



**CERTIFICATION SCHEME FOR PERSONNEL**

**DOCUMENT No. CSWIP-ISO-NDT-11/93-R  
Requirements for the Certification of Personnel Engaged in Non-Destructive Testing in accordance with the requirement of BS EN ISO 9712**

**APPENDIX 1**

**Examination Format and Syllabus for the Certification of Personnel engaged in Non-Destructive Testing of Welded Joints and General Engineering Components**

**PART 1b: Automated Ultrasonic Girth Weld Inspection and Phased Array Ultrasonic Testing, Levels 1, 2 and 3**

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Issued under the authority of the Governing Board for Certification  
All correspondence should be addressed to:

TWI Certification Ltd  
Granta Park, Great Abington,  
Cambridge CB21 6AL, UK  
Telephone: +44 (0) 1223 899000  
Fax: +44 (0) 1223 894219.  
Email: [twicertification@twi.co.uk](mailto:twicertification@twi.co.uk)  
Web: [www.cswip.com](http://www.cswip.com)

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These syllabi are applicable to candidates seeking certification in accordance with Document CSWIP-ISO-NDT-11/93-R, 'Requirements for the Certification of Personnel engaged in Non-Destructive Testing in accordance with the requirements of BS EN ISO 9712', (latest issue).

## **1. Level 1 – Automated Ultrasonic Girth Weld Inspector (AUT)**

### **1.1. General theory examination**

- 40 multiple choice questions
- Time allowed 60 minutes
- Pass mark: 70%

### **1.2. Specific theory examination**

- 20 multiple choice questions
- Time allowed 30 minutes
- Pass mark 70%

### **1.3. General practical examination**

The candidate is required to optimise a calibration run on automated phased array ultrasonic equipment to ensure correct functioning of the equipment and determine the velocity in a given sample.

- Time allowed 2 hours.

### **1.4. Specific practical examination**

- The candidate is required to:
  - a) carry out a calibration on a given calibration block, adjusting the ultrasonic inspection (pitch and catch, pulse echo) channels, as required
  - b) Calibrate the TOFD channel
  - c) Calibrate the motor drive unit
  - d) Perform a full automated inspection on given girth weld samples and an acceptable inspection data file is to be produced
- Time allowed 3 hours
- Pass mark 70%

## **2. Level 2 – Automated Ultrasonic Data Interpreter (AUT DI)**

The candidate shall Interpret and evaluate automated ultrasonic inspection data and the audit of production data.

### **2.1. General theory examination**

- 40 multiple-choice questions
- Time allowed 60 minutes
- Pass mark 70%

### **2.2. Specific theory examination**

- 20 multiple-choice questions
- Time allowed 30 minutes
- Pass mark 70 %

### **2.3. General practical examination**

The candidate is required to assess and evaluate automated ultrasonic data from a typical production run for accuracy and completeness.

- Time allowed 60 minutes
- Pass mark 70%

### **2.4. Specific practical examination**

The candidate is required to assess and evaluate automated Phased array inspection data selected by the examiner.

- Time allowed 2 hours
- Pass mark 70%

## **3. Level 2 - Senior Automated Ultrasonic Girth Weld Inspector (AUT)**

There is no examination for Senior Automated Ultrasonic Girth Weld Inspector, but refer to the CSWIP-ISO-NDT-11-93-R general document for the requirements.

## **4. Level 3 - Automated Ultrasonic Girth Weld Inspector**

### **4.1 Basic examination (exempt if already holding a Level 3 ISO 9712 Certification)**

#### **Section A1 Material Science and Process Technology**

- 25 multiple choice questions
- Time allowed 40 minutes
- Pass mark 70%

#### **Section A2 Knowledge of the Certification Scheme**

- 10 multiple choice questions
- Time allowed 15 minutes
- Pass mark 70%

This section of the examination shall be open book.

#### **Section B - Level 2 Knowledge of other NDT Methods**

This section tests the knowledge of the candidate in at least four methods of NDT at a Level 2 standard. The methods shall be chosen by the candidate and shall include at least one volumetric method.

- 60 multiple choice questions
- Time allowed 90 minutes
- Pass mark 70%

N.B. Exemptions may apply, for this examination section to valid ISO 9712 Level 2 certificate holders in the main NDT methods.

