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PCN/GEN Appendix F2.1 Issue 4 rev B

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Further information concerning the content of PCN documents is available from the PCN Scheme Manager at the above address.

SPECIFIC REQUIREMENTS FOR THE CERTIFICATION OF PERSONNEL IN ULTRASONIC TESTING OF RAILWAY RAIL

ASSOCIATED DOCUMENTS:

Appendix F2.2 to PCN/GEN

Examination Syllabus for the Certification of Personnel in Ultrasonic Testing of Railway Rail.

Appendix F2.3 to PCN/GEN

Specimen Examination Questions for the Certification of Personnel in Ultrasonic Testing of Railway Rail.

CONTENTS

1. SCOPE

1.1 This document defines the specific requirements and procedures by which personnel may be examined and, if successful, certificated for the ultrasonic testing of rail. Requirements contained in this document are supplementary to those contained in PCN/GEN General Requirements for Certification of Personnel engaged in Non-Destructive Testing.

1.2 Candidates are encouraged to use their own equipment including probes for examinations. Test centre equipment may be hired subject to availability. The attention of candidates is drawn to Clauses 2.1.3(i) and 2.2.3(i) on calibration. Extra time will be allowed for candidates hiring test centre equipment.

2. EXAMINATION CONTENT

The examination content is described in PCN General Requirements. This Appendix amplifies the provisions of that document only where necessary.

2.1 Level 1

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 General Theory of the Ultrasonic method. Forty multiple choice questions to be answered in sixty minutes. The minimum pass mark 70%.

2.1.2 Sector Specific Theory of the application of the ultrasonic method in the testing of rail (appropriate to the category of certification sought - see Clauses 3 and 5). Twenty multiple choice questions to be answered in 30 minutes. The minimum pass mark 70%.

2.1.3 Sector Specific Practical examination comprised of:

(i) calibration of test equipment.

(ii) testing specimens appropriate to the certification sought (locating defects therein).

(iii) reporting the results in a prescribed manner in accordance with the NDT instructions provided.

The total time allowed for the practical examination will vary according to the categories of certification sought (see Clause 3 for details). The minimum pass mark is 70% for each sample.

NOTE: Candidates seeking certification in ultrasonic testing of rail must successfully complete the 3.1.1 and 3.1.2 practical examinations before attempting other categories (see Clause 3.1).

2.2 Level 2

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 General Theory of the Ultrasonic method. Forty multiple choice questions to be answered in sixty minutes. The minimum pass mark is 70%.

2.2.2 Sector Specific Theory of the application of the ultrasonic method to the testing of rail. Twenty multiple choice questions and ten further questions covering basic rail production, joining methods and processes and associated defects. The maximum time allowed is 45 minutes. The minimum pass mark is 70%.

2.2.3 Sector Specific Practical examination comprising:

(i) calibration of test equipment.

NOTE: Level 2 candidates holding current valid level 1 ultrasonic rail testing certification will be exempt examination part 2.2.3 (i) above.

(ii) testing of samples (locating and characterising defects therein) appropriate to one or more groups of rail described in Clause 3, depending on the certification applied for. NDT instructions, including information on sensitivity levels and reporting thresholds, will be provided to candidates.

NOTE: Candidates seeking certification in ultrasonic rail testing (3.3) must successfully complete the 3.3.1 and 3.3.2 practical examinations before attempting other categories (see Clause 3.2).

(iii) reporting the results, including any calculations necessary for inspection sensitivities, in a prescribed manner in accordance with instructions provided.

(iv) prepare a detailed NDT Instruction for a rail sample selected by the examiner appropriate to the category of certification sought to a provided code, standard or specification.

The total time allowed for the practical examinations is calculated by adding the time defined in Clause 3 for each sample or group of samples to be attempted to the time allowed for drafting the NDT instruction (1 hour). The minimum pass mark for the practical examination part is 70% for each sample tested and 70% for the NDT instruction (failure to detect and report a reportable discontinuity in any one sample, or failure to produce an acceptable NDT instruction, will result in failure of this examination part).

2.3 Level 3

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

2.3.1 A Basic Examination (total time allowed: 3 hours)

A1) Thirty multiple choice questions covering materials technology and science, including typical defects in a wide range of products including castings welds and wrought products.

A2) Understanding of the requirements for PCN certification. Ten multiple choice questions on the content of the current edition of the PCN General Requirements for Certification of NDT Personnel.

B) Sixty multiple choice questions of level 2 complexity on the general theory of four NDT methods, comprising fifteen questions on ultrasonic testing and a further fifteen on each of three other methods selected by the candidate from the radiographic, eddy current, magnetic particle, visual and liquid penetrant testing methods.

2.3.2 A Main Method Examination (total time allowed: 7 hours)

C1) Thirty multiple choice questions covering the general theory of the ultrasonic testing method.

C2) Twenty multiple choice covering the specific theory of ultrasonic rail testing.

C3) The candidate will be required to produce a comprehensive test procedure embodying an NDT instruction for a typical rail test application to a provided specification, standard or code.

