systems	3 Months verifiable UT experience using phased array systems	Satisfy the experience requirements of PCN/GEN for UT, including 6 months verifiable experience using UT phased array systems

3. EXAMINATION CONTENT

3.1 Level 1 (welds) UTPA data collection

3.1.1 The examination will comprise the following:

a) Sector Specific Theory of the application of the Ultrasonic Phased Array technique to the testing of welds including basic production processes and associated defects.

b) Sector Specific Practical examination comprising:

i. Assembly and calibration of PA data acquisition equipment; see [1] Note

ii. Collect UTPA data from two linear butt welds in accordance with written instructions provided; and

iii. Evaluate data to determine its suitability for interpretation, commenting upon acceptability and whether further scans are required.

[1] **Note***: This part of the examination will involve the setting up of the equipment followed by a calibration exercise to check test system performance. At the discretion of the examiner, this part may include oral questions. Candidates will then be required to demonstrate that they are familiar with the data display, computer and data handling and storage methods used by the PA system in use. If this part of the examination is satisfactory the candidate may proceed to the remainder. If not, they may repeat the exercise once. If it is still unsatisfactory, the examination will be discontinued.*

The total time allowed for the practical examination is 6 hours, and the pass mark is 70% for each data evaluation.

3.2 Level 2

3.2.1 Except where exemptions apply (refer to PCN General Requirements), all candidates will be required to attempt an examination comprising relevant parts from the following:

a) Sector Specific Theory (applicable to interpreters and operators) of the application of the Ultrasonic Phased Array technique in the applicable sector(s):

i. Thirty multiple-choice questions covering specific applications of UTPA.

b) Specific Practical examination (operators only) comprising, for examination candidates in UTPA Castings, Wrought Products, or Welds

i. Assembly and calibration of UTPA data acquisition equipment. Time allowed: 1 hour

NOTE. This part of the examination will involve the setting up of the equipment followed by a calibration exercise to check test system performance. At the discretion of the examiner, this part may include oral questions. Candidates will then be required to demonstrate that they are familiar with the data display, computer and data handling and storage methods within the Phased Array system in use. If this part of the examination is satisfactory the candidate may proceed to the remainder. If not, he may repeat the exercise once. If it is still unsatisfactory, the examination will be discontinued.

ii. Production of suitable set up files and scan plans, carrying out tests, collecting and storing test data for three samples selected by the examiner and relevant to the scope of UTPA certification sought. Time allowed: 2 hours per specimen (6 hours total); pass mark: 70% per specimen tested.

NOTE The testing of specimens will demonstrate, beam steering, focusing, electronic mastering and detection of discontinuities. NDT instructions, including information and basic test parameters, will be provided to all candidates

iii. Prepare a detailed NDT instruction suitable for Level 1 certificate holders to follow for testing of one linear butt weld sample to a provided code, standard or specification and to prove the instruction by testing. Time allowed: 2 hours.

iv. For all candidates (interpreters and operators)

c) All candidates will examine and analyse stored data using suitable software, interpreting and reporting on the three recorded scan data files acquired during the above, displaying the results in the required format, and showing the location and size of discontinuities present in the sample(s) tested. The report shall contain information on characterization, size and position of discontinuities in relation to a known datum. Time allowed: 2 hours for analysis and reporting on each data file (6 hours total)

Note: Level 3 candidates who do not hold PCN level 2 certification for Phased array testing will be required to successfully complete the examination described in Clause 3.2.1b (excepting sub-clause (iii))

3.2.2 The minimum pass mark is 70% per sample tested.

3.3 Level 3

3.3.1 Except where exemptions apply (refer to PCN General Requirements), all candidates will be required to attempt a Main Method examination comprising the following parts.

a) 20 multiple choice questions covering the Specific Theory of the application of the Ultrasonic NDT method using Phased Array transducers. (40 minutes).

b) The candidate will be required to produce a comprehensive Ultrasonic Phased Array test procedure embodying an NDT Instruction for a specific configuration to a provided specification, standard or code. (4 hours)

4. GRADING

General information on the grading of examinations will be as specified in the current edition of PCN General Requirements, and information on the grading of practical examinations is provided in PCN document CP22.

