

Certification Services Division
Newton Building, St George's Avenue
Northampton, NN2 6JB
United Kingdom

Tel: +44(0)1604-893-811.
Fax: +44(0)1604-893-868.
E-mail: pcn@bindt.org



PCN/GEN APPENDIX C4 ISSUE 2 Rev D

CERTIFICATION OF PERSONNEL FOR ULTRASONIC TIME OF FLIGHT DIFFRACTION TESTING OF LINEAR BUTT WELDS IN FERRITIC STEEL

ASSOCIATED DOCUMENTS:

Appendix Z1 to PCN/GEN (examination syllabus compendium)

Appendix Z2 to PCN/GEN (example examination questions)

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The British Institute of Non-Destructive Testing is an accredited certification body offering personnel and quality management systems assessment and certification against criteria set out in international and European standards through the PCN Certification Scheme.



SPECIFIC REQUIREMENTS FOR THE CERTIFICATION OF PERSONNEL ENGAGED IN ULTRASONIC TIME OF FLIGHT DIFFRACTION TESTING OF LINEAR BUTT WELDS IN FERRITIC STEEL

1. SCOPE

1.1 This document prescribes the specific requirements and procedures by which personnel may be examined and, if successful, certified competent for Ultrasonic Time of Flight Diffraction Testing of linear butt Welds in ferritic steel. Requirements contained in this document are supplementary to those contained in the current edition of the PCN General Requirements for Certification of Personnel engaged in Non-Destructive Testing. Information on the status of PCN documents is available from PCN or from any PCN examination centre.

1.2 Certification described in this document is available only to holders of current, valid UT Welds certification issued by a certification body recognised by the British Institute of NDT (BINDT). For those candidates who do not hold UT Weld testing certification details of the examination requirements can be found in PCN Appendix C1.

1.3 Candidates will be required to demonstrate that they meet the following minimum supplementary Training requirements before they will be allowed to take TOFD examinations. Training must have been taken at a British Institute of NDT Accredited Training Centre or at the training centre recognised by BINDT.

Minimum Training Requirements

Level 1	40 Hours
Level 2	40 Hours
Level 2 direct with no time at Level 1	80 Hours

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

Minimum Experience Requirements

Level 1	3 Months
Level 2	9 Months
Level 2 direct with no time at Level 1	12 Months

1.5 Each candidate is encouraged to bring his own equipment including probes, but examination centre equipment may be hired subject to availability. The candidate's attention is drawn to Clauses 2.1.2 and 2.2.2 on calibration; extra time will be allowed in the practical examination part (i) for candidates hiring examination centre equipment. Additional hours to be attended at a BINDT Accredited Training Centre or at a training centre recognised by BINDT.

2. EXAMINATION CONTENT

General information on examination content and time allowed for each written part is described in PCN General Requirements for Certification of Personnel engaged in Non-Destructive Testing. This Appendix amplifies the provisions of that document only where necessary.

2.1 Level 1

All Candidates attempting this examination must hold level 1 certification in Ultrasonic Weld Testing, issued by a certification body recognised by BINDT. Except where exemptions apply (refer to PCN General Requirements), all candidates will be required to attempt an examination comprised of the following parts:

2.1.1 Sector Specific Theory of the application of the Ultrasonic Time of Flight Diffraction method for testing of welds including basic weld production processes and associated defects.

2.1.2 Sector Specific Practical examination comprising:

- (i) assembly and calibration of TOFD data acquisition equipment.

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 TOFD 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) collect TOFD data from two linear butt welds in accordance with written instructions provided.
- (iii) examine and evaluate data to determine its suitability for interpretation or whether further scans are required.

The total time allowed for the practical examination is 5 hours.

2.2 Level 2

All candidates attempting this examination must hold level 2 certification in Ultrasonic Weld Testing issued by a certification body recognised by BINDT.

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

2.2.1 Sector Specific Theory of the application of the Ultrasonic Time of Flight Diffraction method to the testing of welds.

2.2.2 Sector Specific practical examination comprising:

- (i) calibration of TOFD test equipment as defined for level 1.
- (ii) test collect and store test data for two linear weld samples selected by the Examiner. Candidates holding current level 1 TOFD certificates will be required to attempt only one specimen. NDT instructions, including information and test parameters will be provided to all candidates. Time allowed: one hour per specimen.
- (iii) interpret and report on a total of five recorded weld scan data files representative of a range of TOFD examinations. Display the results in an indicated format, showing the location and size of flaws present in the weld. Time allowed: 3 hours.
- (iv) 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: one hour.

