



**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 EN 473 and 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 and Manual and Encoded 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, (latest issue).

## **1. LEVEL 1 – AUTOMATED ULTRASONIC GIRTH WELD OPERATOR**

**Set up, calibration and inspection of pipe girth welds using automated phased array ultrasonic equipment.**

### **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. Determine the velocity of a given sample.

- Time allowed 2 hours.

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

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.

Calibrate the TOFD channel.

Calibrate the motor drive unit.

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%

## **2. LEVEL 1 – MANUAL AND ENCODED PHASED ARRAY ULTRASONIC OPERATOR**

**Set up, calibrate and inspect weldments using manual phased array ultrasonic equipment.**

### **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 assemble, calibrate and function check the MPAUT equipment.

- Time allowed 1 hour
- Pass mark 70%

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

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

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

## **3. LEVEL 2 – AUTOMATED ULTRASONIC DATA INTERPRETER**

**Interpretation and evaluation of automated ultrasonic inspection data and the audit of production data**

### **3.1. General theory examination**

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

### **3.2. Specific theory examination**

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

### **3.3. 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

### **3.4. Specific practical examination**

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

- Time allowed 4 hours
- Pass mark 70%

## **4. LEVEL 2 – SENIOR AUTOMATED ULTRASONIC GIRTH WELD INSPECTOR**

### **4.1. General theory examination**

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

#### **4.2. Specific theory examination**

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

#### **4.3. General Practical Examination**

- Optimisation of a calibration run
- Determination of the velocity of a given sample of material
- Time allowed 2 hours

#### **4.4. Specific Practical Examination**

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

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

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

- Time allowed 4 hours.
- Pass mark 70%

### **5. LEVEL 2 MANUAL AND ENCODED PHASED ARRAY ULTRASONIC TESTING (MPAUT) - Welds**

The examination shall comprise of the following parts:

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

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

#### **5.2. Specific practical examination**

- a) Assembly, calibration and function checking of the MPAUT equipment.
  - Time allowed 1hour
- b) Production of two complete data files from samples selected by the examiner. The candidate shall demonstrate beam steering, encoding parameters, focusing and DAC production and, in addition, demonstrate completeness of data.
  - Time allowed 2.5 hours per sample.
- c) Analysis of three data files, as selected by the examiner, using appropriate viewing software. Candidates shall record the results in a prescribe format which indicates defect location and size. The report shall also include echodynamic characterisation and datum references.
  - Time allowed 1 hour per data file.
- d) Develop an NDT instruction for one of the samples given for para 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.

### 5.3. Critical sizing endorsement for MPAUT operators

This additional endorsement examination is available to Level 2 & 3 MPAUT Operators who hold current certification in compliance with EN 473/ISO 9712.

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

- a) Size four defects in welds selected by the examiner.
- b) Report on the following parameters:
  - (i) depth below a datum surface
  - (ii) through-wall extent
  - (iii) defect length
  - (iv) start point of defect from a datum
  - (v) 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. LEVEL 3 – BASIC EXAMINATION

The basic examination consists of three parts as detailed below. It is recommended that this examination is passed first. It will remain valid providing that the first method examination is passed within five years after passing the basic examination.

### 6.1. Section A1

Materials Science and Process Technology

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

#### Section A2

Knowledge of the certification body system based on relevant standards. This part of the examination may be open book.

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

### 6.2. Section B

Knowledge of 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%

## **7. 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:

- Manual and Encoded Phased Array Ultrasonic

### **7.1. Section C1**

Level 3 knowledge relating to the test method for which certification is sought.

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

### **7.2. Section C2**

Application of the NDT method in the sector concerned using the applicable codes and standards. Relevant sections of the codes and standards may be provided as reference material.

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

### **7.3. Section C3**

Drafting of an NDT procedure in the relevant method and sector. The applicable codes standards and specifications shall be available during this part of the examination.

- Time allowed 4 hours
- Pass mark 70%

## **8. TEN YEAR RENEWAL 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 renewal examination comprising practical tests only as detailed below.

