



**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 1c: Time of Flight Diffraction Ultrasonic Inspector (TOFD) of Welds in Ferritic and Non-Ferritic Materials, Levels 1, 2 and 3**

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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 –TOFD Ultrasonic Operator (Welds)**

**Set up, calibration and data gathering of plate and pipe welds using TOFD ultrasonic equipment for the material selected.**

### **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 of TOFD ultrasonic equipment to the requirements of TechSpec EN 1475 Section 10.

- Time allowed 1 hour
- Pass mark 70%

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

The candidate is required to complete an examination of two welds from the categories required selected by the examiner and produce complete and accurate data files.

Calibrate the TOFD sensitivity  
Calibrate the motor drive unit (where appropriate)

- Time allowed 3 hours
- Pass mark 70%

**Note:** The samples shall be in the thickness range of 6 to 15mm and above 15mm.

## **2. Level 2 –TOFD Ultrasonic Operators (Welds)**

### **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 optimise a calibration of TOFD ultrasonic equipment to the requirements of TechSpec EN 1475 Section 10.

- Time allowed 60 minutes
- Pass mark 70%

### 2.4. Specific practical examination

The candidate is required to complete an examination, collect and store test data of two linear welds from the categories required selected by the examiner and produce complete and accurate data files. Weld preparation should include double-V and single-V configurations.

- Time allowed: 2 hours
- Pass mark 70%

Interpret the results of four recorded weld scan data files selected by the examiner and report the results of the inspections in an indicated format, showing the size and location of flaws in the welds.

- Time allowed 2 hours
- Pass mark 70%

The candidate is in addition required to draft an NDT instruction suitable for a Level 1 operator for a testing of one linear butt weld selected by the examiner, to a provided code, standard or specification, and to prove the instruction by testing.

- Time allowed 1.5 hours
- Pass mark 70%

**Note:** The samples shall be selected by the examiner. The samples shall be in the thickness range of 6 to 15mm and above 15mm.

Candidates who hold Level 1 TOFD certification in compliance with EN 473 or ISO 9712 will be have the following allowances/exemptions from the following parts of the Level 2 examination:

- Level 2 General Practical Examination
- Production of two data file as required in the Level 2 Specific Practical examination

## 3. Level 2 – TOFD Ultrasonic Data Analysis

Interpretation and evaluation of TOFD ultrasonic inspection 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. Specific Practical Examination**

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

- Time allowed 2 hours
- Pass mark 70%

## **4. Level 3**

### **4.1. Basic Examination**

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

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

#### **Section A2 – Knowledge of the Certification System**

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

This part of the examination may 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 (15 per test method)
- 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**

#### **Section C1 – Level 3 General Theory**

The candidate will be tested on Level 3 knowledge relating to the test method for which certification is sought.

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

### **Section C3 – Procedure**

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

- Time allowed 4 hours
- Pass mark 70%

## **5. 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.

### **5.1. Level 1 –TOFD Ultrasonic Operator (Welds)**

The candidate is required to calibrate the TOFD sensitivity and calibre the motor drive unit (where appropriate).

A full inspection is performed on two given weld samples and accurate and complete data files produced.

- Time allowed 3 hours
- Pass mark 70%

**Note:** The samples shall be selected by the examiner. The samples shall be in the thickness range of 6 to 15mm and above 15mm.

### **5.2. Level 2 – TOFD Ultrasonic Operator (Welds)**

The candidate is required to complete an examination of two welds from the categories required selected by the examiner and produce complete and accurate data files.

- Time allowed: 2 hours
- Pass mark 70%

Interpret the results of four data files selected by the examiner and report the results of the inspections.

- Time allowed 2 hours
- Pass mark 70%

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

- Time allowed 1.5 hours
- Pass mark 70%

### **5.3. Level 2 – TOFD Ultrasonic Data Analyst**

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

- Time allowed 2 hours
- Pass mark 70%

## **6. Examination Syllabus**

### **6.1. Level 1 – TOFD Ultrasonic Testing**

#### **6.1.1. 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.

#### **6.1.2. Specific Theory**

**a) TOFD instrumentation**

Set up and function of instrument controls  
Basic software details  
Internal circuitry processing

**b) TOFD transducers/probes**

Principles of design and performance  
Typical arrays

**c) Scan types**

Radial  
Linear  
Offset  
Scan limitations

**d) Sensitivity**

Reference reflectors and blocks for sensitivity settings

**e) Calibration and checks**

Probe spacing  
Exit points  
Scans in thick material

**f) Data collection software**

File structures and naming  
Data acquisition control  
Encoder parameter sand set-up  
Storage  
Real time scans

**g) Data analysis**

Data transfer protocols  
Analysis tools  
A, B scan formats  
Saving files  
Report generation  
Flaw verification procedures

**6.2. Level 2 – TOFD Ultrasonic Testing**

**6.2.1. General Theory**

As for Level 1 Inspector.

**6.2.2. Specific Theory**

As for Level 1 Inspector, with in addition

- a) Introduction to data analysis
- b) Defect length determination
- c) Defect height determination
- d) Near surface defect parameter determination
- e) Practical defect determination
- f) Reporting
- g) Data analysis and acceptance criteria
- h) Effects of different materials on defect sizing

**6.3. Level 3 – TOFD**

**6.3.1. Section C1 – General theory**

Candidates for Level 3 examinations will be questions on the contents of the syllabus for Levels 1 and 2, the questions will however be of a more complex nature.

### 6.3.2. Section C2 – Specific theory

Candidates for Level 3 examinations will be questioned on the contents of the syllabus for Levels 1 and 2, the questions will however be of a more complex nature. In addition they will be questioned on:

#### a) Alternative probe arrangements

The purpose and performance of twin crystal probes, special arrays for the detection of near surface defects, focused probes, probes with wide band frequency, phased array probes.

#### b) Immersion testing, gap scanning

#### c) Phased array, guided waves

#### d) Methods of digital processing

#### e) Flaw sizing systems

### 6.3.3. Section C3 – Procedure writing

Candidates are required to produce a fully detailed NDT procedure for a sample selected by the examiner from the sector in which the candidate is undergoing examination.

The ultrasonic procedure must include the scope of examination, test operator approvals, equipment and calibration, reference documents, acceptance and recording levels, reporting requirements, timings in relation to complementary NDT methods and stages of production/manufacture and actions in the case of procedure non-compliance.

## 7. 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.
- Technical Specification EN 1475: Section 10.
- BS EN 583.5:2001 Annex G.

## **TOFD REFERENCE LITERATURE**

### **ASTM Standards**

- E 2373-09 Standard Practice for the Use of the Ultrasonic Time of Flight Diffraction (TOFD) Technique.
- (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 1324 Guide for measuring some electronic characteristics of ultrasonic examination instruments.
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- E 1316 Terminology for Non-destructive Examinations.
- ASME Code Case 2235 – Boiler & Pressure Vessel code.

### **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**

BS EN 583(2008) 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.