5. CERTIFICATION AVAILABLE

5.1 Level 1 UTPA Data Collection (welds only).

5.2 Level 2 UTPA (includes Interpretation) of general engineering materials, components and fabrications in the pre and in-service inspection multi-sector.

Alternatively Level 2 candidates may apply for single sector certification covering one **(only)** of the following groups:

5.2.1 Castings

5.2.2 Welds

5.2.3 Wrought Products

5.3 Interpretation of UTPA data covering **one** of the following: Multi Sector or single sector for Castings, Welds **or** Wrought Products

5.4 Level 3 UTPA of general engineering materials, components and fabrications in the pre and in-service inspection multi-sector.

Alternatively Level 3 candidates may apply for single sector certification covering one **(only)** of the following groups:

5.4.1 Castings

5.4.2 Welds

5.4.3 Wrought Products

Candidates who achieve an overall score of 80% or more for Level 1, 2 and 3 examinations shall be awarded with the distinction level 'D' (refer to PCN GEN – Grading of Examinations).

6. RENEWAL AND RECERTIFICATION

6.1 The general rules for Level 2 renewal and recertification are fully described in PCN document CP16, and the rules for Level 3 renewal and recertification are introduced in PCN/GEN and in PCN document CP17.

6.2 Level 1 and Level 2 certificate holders seeking recertification will be required to undertake the practical examination described above for their level.

7. SUPPLEMENTARY EXAMINATIONS

7.1 Candidates holding certification in one product sector who wish to add another single sector will be required to pass a further practical examination comprising the testing of 3 samples selected by the examiner as representative of the single sector sought.

Candidates should note that this will result in 2 separate certificates being held and will need to be maintained separately.

7.2 Candidates holding certification in one product sector who apply for certification in the multi-sector (all product sectors) will be required to pass a further practical examination comprising the testing of three samples selected by the examiner as representative of the additional sectors sought (see Clause 5.2 above). Level two candidates attempting supplementary examination will not be required to produce a written instruction (Clause 3.2.1 (b)).

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PCN/GEN Appendix E9.2

SYLLABUS FOR THE TRAINING AND EXAMINATION OF PERSONNEL ENGAGED IN ULTRASONIC TESTING USING PHASED ARRAY TRANSDUCERS.

ASSOCIATED DOCUMENTS:

App E9 Specific Requirements

Appendix Z2 to PCN/GEN (specimen examination questions compendium)

CONTENTS: **PAGE**

SYLLABUS SPECIFIC TO ULTRASONIC TESTING USING PHASED ARRAY TRANSDUCERS

Candidates for this examination will hold valid PCN Level 1, 2 or 3 certification for ultrasonic testing of castings, welds or wrought products as appropriate. The general UT examination syllabuses for these applications are not reproduced here since candidates and trainers may refer to the specific syllabus documents concerned. The following training and examination syllabus is specific to ultrasonic testing using phased array transducers. The duration of the training course will be 40 hours to Level 1, plus 40 hours to Level 2.

1. LEVEL 1

1.1 Principles of phased array probes

1.1.1 Array of piezo-electric elements

1.1.2 Delays

1.1.3 Control of beam shape and angle

1.1.4 Laws

1.1.5 Fundamental principles of probe performance and design

1.2 Principles of inspection sensitivity

1.2.1 Reference reflectors

1.2.2 Sensitivity to mis-aligned defects

1.3 Phased Array Instrument

1.3.1 Control panel including input and output sockets

1.3.2 Block diagram of internal circuit modules

1.4 Scanning with phased array probes

1.4.1 Swept beams

1.4.2 Linear scans

1.4.3 Fixed beam scans

1.4.1 Line scans – raster scans

1.5 Calibration and checks

1.5.1 Checking probe elements

1.5.2 Beam angles and offsets/index point

1.5.3 Beam shape

1.6 Software for data collection

1.6.1 File structure

1.6.2 Basic interface and windows options or panes

1.6.3 Status bar

1.6.4 Setup parameters

1.6.4.2 Inspection sequence – tabs: sequence and encoder settings

1.6.4.3 UT settings – tabs: acquisition, probe, configuration, etc.

1.6.5 Data acquisition controls and protocol

1.6.5.1 Acquisition toolbar

1.6.5.2 Online views of data presentation

1.7 Software familiarity

1.7.1 Displays and display types – options available to customise these including echo-dynamic patterns B, C, D scan formats and merged volumetric views