### **4.2 Main method examination**

There is only one category of certification available:

- AUT Girth Welds

## **Section C1 - Knowledge of the Method General Theory**

- 30 multiple choice questions
- Time allowed 45 minutes
- Pass mark 70%.

## **Section C2 – Application of the NDT Method**

This section of the examination may be open book in relation to codes, standards and specifications.

- 20 multiple choice questions
- Time allowed 30 minutes
- Pass mark 70%

## **Section C3 - Procedure Writing**

The candidate is required to draft an NDT procedure for a component selected by the examiner.

- Time allowed 4 hours
- Pass mark 70%

## **Phased Array Ultrasonic Testing**

### **5. Level 1 – Phased Array Ultrasonic Operator**

#### **5.1. Specific theory examination**

- 20 multiple choice questions
- Time allowed 30 minutes
- Pass mark: 70%

#### **5.2. General practical examination**

The candidate is required to assemble, calibrate and function check the MEPAUT equipment.

- Time allowed 1 hour
- Pass mark 70%

#### **5.3. Specific practical examination**

The candidate is required to produce two complete data files from samples selected by the examiner. The candidate shall demonstrate beam steering encoding parameters, focusing, DAC/TCG production and completeness of data against a given instruction, code or standard.

- Time allowed 2.5 hours per sample
- Pass mark 70%.

### **6. Level 2 Phased Array Ultrasonic Testing (PAUT) - Welds**

The examination shall comprise of the following parts:

#### **6.1. Specific theory examination**

- 20 multiple choice questions
- Time allowed 30 minutes

- Pass mark 70%

## 6.2. Specific practical examination

- a) Assembly, and functional check of the MEPAUT equipment, including probe/s and encoder. Probe 'element check', to be saved as 'data file' and 'html report'.
- Time allowed 60 minutes
- b) Production of complete data files from three samples selected by the examiner, including set up and preparation of the specimen and visual examination, scan plans, carrying out tests, post test procedures, collecting and storing test data. The candidate shall demonstrate beam steering, encoding parameters, focusing and DAC/TCG production and, in addition, demonstrate completeness of data. Weld preparation should include double-V and single-V configurations, with varying wall thicknesses.
- Time allowed 2 hours per sample.
- c) Examination and assessment and analysis of the three data files from the above samples,, using appropriate viewing software. Candidates shall complete a test report with the results in a prescribed format which indicates defect location and size. The report shall also include discontinuity characterisation (size and position of defects in relation to a known datum/s) and evaluation,, echo dynamic characterisation. The report shall include detection of mandatory discontinuities.
- Time allowed 2 hour per data file.
- d) Develop an NDT instruction suitable for a Level 1 operator for one of the samples given for paragraph (b) above to a provided code or specification. The instruction shall detail the methods of scanning, file structure, collecting and storing data and the necessary calculations to achieve this. The instruction shall include scope, status, authorisation, personnel, apparatus and settings, product and test area, test conditions, preparation for testing, application of test instructions, recording and classifying results and report the results.
- Time allowed 2 hours

The minimum pass mark for the practical overall is 70% and 70% minimum for each sample scanned or data file interpreted. A failure to report a reportable defect in any sample or data file will result in failure of that examination part.

## 6.3. Critical Sizing Endorsement for Level 2 PAUT operators

This additional endorsement examination is available to Level 2 & 3 PAUT Operators who hold current certification in compliance with ISO 9712 or equivalent.

Candidates for Level 2 PAUT Critical Sizing shall undertake the following:

- a) Size four defects in welds selected by the examiner.
- b) Report on the following parameters:
- depth below a datum surface
  - through-wall extent
  - defect length
  - start point of defect from a datum
  - defect position in relation to weld centre-line
- Time allowed: 4 hours
  - Pass mark: 70%

Candidates must successfully size all four defects to gain certification. Candidates will be given information on defect position. This examination is to test the accuracy of sizing techniques and not the ability to detect defects.

#### **6.4. Corrosion & Erosion Monitoring Endorsement for Level 2 PAUT Operators**

This additional endorsement examination is available to Level 2 and 3 PAUT Operators who hold current certification in compliance with ISO 9712 or equivalent.