NOTE. Level 2 candidates holding current valid level 1 Ultrasonic Time of Flight Diffraction testing of welds certification will be exempt examination part 2.2.2 (i) above.

The time allowed for the practical examination is 6 hours.

2.3 Level 3

All candidates attempting this examination must hold level 3 certification in Ultrasonic Weld Testing issued by a certification body recognised by BINDT. Except where exemptions apply (refer to PCN General Requirements), all candidates will be required to attempt an examination comprised of the following parts:

- E Twenty multiple choice questions covering the specific theory of Ultrasonic Time of Flight Diffraction Testing of Welds.
- F The candidate will be required to produce a comprehensive Ultrasonic Time of Flight Diffraction test procedure embodying an NDT instruction for a specific weld configuration to a provided specification, standard or code.

2.3.2 Level 3 candidates who do not hold PCN level 2 certification for the ultrasonic time of flight diffraction testing of welds will be required to successfully complete the examination described in Clause 2.2.2 (excepting sub-clause (iv))

3. CERTIFICATION AVAILABLE

3.1 Level 1 Ultrasonic time of flight diffraction testing of linear butt welds.

3.2 Level 2 Ultrasonic time of flight diffraction testing of linear butt welds.

3.3 Level 3 Ultrasonic time of flight diffraction testing.

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).

4. RENEWAL AND RECERTIFICATION

4.1 The general rules for level 1 and level 2 renewals and recertification are fully described in PCN document CP16, and the rules for level 3 recertification are detailed in PCN document CP17.

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

4.3 Level 3 certificate holders seeking recertification will be required to undertake the practical examination detailed in Clause 2.2.2 above, as well as satisfying the recertification requirements detailed in CP17.

4.4 The minimum pass mark for recertification is 70% for each sample and the NDT instruction. Only one retest of failed recertification examinations is permitted. Level 2 candidates MUST pass the NDT instruction writing part in order to recertify.

5. SUPPLEMENTARY EXAMINATION CONTENT

PCN level 1 Ultrasonic Time of Flight Diffraction testing of linear welds certificate holders wishing to upgrade to level 2 are required to be successful in all level 2 written examination parts detailed in Clause 2.2 above, and to test one sample selected by the examiner.

6. GRADING

General information on the grading of examinations will be as specified in the current edition of PCN General Requirements for Certification of Personnel engaged in Non-Destructive Testing, and information on the grading of practical examinations is provided in PCN document CP22.

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EXAMINATION SYLLABUS FOR ULTRASONIC TIME OF FLIGHT DIFFRACTION TESTING OF WELDS

ASSOCIATED DOCUMENTS:

Appendix Z1 to PCN/GEN (examination syllabus compendium)

Appendix Z2 to PCN/GEN (example examination questions)

LEVEL 1 SYLLABUS

1. Level 1 General Theory

Note: Candidates for this exam will already hold UT Welds Level 1 and its syllabus is contained in PCN/GEN Appendix Z1.

2. Sector Specific Theory

- 2.1 Background to the Importance of the TOFD Technique.
- 2.2 History of TOFD Development.
- 2.3 Principles of TOFD.
- 2.4 Diffraction Process.
- 2.5 Basic TOFD Set-up.
- 2.6 Types of TOFD Scan.
- 2.7 Summary of Advantages and Disadvantages of TOFD, including limitations.
- 2.8 Basic Hardware.
- 2.9 Advantage of Digital Recording.
- 2.10 Digitisation of the Analogue Ultrasonic Signals.
- 2.11 Amplitude.
- 2.12 Sampling Rate.
- 2.13 Selection of Frequencies for Filtering.
- 2.14 Amount of Data collected during an Inspection.
- 2.15 Grey scale imaging and B-scans.
- 2.16 Signal Averaging.
- 2.17 Pulse Width Control.
- 2.18 Software.
- 2.19 On-line.
- 2.20 Analysis and Off-line Facilities.
- 2.21 Precision and Resolution.
- 2.22 Beam Spread Considerations.
- 2.23 Basics for Calculation of Beam Spread.