1.7.2 Cursors and gates

1.7.3 Reporting and data file conversions available

1.7.4 Saving files

1.8 Procedures for verification of flaw existence and position

1.9 Reporting

2. LEVEL 2

2.1 Principles of phased array probes

2.1.1 Array of piezo-electric elements

2.1.2 Delays

2.1.3 Control of beam shape and angle

2.1.4 Laws

2.1.5 Fundamental principles of probe performance and design

2.2 Principles of inspection sensitivity

2.2.1 Reference reflectors

2.2.2 Sensitivity to mis-aligned defects

2.3 Phased Array Instrument

2.3.1 Control panel including input and output sockets

2.3.2 Block diagram of internal circuit modules

2.4 Scanning with phased array probes

2.4.1 Swept beams

2.4.2 Linear scans

2.4.3 Fixed beam scans

2.4.1 Line scans – raster scans

2.5 Calibration and checks

2.5.1 Checking probe elements

2.5.2 Beam angles and offsets/index point

2.5.3 Beam shape

2.6 Software for data collection and data analysis

2.6.1 File structure

2.6.2 Basic interface and windows options or panes

2.6.3 Status bar

2.6.4 Setup parameters

2.6.4.1 Inspection sequence – tabs: sequence and encoder settings

2.6.4.2 UT settings – tabs: acquisition, probe, configuration, etc.

2.6.5 Data acquisition controls and protocol

2.6.5.1 Acquisition toolbar

2.6.5.2 Online views of data presentation

2.6.6 Analysis mode

2.6.6.1 Data analysis view types

2.6.6.2 Analysis tools

2.6.6.3 Volumetric image merging principles

2.7 Principles of data analysis

2.7.1 Review of data analysis for conventional ultrasonic inspection image formats and specific application to ultrasonic phased arrays

2.8 Software familiarity

2.8.1 Volumetric merge options

2.8.2 Displays and display types – options available to customise these including echo-dynamic patterns B, C, D scan formats and merged volumetric views

2.8.3 Soft gain and thresholds including gating and DAC Curves

2.8.4 Overlays – creating and importing/manipulating

2.8.5 Cursors and gates

2.8.6 Reporting and data file conversions available

2.8.7 Saving files

2.9 Use of software tools for defect detection and sizing

2.10 Data analysis

2.11 Procedures for verification of flaw existence and position

2.12 Reporting

3. LEVEL 3

As Level 2, but in addition:

3.1 Principles of phased array probes

3.1.1 Probe parameters: elements, pitch, frequency, focussing, focal range, depth of field, limitation of steering

3.1.2 Grating Lobes location of and predictions

3.2 Principles of inspection sensitivity – advantages and limitations

3.2.1 Grain interference –

3.2.2 Specific reference block designs – illustrations and uses of

3.3 Phased Array Instrument

3.3.1 Familiarity with common branded systems – overview

3.4 Scanning with phased array probes

3.4.1 Phased array TOFD – principles of

3.5 Calibration and checks

3.5.1 Squint

3.5.2 Effect of wedges

3.5.3 Acoustic properties of wedge materials that affect phased arrays

3.6 Procedure writing – inspection design, restrictions, array sizes, use of different phased array techniques, complementary ultrasonic applications, resolution, sensitivity, sizing, reporting, archiving data, requirements for data analysis, personnel requirements.

3.7 Methods of simulating phased array inspection

3.8 Basic knowledge of specialised applications – Turbine disk and blade root inspections, Tube inspections, Pipeline applications, Bar testing, Rail axle testing, Complex geometry applications and restrictions.

Level 3 personnel are expected to be competent to assume the responsibilities of management of an industrial NDT facility. The PCN Level 3 examination will therefore evaluate the candidate's knowledge of the following:

Allocation of staff with appropriate certification according to customer's requirements. Supervision and maintenance of subordinate's certification and recertification documents and records.