Candidates for Level 2 Corrosion & Erosion Monitoring shall undertake the following:

##### **6.4.1. Specific theory examination**

- 20 multiple choice questions
- Time allowed 30 minutes
- Pass mark 70%

##### **6.4.2. Specific practical examination**

- a) Assembly, calibration and functional checking of the PAUT equipment.
  - Time allowed 60 minutes.
- b) Production of four complete data files from samples selected by the examiner. The candidate shall demonstrate beam formation, TCG, encoding and demonstrate completeness of the data.
  - Time allowed 45 minutes per sample.
- c) Analysis of four data files, as selected by the examiner, using appropriate viewing software. Candidates shall record the results in a prescribed format which indicates defect location in relation to datum, defect size, depth from surface and through-wall extent. The report shall also include characterisation and datum references.
  - Time allowed 45 minutes per data file.
- d) Draft an NDT instruction for one of the samples given for paragraph (b) above. The instruction shall detail equipment to be used, the method/s of scanning, file structure, acquisition set-up, and storing of acquired data, including the necessary calculations to achieve this.
  - Time allowed 2 hours.

The minimum pass mark for the practical overall is 70% and 70% minimum for any sample scanned or data file interpreted. A failure to report a reportable defect in any sample or data file will result in failure of that examination part.

#### **6.5. Composite Testing and Monitoring Endorsement for PAUT L2 Operators**

This additional endorsement examination is available to Level 2 and 3 MPAUT Operators who hold current certification in compliance with ISO 9712 or equivalent.

Candidates for Level 2 Composite Testing and Monitoring shall undertake the following:

##### **6.5.1. Specific theory examination**

- 20 multiple choice questions
- Time allowed 30 minutes
- Pass mark 70%

### **6.5.2. Specific practical examination**

- a) Assembly, calibration and functional checking of the PAUT equipment.
  - Time allowed 60 minutes
- b) Production of four complete data files from samples selected by the examiner. The candidate shall demonstrate beam formation, TCG, encoding and demonstrate completeness of the data.
  - Time allowed 45 minutes per sample.
- c) Analysis of four data files, as selected by the examiner, using appropriate viewing software. Candidates shall record the results in a prescribed format which indicates defect location in relation to datum, defect size, depth from surface and through-wall extent. The report shall also include characterisation and datum references.
  - Time allowed 45 minutes per data file.
- d) Draft an NDT instruction for one of the samples given for paragraph (b) above. The instruction shall detail equipment to be used, the method/s of scanning, file structure, acquisition set-up, and storing of acquired data, including the necessary calculations to achieve this.
  - Time allowed 2 hours.

The minimum pass mark for the practical overall is 70% and 70% minimum for each sample scanned or data file interpreted. A failure to report a reportable defect in any sample or data file will result in failure of that examination part.

## **7. Level 2 PAUT Ultrasonic Data Analysis**

Interpretation and evaluation of the PAUT data.

### **7.1. General theory examination**

- 40 multiple choice questions
- Time allowed 60 minutes
- Pass mark 70%

### **7.2. Specific theory examination**

- 20 multiple choice questions
- Time allowed 30 minutes
- Pass mark 70%

### **7.3. Specific practical examination**

The candidate is required to assess and evaluate four data files from the categories required; these shall be selected by the examiner, the candidate shall report the results therein.

- Time allowed 2 hours
- Pass mark 70%

## **8. Level 2 Phased Array Ultrasonic Data Interpreter (PAUT- DIInt)**

The candidate shall Interpret and evaluate PAUT ultrasonic inspection data and the audit of production data.

### 8.1. General theory examination

- 40 multiple choice questions
- Time allowed 60 minutes
- Pass mark 70%

### 8.2. Specific theory examination

- 20 multiple choice questions
- Time allowed 30 minutes
- Pass mark 70 %

### 8.3. General practical examination

The candidate is required to assess and evaluate automated ultrasonic data from a typical production run for accuracy and completeness.

- Time allowed 60 minutes

### 8.4. Specific practical examination

The candidate is required to assess and evaluate automated Phased array inspection data selected by the examiner.