- 2.24 Example of Selection of Number of Scans for an Inspection.
- 2.25 Choice of Probe Angle.
- 2.26 Transducer size and frequency.
- 2.27 Choice of Probe Centre Separation.
- 2.28 Calibration of Setting of Gain.
- 2.29 Digitisation Rate.
- 2.30 Signal Averaging and Pulse Width.
- 2.31 No Signals – common faults.
- 2.32 Manual versus Mechanical Scanning.
- 2.33 General.
- 2.34 Manual Scanning.
- 2.35 Mechanical Scanning.
- 2.36 Sampling Interval.
- 2.37 Summary of Choice of Parameters for TOFD Scan.
- 2.38 Introduction.
- 2.39 Timing Errors.
- 2.40 Near Surface Problems.
- 2.41 Off-axis Error and Back Wall Blind Zone.
- 2.42 Off-axis Depth Error.
- 2.43 Back Wall Blind Zone.
- 2.44 Errors in Couplant Thickness, Surface Height Variations and Velocity.
- 2.45 Large Grained Materials.
- 2.46 Overall Errors and Monitoring Growth.
- 2.47 Overall Errors.
- 2.48 Monitoring Defect Growth.
- 2.49 Data Assessment – flaw characterisation.
- 2.50 Shear Waves.
- 2.51 Pores and Slags in TOFD Records.
- 2.52 Internal Cracks.
- 2.53 Upper Surface Breaking Cracks.
- 2.54 Lower Surface Breaking Cracks.
- 2.55 Effect of Changing Defect Profile.
- 2.56 Weld Root Flaws.
- 2.57 Check Transparency.
- 2.58 Transverse Flaws.
- 2.59 Analysis Software.
- 2.60 Linearisation.
- 2.61 Lateral/Back Wall Straighten and Removal.
- 2.62 Parabolic Cursor.
- 2.63 Synthetic Aperture Focusing Technique (SAFT).
- 2.64 Split Spectrum Processing.

2.65 Curved Surface.

2.66 Complex Geometry.

LEVEL 2 SYLLABUS

3. General Theory

Note: Candidates for this exam will already hold UT Welds Level 2 and its syllabus is contained in PCN/GEN Appendix Z1.

4. Sector Specific Theory

As level 1, but in addition:

4.1 Flaw Sizing with the Pulse Echo Technique.

4.2 Comparison of Flaw Sizing Accuracy for Different Techniques.

4.3 Angular Variation of Diffraction Signals.

4.4 Effect of Change in Probe Separation and Importance of Calibration with Lateral and Back Wall Signals.

4.5 Change in Probe Separation.

4.6 Importance of Calibration.

4.7 Error due to Variations in Couplant Depth.

4.8 Error due to Variations in Surface Profile.

4.9 Velocity Error.

4.10 Index Point Migration Errors.

4.11 Other Errors.

4.12 Multiple Arcs.

4.13 Procedure Writing.

4.14 Equipment and Probe Checks.

4.15 Equipment Checks.

4.16 Screen Height Linearity.

4.17 Amplitude Linearity.

4.18 Time Base Linearity.

4.19 Probe Index Emission Point.

4.20 Beam Angle.

4.21 Beam Spread.

4.22 TOFD Combined Probe Delay.

4.23 Sensitivity.

4.24 Resolution.

4.25 Probe Checks.

4.26 Material Velocity Measurement.

4.27 Probe Frequency.

4.28 Probe Pulse Length.

5. Sector Specific Practical - Instruction Writing

Refer to PCN/GEN Appendix C4 Para 2.2. PCN publishes a document, CP25, for the information of candidates for this examination.

LEVEL 3 SYLLABUS

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.

The examination syllabus is as follows:

6. General Theory of the Ultrasonic Method

Exempt – Candidate will hold Level 3 UT Welds.

7. Sector Specific Theory

Application of the method in respect of Codes and Standards.

8. NDT Procedure Writing

The candidate will be required to produce a comprehensive test procedure for a specific variable geometry welded component to a provided standard or code. PCN publishes a document, CP25, for information and for use by candidates in this open book examination.

REFERENCE LITERATURE

BS EN 583-6: Non-destructive testing - Ultrasonic examination - Time-of-flight diffraction technique as a method for detection and sizing of discontinuities

Engineering Applications of Ultrasonic Time-of-Flight Diffraction (Ultrasonic Inspection in Engineering Series) (Charlesworth & Temple). ISBN: 0863802397