Compilation of records of equipment performance, repairs and maintenance; the work done and results achieved by supervised staff. The review of reports of work done by subordinates, its periodic validation, and the endorsement of routine reports. Review of current practices, equipment, techniques and instructions. Maintenance of standards and text book libraries. Safe working practices and current legislation.

7. REFERENCE LITERATURE

Essential Reading

Introduction to Phased Array Ultrasonic Technology Applications.
ISBN: 0-9735933-0-X. Published by RD Tech (http://www.rd-tech.com/).

Advice Note 23/08/2007: Essential capabilities of Phased Array equipment to comply with ASME 5: 2004 article 4, ASME code case 2235-9 : 2005 and ASME code case 2557 : 2006

Phased Array Technical Guidelines
ISBN 0-9735933-1-8. Published by Olympus

8. COMPLIANCE WITH ASME REQUIREMENTS

Essential capabilities of Phased Array equipment to comply with ASME 5: 2004 article 4, ASME code case 2235-9 : 2005 and ASME code case 2557 : 2006.

Introduction

This advice note was prepared by Mr. T Armitt of Lavender International NDT Ltd. The advice is prepared without prejudice as a technical review of current ASME code mandates. The reader is advised that it may be superseded by later editions of the code.

Care should be taken when selecting a Phased Array (PA) instrument for the purpose of weld scanning when the purpose is to be code compliant, since not all PA instruments currently comply with these code requirements.

As at 1st September 2007, no European standard for PA applications has been released. However, optional use of PA can be justified technically under conventional UT pulse echo codes or standards. The use of PA based on BS EN1714, for example, necessitates the PA instrument to be calibrated ensuring compensation for beam sensitivity across all focal laws is achieved. In addition relevant DAC or TCG functions need to be applied to compensate for sensitivity along the beam path.

Use of conventional UT standards based on pulse echo principles is acceptable practice but it is strongly advised that all the essential variables unique to phased array technology are controlled closely in procedural documents with specific techniques.

Replacement of radiography with UT is often contractual and usually requires demonstration before being considered as a viable option, but it is worth noting that many major pipeline owners and contractor have and are currently reducing RT usage in favour of automated UT applications.

ASME 5 Article 4 section E420 (Use of Computerised Imaging Techniques (CIT's) to replace radiography)

Quote: *"The written procedure for CIT applications shall identify the specific test frequency and bandwidth to be utilised. In addition, such procedures shall define the signal processing techniques, shall include explicit guidelines for image interpretation, and shall identify the software code/program version to be used"*

Procedures are necessary to ensure control of essential variables during the inspection. Ultrasonic phased array applications have many essential variables adjustable by the operator, many of which will change the beam profile. Specific techniques are therefore necessary to control essential variables for each individual joint detail or component geometry. Use of TOFD as a separate or complementary inspection method will likewise necessitate procedural control including the provision of specific technique sheets.

Quote: *"each examination report shall document the specific scanning and imaging processes that were used so that these functions may be accurately repeated at a later time if necessary"*

Use of swept angle, linear angle and merged data file scans shall be documented. Techniques used to modify the data for analysis shall also be documented including the version of software to be used. It should be noted that different versions of software may give significantly differing results therefore care in ensuring the correct revision of a brand of software is also very important.

Quote: *"The computerized imaging process shall include a feature that generates a dimensional scale (in either two or three dimensions, as appropriate) to assist the operator in relating the imaged features to the actual relevant dimensions of the component being examined"*

Computerized Imaging Techniques (CITs) used to generate phased array or TOFD data shall be capable of encoding the scan distance during data collection. From this the electronic file will contain the dimensional location of indications that can be rescanned at later dates and data be accurately compared.

Quote: *"In addition, automated scaling factor indicators shall be integrally included to relate colours and / or image intensity to the relevant variable (i.e., signal amplitude, attenuation, etc.)."*

If the CIT is to be used in lieu of radiography then it is mandatory to encode the scan. A mechanism of calibrating the encoder/s is essential within the test instrument software. Encoded scans can be single axis line scans or two axis raster scans. Single axis line scans can be manually manipulated but two axis scans require special probe manipulators to ensure precision.