- Time allowed 2 hours
- Pass mark 70%

## 9. Level 3 Phased Array Ultrasonic Testing (PAUT)

### 9.1. Basic Examination (exempt if already holding a Level 3 ISO 9712 Certification)

#### Section A1 Materials Science and Process Technology

- 25 multiple choice questions
- Time allowed 40 minutes
- Pass mark 70%

#### Section A2 Knowledge of the Certification Scheme

- 10 multiple choice questions
- Time allowed 15 minutes
- Pass mark 70%

This section of the examination shall be open book.

#### Section B – Level 2 Knowledge of other NDT Methods

This section tests the knowledge of the candidate in at least four methods of NDT at a Level 2 standard. The methods shall be chosen by the candidate and shall include at least one volumetric method.

- 60 multiple choice questions
- Time allowed 90 minutes
- Pass mark 70%

N.B. Exemption may apply, for this examination section to valid ISO 9712 Level 2 certificate holders in the main NDT method.



## 9.2. Main Method Examination

This written examination shall assess the candidate's knowledge of the main method subject using the examination sections detailed below. Sector examinations available in the ultrasonic main method are:

- Phased Array Ultrasonic Testing (PAUT)

### Section C1 – Knowledge of the Method General Theory

- 30 multiple choice questions
- Time allowed 45 minutes
- Pass mark 70%

### Section C2 - Application of the NDT Method

This section of the examination may be open book with respect to codes, standards and specifications.

- 20 multiple choice questions
- Time allowed 30 minutes
- Pass mark 70%

### Section C3

The candidate is required to draft an NDT procedure for a component selected by the examiner.

- Time allowed 4 hours
- Pass mark 70%

## 10. Ten Year Recertification Examination

Level 1 and Level 2 candidates whose certificates expire at the end of the maximum ten year period of validity will be required to undertake a recertification examination comprising practical tests only as detailed below.

Level 3 candidates should refer to CSWIP-ISO-NDT-11/93R, Section 7.5.3.

### 10.1. Level 1 – Automated Ultrasonic (AUT) Girth Weld Operator

The candidate is required to optimise a calibration run on automated phased array ultrasonic equipment to ensure correct functioning of the equipment. Determine the velocity in a given sample.

- Time allowed 2 hours.

The candidate is required to carry out a calibration on a given calibration block, adjusting the ultrasonic inspection (pitch and catch, pulse echo) channels, as required.

- a) Calibrate the TOFD channel.
- b) Calibrate the motor drive unit.
- c) A full automated inspection is performed on a given girth weld samples and an acceptable inspection data file to be produced.

- Time allowed 3 hours
- Pass mark 70%

#### **10.2. Level 1 –Phased Array Ultrasonic Testing (PAUT) Operator**

The candidate is required to assemble, calibrate and function check the PAUT equipment.

- Time allowed 1 hour
- Pass mark 70%

The candidate is required to produce two complete data files from samples selected by the examiner. The candidate shall demonstrate beam steering, encoding parameters, focusing, DAC/TCG production and completeness of data against a given instruction, code or standard.

- Time allowed 2.5 hours per sample
- Pass mark 70%

#### **10.3. Level 2 –Automated Ultrasonic Data Interpreter (AUT DI)**

The candidate is required to assess and evaluate automated ultrasonic data from a typical production run for accuracy and completeness.

- Time allowed 60 minutes
- Pass mark 70%

#### **10.4. Level 2 – Senior Automated Ultrasonic Girth Weld (AUT) Inspector**

- Optimisation of a calibration run
- Determination of the velocity in a given sample of material
- Time allowed 4 hours

Complete an examination of girth welds selected by the examiner and include an end calibration.

Interpret the results of the girth weld tested and the end calibration and report the results of the inspections.

The candidate is in addition required to draft a NDT instruction for a girth weld selected by the examiner.

- Time allowed 4 hours
- Pass mark 70%

#### **10.5. Level 2 – Phased Array Ultrasonic Testing (PAUT) Operator**

Inspectors whose certificates expire at the end of the maximum ten year period of validity will be required to undertake a recertification examination comprising practical tests only. A written examination is not required.

a) Assembly, calibration and function checking of the PAUT equipment.