Level 3 candidates should refer to CSWIP-ISO-NDT-11/93R, Section 7.5.4.

### **8.1. Level 1 – Automated Ultrasonic 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 of 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.

Calibrate the TOFD channel.

Calibrate the motor drive unit.

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%

## **8.2. Level 1 – Manual and Encoded Phased Array Ultrasonic Operator**

The candidate is required to assemble, calibrate and function check the MPAUT 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 production and completeness of data against a given instruction, code or standard.

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

## **8.3. Level 2 –Automated Ultrasonic Data Interpreter**

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

- Time allowed: 60 minutes
- Pass mark: 70%

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

- Time allowed: 4 hours
- Pass mark: 70%

## **8.4. Level 2 – Senior Automated Ultrasonic Girth Weld Inspector**

- Optimisation of a calibration run
- Determination of the velocity of 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%.

## **8.5. Level 2 – Manual and Encoded Phased Array**

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

- a) Assembly, calibration and function checking of the MPAUT 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 production and, in addition, demonstrate completeness of data.
  - Time allowed: 2.5 hours per sample.
- c) Analysis of three data files, as selected by the examiner, using appropriate viewing software. Candidates shall record the results in a prescribed format which indicates defect location and size. The report shall also include echodynamic characterisation and datum references.
  - Time allowed: 1 hour per data file.
- d) Develop an NDT instruction for one of the samples given for para 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.

## 9. SYLLABUS FOR LEVEL 1 - AUTOMATED ULTRASONIC GIRTH WELD OPERATOR

### 9.1. 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.

**9.2. 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 set up, 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.

**10. SYLLABUS FOR LEVEL 1 MANUAL AND ENCODED PHASED ARRAY ULTRASONIC 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-11/93R Appendix 1, Part 1a as a separate item.

**10.1. Phased array instrumentation**

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

## **10.2. 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.

## **10.3. Scan types**

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

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

- a) Reference reflectors and blocks for DAC settings.

## **10.5. Calibration and checks**

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

## **10.6. 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. SYLLABUS FOR LEVEL 2 AUTOMATED ULTRASONIC DATA INTERPRETER**

## **11.1. General Theory**

As for Level 1 Inspector.

## **11.2. Specific Theory**

As for Level 1 Inspector, with the addition of:

### **Analysis of data**

System set up, ultrasonic gates, amplitude thresholds, and audit of production scans.

Chart evaluation, image classification, characterisation and marking of defects.

# **12. SYLLABUS FOR LEVEL 2 SENIOR AUTOMATED ULTRASONIC GIRTH WELD INSPECTOR**

## **12.1. General Theory**

As for Level 1 Inspector / interpreter.

## **12.2. 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

## **13. SYLLABUS FOR LEVEL 2 – MANUAL AND ENCODED PHASED ARRAY**

This syllabus applies only to manual 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.

### **13.1. Phased array instrumentation**

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

### **13.2. 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.

### **13.3. Scan types**

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

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

- a) Reference reflectors and blocks for DAC settings.

### **13.5. Calibration and checks**

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

### **13.6. 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.

### **13.7. 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.

## **14. SYLLABUS FOR LEVEL 3 MANUAL AND ENCODED PHASED ARRAY**

As for Level 2 and:

### **14.1. 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.

### **14.2. 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.

### **14.3. Phased array scans**

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

### **14.4. Procedure design**

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

### **14.5. Simulation tools**

Principles and use of modelling tools.

### **14.6. 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 Lambie. 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

## **PHASED ARRAY REFERENCE LITERATURE**

### **ASTM Standards**

E 1961 – 98 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 above obtainable from the Annual Book of ASTM Standards. Vol. 03.03.)

### **British Standard**

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.

### **European Standard**

EN 583-6 (1995) Non-destructive testing ultrasonic examination – Part 6: Time-of-flight diffraction technique for defect detection and sizing.

### **API Standards**

API – 1104 Welding of Pipeline and Related Facilities.  
Available from American Petroleum Institute.

### **CSA (Canadian Standards Association) Standard**

CSA Z-662 Oil and Gas Pipeline Systems.