When PA is used the instrument shall be capable of compensating for amplitude variation across the beam due to wedge design and material attenuation. Each 'A' scan across a PA beam shall be able to be compensated for sensitivity due to distance by use of calibrated DAC or TCG functions.

Code case 2235-9: 2005

This code case allows use of ultrasonic methods to replace radiography of welded joints over ½ "or 13mm thickness. The code case has mandatory requirements for any ultrasonic method being employed. The following points summarise code case 2235-9 mandates:

- Ultrasonic examination can be used in lieu of radiography when RT is called for in ASME Section I; Section VIII Divisions1 and 2; and Section XII.
- A scanning device shall be used to record positional information of the UT transducer.
- The ultrasonic examination shall be recorded with a device employing automatic computer based data acquisition.
- A procedure shall be made and proven using a demonstration test piece.
- The procedure shall have been demonstrated to perform acceptably on a qualification block(s).
- The qualification block(s) shall be prepared by welding and shall contain a minimum of three flaws, orientated to simulate flaws parallel to the production welds fusion line:
    - One surface flaw on the side of the block representing the vessel OD surface.
    - One surface flaw on the side of the block representing the vessel ID surface.
    - One subsurface flaw.
- The size of flaws are stated in a table with respect to material thickness
- When PA is used swept angle scans may be used but shall be demonstrated satisfactorily to detect all the flaws in the qualification test piece. Swept angle scans produce a fan beam from a single emission point which covers part or all of the weld. Swept angle beams cover the weld at different angles across the weld thickness and this can lead to lack of detection of misoriented fusion defects or cracks.
- A series of linear angle scans are recommended to complement swept angle scans especially for joint thicknesses greater than 1" or 25mm.
- An adequate number of flaws should be used in the demonstration block to ensure detectability for the entire weld volume.
- Operators shall be trained using the equipment to acquire and analyse the data.
- Operator certification shall be in accordance with the employer's written practice.
- ASNT SNT-TC-1A or CP189 shall be used as guidelines in writing the written practice but specific method and equipment requirements need to be considered beyond the scope of these documents.
- Only Level II or Level III personnel shall analyse the data or interpret the results.
- Level II and Level III personnel shall have been qualified specifically using the equipment including a practical exam.

Code case 2557: 2006 (Use of Manual Phased Arrays)

This code case acknowledges that ultrasonic phased arrays (PA) can be a useful imaging medium and may be beneficial in sizing indications. This code case does not allow manual PA to be used in lieu of radiography.

Manual PA involves unencoded scanning of a welded joint using an identical approach to traditional 'A' scan UT inspections. The code case allows manual phased array instrument to be used in place of the traditional 'A' scan flaw detector or supplementary to the use of code compliant A scan inspections. Specifically the code case allows use of manual PA for UT examinations in accordance with ASME V article 4.

The S scan image can be used when manually rastered across the welded joint provided the following points are met:

- Beam calibration shall be calibrated so that all individual beams provide distance and amplitude correction over the sound path employed in the examination. This shall include applicable compensation for wedge sound path variations and wedge attenuation effects.
- The focal law used for calibration shall be used for examination.
- Amplifier linearity checks shall be performed on each of the pulser-receiver circuits in the ultrasonic unit. For example a 16/128 unit can pulse up to 16 elements individually or cumulatively and receive on up to 128 element connections.
- In addition to the essential variables required to be recorded in ASME V article 4 there is a comprehensive list of essential PA variables that shall be recorded in inspection documentation.

The S scan image normally refers to linear angle beam applications in reference to this document although it is permitted to use other types of array.

If the phased array instrument can display multiple scans simultaneously on the screen, then these can be used concurrently.

It should be noted that extreme care must be taken when manual scanning using multiple screen displays as the operator can only concentrate on one display at a time and the data is not being recorded for viewing afterwards.

Summary of changes

Issue	Issue date	Summary of changes
9	01.07.2019	Eligibility clause 2.1 amended to include new accepted criteria: *Where a candidate has recently successfully passed a PCN UT examination relevant to the level and sector for which they wish to attempt but has not yet received the PCN certificate. A copy of the relevant PCN Results Notice that states the candidate has successfully passed the UT exam (in the relevant sector in which certification is sought) and is eligible for certification may also be accepted by the AQB*