- Time allowed 1 hour

b) Production of two complete data files from samples selected by the examination. The candidate shall demonstrate beam steering, encoding parameters, focusing and DAC/TCG production and, in addition, demonstrate completeness of data.

- Time allowed 1.5 hours per sample.

c) Analysis the two data files produced in (b) using appropriate viewing software. Candidates shall record the results in a prescribe format which indicates defect location and size. The report shall also include echo dynamic characterisation and datum references.

- Time allowed 1 hour per data file.
- d) Develop an NDT instruction for one of the samples given for paragraph b) above. The instruction shall detail the methods of scanning, file structure, collecting and storing data and the necessary calculations to achieve this.
- Time allowed 2 hours

The minimum pass mark for the practical overall is 70% and 70% minimum for each sample scanned or data file interpreted. A failure to report a reportable defect in any sample or data file will result in failure of that examination part.

#### **10.6. Level 2 – Phased Array Ultrasonic Data Interpreter (PAUT DI)**

The candidate is required to assess and evaluate PAUT ultrasonic data from a typical production run for accuracy and completeness.

- Time allowed 60 minutes
- Pass mark 70%

#### **10.7. Level 2 – Phased Array Data Analyst**

The candidate is required to assess and evaluate four data files from the categories required; these shall be selected by the examiner, the candidate shall report the results therein.

- Time allowed 2 hours
- Pass mark 70%

### **11. Examination Syllabus**

#### **11.1. Level 1 - Automated Ultrasonic Girth Weld (AUT) Operator**

##### **11.1.1. General Theory**

- a) Brief history of development of ultrasonic testing theory.**
- b) Ultrasonic capabilities in relation to other NDT methods.**
- c) Physical principles of sound**

Nature of sound, relationship between wavelength, frequency and velocity. Wave motions and particle vibrations, velocities of sound in common materials.

- d) Behaviour of ultrasonic waves**

Reflection, refraction, diffraction. Snell's laws, attenuation, acoustic impedance, mode conversion, resonance, scattering from defects.

- e) Production of ultrasonic waves**

Piezo-electric effect. Types and properties of transducers pulse width, near and far fields, effect of frequency and sound velocity on near field, far field and beam divergence. Dead zone, production of compression, shear and surface waves, critical angles, construction of single and twin crystal probes. Couplants.

- f) Ultrasonic equipment**

Block diagrams of flaw detector, functions of controls, amplifier and equipment performance characteristics. A-scan, B-scan and C-scan displays.

**g) Calibration and equipment checks**

Calibration and reference blocks, check for dead zone, penetrative power, resolution, sensitivity, probe index, angle of refraction, linearity of time base and amplifier. Plotting beam spread diagrams. Calibration of time base ranges. Comparison of probe sensitivities. Setting sensitivity levels for scanning.

**h) Practical applications - parent material and weld examination**

Information required prior to examination. Parent material examination, attenuation measurements, methods of flaw sizing 20dB, 6dB, DGS, maximum amplitude, use of flaw location slide, reporting methods. Brief knowledge of component surface finish and its measurement.

**11.1.2. Specific Theory**

**a) Mechanical set up requirements of Phased array equipment.**

Set up procedures for the scanner, adjustment of the tractor according to the width of the welding band of the weld. Installation requirements for adjusting Phased array modules. Knowledge of automated instrumentation set up and computer users' software.

**b) Calibration of Phased Arrays.**

Zone discrimination in relation to weld calibration. Automated ultrasonic calibration of the customised calibration blocks. Knowledge of the weld definition software, computer boot up, modifying the setup, adding ultrasonic channels and gates. Data handling. Computer view configuration and the loading of panes. Calibration of Time of flight Diffraction (TOFD) channels. Encoder calibration.

**c) Inspection using Phased arrays**

Inspection Philosophy. Scanning procedures for the detection of flaws in girth welded joints. Advantages and disadvantages of ultrasonic Phased arrays. Zone discrimination in relation to weld inspection, ultrasonic overlap requirements from one zone to another. Use of twin gates for channel amplitude and time of flight.

**d) Welding Technology**

Terminology for welds, welded joints, welding procedures, types of defects in welds and parent metals detectable by ultrasonics. Defect parameters, which influence detectability, e.g. size, geometry, distance from surface, orientation, reflectivity and opacity.