2.3.3 Level 3 candidates who do not hold PCN level 2 certification for ultrasonic rail testing will be required to successfully complete the examination described in Clause 2.2.3 (excepting sub-clause (iv)).

3. CERTIFICATION AVAILABLE

3.1 Level 1 Ultrasonic Testing of Rail

Groups: Practical rail samples are divided into 8 different categories appropriate to the certification available. Candidates may apply for examination in one or more of the following:

3.1.1 U1/U2 - Fish-plated joints in plain rail and switches and crossings (five samples). Time allowed: 3 hours.

3.1.2 U3 - Rail testing - 070 system (three samples). Time allowed: 45 minutes.

3.1.3 U4 – Bolt hole crack size estimation, in rolled high manganese steel rail only (two samples). Time allowed: 45 minutes.

3.1.4 U5 – Assessment of squats and inspection of rail head repairs (three samples). Time allowed: 45 minutes.

3.1.5 U7 - Rail measurement to determine the width of the head and web, rail depth and gall in normal grade (BS11) rail (four samples). Time allowed: 1 hour.

3.1.6 U8 - Manual confirmation of vertical and longitudinal defects (three samples). Time allowed: 45 minutes.

3.1.7 U10 - Adjustment switches (three samples). Time allowed: 2 hours.

3.1.8 U14 - Detection and sizing of gauge corner cracking (three samples). Time allowed: 45 minutes.

NOTE: Any or all of the above categories may be attempted during an initial examination, but candidates must successfully complete 3.1.1 and 3.1.2 before proceeding to other categories.

3.2 Level 1 Ultrasonic Testing of Rail Welds

Groups: U6 - Alumino-Thermic welds (two samples). Time allowed: 2 hours.

NOTE: Certification for ultrasonic testing of Rail welds (U6) is stand-alone and eligibility for the examination is not dependent on candidates holding the mandatory categories required for Ultrasonic Testing of Rail (3.1.1 and 3.1.2). Candidates holding current valid level 1 certification for Ultrasonic testing in the Welding Sector (Category 3.1) will be exempt examination parts 2.1.1.

3.3. Level 2 Ultrasonic Testing of Rail

Practical rail samples are divided into 9 different categories appropriate to the certification available. Candidates may apply for examination in one or more of the following groups:

3.3.1 U1/U2- Fish-plated Joints in plain rail and switches and crossings (five samples). Time allowed: 3 hours.

3.3.2 U3 -Rail testing - 070 system (three samples). Time allowed: 45 minutes.

3.3.3 U4 - Bolt hole crack size estimation, in rolled high manganese steel rail only (two samples). Time allowed: 45 minutes.

3.3.4 U5 - Assessment of squats and inspection of railhead repairs (three samples). Time allowed: 45 minutes.

3.3.5 U7 - Rail measurement to determine the width of the head and web, rail depth and gall in normal grade (BS11) rail (four samples). Time allowed: 1 hour.

3.3.6 U8 - Manual confirmation of vertical and longitudinal defects (three samples). Time allowed: 45 minutes.

3.3.7 U10 - Adjustment switches (three samples). Time allowed: 2 hours.

3.3.8 U14 - Detection and sizing of gauge corner cracking (three samples). Time allowed: 45 minutes.

NOTE: Any or all of the above categories may be attempted during an initial examination but candidates must successfully complete 3.3.1 and 3.3.2. before proceeding to other categories.

3.4 Level 2 Ultrasonic Testing of Rail Welds

Group: U6 - Alumino-Thermic welds (two samples). Time allowed: 2 hours.

NOTE: Certification for ultrasonic testing of Rail welds (U6) is stand-alone and eligibility for the examination is not dependent on candidates holding the mandatory categories required for Ultrasonic Testing of Rail (3.3.1 and 3.3.2). Candidates holding current valid level 2 certification for Ultrasonic testing in the Welding Sector (Category 3.1) will be exempt examination parts 2.2.1.

3.5 Level 3 Ultrasonic Testing of Rail

4. RENEWAL AND RECERTIFICATION

4.1 The general rules for level 1 and level 2 renewal 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 certificate holders seeking recertification will be required to undertake the practical examination defined in clause 3.1 and/or 3.2. The time allowed is defined in Clause 3, dependent on the level and categories attempted.

4.3 Level 2 certificate holders seeking recertification will be required to undertake the practical examination defined in Clause 3.3 and/or 3.4 . The time allowed is defined in Clause 3, dependent on the level and categories attempted.

4.4 The minimum overall pass mark for recertification in any category is 80%, comprised of an average of the marks awarded for instruction writing and each practical sample tested within the category attempted. The minimum mark for each individual element of the examination is 70%. Only one retest of failed recertification examinations is permitted. Level 2 candidates MUST pass the NDT instruction writing part to gain certification.

4.5 Level 1 and level 2 Rail Testing certificate holders who attempt a multiple category re-certification examination and fail some of the categories taken may be awarded certification for the categories in which they were successful. However, candidates that fail the mandatory categories (see Clause 3) but achieve success in one or more other categories may have them held over pending one, and only one re-test of the failed categories Subject to successfully passing the mandatory categories in the re-test examination, candidates will be awarded PCN certification for all other categories passed, including those held over from the original examination. Failure of the mandatory categories in the re-test examination will result in the individual returning to initial candidate status for certification in the sector, method and level concerned.