**11.2. Level 1 Phased Array Ultrasonic Testing (PAUT) Operator**

This syllabus applies only to manual and encoded phased array ultrasonic testing. The syllabus for manual ultrasonic testing is published in CSWIP-ISO-NDT-11/93-R Appendix 1, Part 1a as a separate item.

**11.2.1. Phased array instrumentation**

- a) Set-up and function of instrument controls
- b) Basic software details
- c) Internal circuitry processing

**11.2.2. Phased array transducer/probes**

- a) Principles of design and performance
- b) Typical arrays
- c) Focal laws

- d) Beam shape and steering
- e) Element checks and effects of dead elements

### **11.2.3. Scan types**

- a) Sectoral scans
- b) Linear scans
- c) Axial scans
- d) Scan limitations

### **11.2.4. Distance amplitude correction and sensitivity**

- a) Reference reflectors and blocks for DAC and/or TCG settings.

### **11.2.5. Calibration and checks**

- a) Depth calibration
- b) Offsets and wedge characteristics
- c) Exit points

### **11.2.6. Data collection software**

- a) File structures and naming
- b) Data acquisition control
- c) Probe, aperture data
- d) Encoder parameters and set-up
- e) In-machine storage
- f) Real time scans

## **11.3. Level 2 Automated Ultrasonic Data (AUT D.I) Interpreter**

### **11.3.1. General Theory**

As for Level 1 Inspector.

### **11.3.2. Specific Theory**

As for Level 1 Inspector, with the addition of:

### **11.3.3. Analysis of data**

System set up, ultrasonic gates, amplitude thresholds and audit of production scans. Chart evaluation, image classification, characterisation and marking of defects.

## **11.4. Level 2 Senior Automated Ultrasonic Girth Weld (AUT) Inspector**

### **11.4.1. General Theory**

As for Level 1 Inspector / interpreter.

### **11.4.2. Specific Theory**

As for Level 1 Inspector / interpreter, with the addition of:

- In-depth knowledge of applicable standards
- Welding technology relating to pipeline welding and the associated flaws for each method
- Instruction writing for samples provided by the examiner

## **11.5. Level 2 –Phased Array (PAUT) Inspector**

This syllabus applies only to manual and encoded phased array ultrasonic testing. The syllabus for manual ultrasonic testing is published in CSWIP-ISO-NDT-11/93R Appendix 1, Part 1a as a separate item.

### **11.5.1. Phased array instrumentation**

- a) Set-up and function of instrument controls
- b) Basic software details
- c) Internal circuitry processing

### **11.5.2. Phased array transducer/probes**

- a) Principles of design and performance
- b) Typical arrays
- c) Focal laws
- d) Beam shape and steering
- e) Element checks and effects of dead elements

### **11.5.3. Scan types**

- a) Sectoral scans
- b) Linear scans
- c) Axial scans
- d) Scan limitations

### **11.5.4. Distance amplitude correction and sensitivity**

- a) Reference reflectors and blocks for DAC and/or TCG settings.

### **11.5.5. Calibration and checks**

- a) Depth calibration
- b) Offsets and wedge characteristics
- c) Exit points

### **11.5.6. Data collection software**

- a) File structures and naming
- b) Data acquisition control
- c) Probe, aperture data
- d) Encoder parameters and set-up
- e) In-machine storage
- f) Real-time scans

### **11.5.7. Data Analysis**

- a) Data transfer protocols
- b) Analysis tools
- c) A, B, C, D scan formats
- d) Cursors and analysis box selection
- e) Soft gain and its uses
- f) Saving files
- g) Report generation
- h) Flaw verification procedures

## **11.6. Level 2 Phased Array Ultrasonic Data Interpreter (PAUT-DInt)**

### **11.6.1. General Theory**

As for Level 1 Inspector.

### **11.6.2. Specific Theory**

As for Level 1 Inspector, with the addition of:

### **11.6.3. Analysis of data**

System set up, ultrasonic gates, amplitude thresholds and audit of production scans. Chart evaluation, image classification, characterisation and marking of defects.

## **11.7. Level 2 Phased Array Data Analysis**

### **11.7.1. Phased array instrumentation**

- d) Set-up and function of instrument controls
- e) Basic software details
- f) Internal circuitry processing.

### **11.7.2. Phased array transducer/probes**

- f) Principles of design and performance
- g) Typical arrays
- h) Focal laws
- i) Beam shape and steering
- j) Element checks and effects of dead elements.

### **11.7.3. Scan types**

- e) Sectoral scans
- f) Linear scans
- g) Axial scans
- h) Scan limitations.

### **11.7.4. Distance amplitude correction and sensitivity**

- b) Reference reflectors and blocks for DAC and/or TCG settings.

### **11.7.5. Calibration and checks**

- d) Depth calibration
- e) Offsets and wedge characteristics
- f) Exit points.

## **11.8. Level 3 Phased Array (PAUT) Inspector**

As for Level 2 and:

### **11.8.1. Phased array probes and wedges**

- a) Relationship of element pitch to wavelength
- b) Focusing, focal range, depth of field
- c) Limits of scanning and resolution
- d) Grating lobes and the limitation.

### **11.8.2. Calibration and sensitivity**

- a) Effects of squint, skew and tilt on calibration
- b) Velocity effects and wedge influences
- c) Reference blocks
- d) Setting gain with grain interference techniques.

### **11.8.3. Phased array scans**

- a) Relationship between aperture and thickness tested
- b) Scan design.

### **11.8.4. Procedure design**

Scope of inspection, array use, resolution, sampling rates, focalisation used, sensitivity, reporting thresholds, sizing, data control, analysis requirements, levels of personnel, reports.

### **11.8.5. Simulation tools**

Principles and use of modelling tools.

### **11.8.6. Weld inspection applications**

## **15 Reference Literature**

- Product Technology Classroom Training Handbook – The British Institute of Non-Destructive Testing.
- Procedures and Recommendations for Ultrasonic Testing of Butt Welds', 2<sup>nd</sup> edition. The Welding Institute.
- Guide to the Preparation of a Quality Manual'. The Institute of Quality Assurance.
- Ultrasonic Testing of Materials' by J and H Krautkramer. George Allen & Unwin Limited, London. Springer-Verlag Berlin, Heidelberg New York.
- Principles and practice of non-destructive testing' edited by Dr J H Lamble. Heywood and Company, London.
- Non-Destructive Testing (second edition, 1991) by R Halmshaw. Edward Arnold.
- Ultrasonic Flaw Detection for Technicians' by J C Drury. Obtainable from the British Institute of Non-destructive Testing.
- ASNT Classroom Training Handbook originally published by General Dynamics.
- ASNT Self Study Handbook originally published by General Dynamics.
- ASNT Question and Answer Book.
- ASNT Level III Study Guide.
- NDT Handbook, second edition, volume 7 (1991).
- ASNT Student Package.
- ASNT Instructor Package (overheads for training).
- Phased Arrays and Mechanised Ultrasonic Testing by E. Ginzel.



- Automated Ultrasonic Inspection of Welds Obtainable from BINDT.
- E 1961 – 2011 Standard Practice for the Mechanised Ultrasonic Examination of Girth Welds using Zonal Discrimination with Focused Search Units.
- (The above practice is under the jurisdiction of ASTM Committee E-7 on Non-destructive Testing).
- E 164 Practice for the Ultrasonic Contact Examination of Weldments.
- E 317 Practice for Evaluating Performance Characteristics of Pulse-Echo Testing Systems Without the use of Electronic Measurement Instruments.
- E 1316 Terminology for Non-destructive Examinations.

(The ASNT documents are obtainable from the current publication of the Annual Book of ASTM Standards).

- BS 7706 (1993) Guide to calibration and setting-up of the ultrasonic time-of-flight diffraction (TOFD) technique for detection, location, and sizing of flaws.
- BS EN EN 583-6 (2008) Non-destructive testing ultrasonic examination – Part 6: Time-of-flight diffraction technique for defect detection and sizing.
- API – 1104 Welding of Pipeline and Related Facilities (Available from American Petroleum Institute).
- CSA Z-662 Oil and Gas Pipeline Systems.