5. SUPPLEMENTARY EXAMINATION CONTENT

5.1 PCN Level 1 ultrasonic rail testing certificate holders wishing to upgrade to level 2 must achieve passing grades in the level 2 examination detailed in Clause 2.2 above (see Clauses 3.3 & 3.4).

5.1 Existing PCN level 1 & 2 certificate holders who apply to be certificated for the ultrasonic testing of additional rail categories will be required to pass a further practical examination comprising of samples from the group in which certification is sought (see Clause 3 above).

6. GRADING

The method for grading of initial examinations and supplementary examinations, and the rules for re-examination of failed parts, will be as specified in the current edition of PCN General Requirements.

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PCN/GEN Appendix F2.2 Issue 4 Rev B

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EXAMINATION SYLLABUS FOR THE CERTIFICATION OF PERSONNEL IN ULTRASONIC TESTING OF RAILWAY RAIL

ASSOCIATED DOCUMENTS:

Appendix F2.1 to PCN/GEN

Specific Requirements for the Certification of Personnel in Ultrasonic Testing of Railway Rail.

Appendix F2.3 to PCN/GEN

Specimen Examination Questions for the Certification of Personnel in Ultrasonic Testing of Railway Rail.

CONTENTS

LEVEL 1 SYLLABUS

1. General Theory

1.1 Essential features of Ultrasonic Testing

1.1.1 Wave properties - types of wave, vibration, waves, sound waves, continuous wave, pulse, frequency, velocity, wavelength. Units, relationship between frequency velocity and wavelength.

1.1.2 Principles of reflection and transmission of sound waves at perpendicular incidence. Effect of coupling media on transmission. Acoustic impedance.

1.1.3 Principles of reflection and refraction of sound waves at inclined incidence. Factors affecting angles of reflection, refraction and mode conversion.

1.1.4 Mode conversion echoes due to geometry.

1.1.5 Effect of reflector on echo response.

1.1.6 Sound field - influence of frequency, sound velocity and size of transducer. Estimate of near field, far field and beam divergence.

1.1.7 Influence of properties of test object on sound propagation, sound velocity, attenuation, geometry and surface condition.

1.2 Equipment

1.2.1 Construction and mode of operation.

1.2.2 Block diagram of an ultrasonic instrument with single and double transducer, controls and functions of ultrasonic instrument.

1.2.3 Types of probe - normal beam, single and twin crystal, angle beam. Construction and mode of operation.

1.2.4 Signal presentation - A, B, C scans.

1.2.5 Definition and use of decibel.

1.2.6 Test methods - manual, semi-automatic, automatic.

1.3 Testing Techniques

1.3.1 Pulse-echo technique - basic principle, measured values (transmit time, echo amplitude), advantages and limitations.

1.3.2 Through-transmission technique - basic principle, measured value (intensity), advantages and limitations.

1.3.3 Application of compression and shear waves.

1.3.4 Coupling:

1.3.4.1 contact technique - couplant, protective layer

1.3.4.2 gap scanning

1.3.4.3 immersion technique - basic principle

2. Sector Specific Theory

2.1 Calibration of Testing Systems

2.1.1 Timebase calibration - normal, single, twin crystal and angle beam probes. Calibration blocks and sensitivity checks. Effect of different sound velocities in calibration block and test piece.

2.1.2 Sensitivity and signal to noise ratio.

2.1.3 Effect of finish, geometry, attenuation in specimen.

2.1.4 Probe index, beam angle, squint and pulse duration.

2.2 Detectability of Defects

2.2.1 Advantages and limitations of the test method with regard to defect detection.

2.3 Factors affecting the Performance of the Ultrasonic Test

2.3.1 Mechanical properties of the material, attenuation.

2.3.2 Sound behaviour in rail.

2.3.3 Surface condition.

2.4 Codes of Practice and Standards

See essential reading list.

2.5 Conducting and Recording the Tests

2.5.1 Scanning techniques for rail defects.

2.5.2 Reporting.

LEVEL 2 SYLLABUS

3. General Theory

All of the syllabus for level 1 and, in addition:

3.1 Principles of Ultrasonic Testing

3.1.1 Physical principles.

3.1.2 Behaviour of sound wave for perpendicular incidence. Acoustic impedance. Reflection and transmission factors. Calculations of reflected and transmitted energy.

3.1.3 Behaviour of sound wave for inclined incidence. Snell's Law concerning reflection, refraction and mode conversion. Critical angles. Calculations.

3.1.4 Interpretation and prediction of boundary echoes. Time base position of mode converted echoes under known conditions.

3.1.5 Influence on sound waves of reflector size (reflection, scatter, refraction, interference).

3.1.6 Echoes from defined reflectors. Laws concerning distance and size of back-wall echo, side drilled hole and disc reflectors. Comparison with real flaws.

3.1.7 Generation of ultrasonic waves. Electromechanical transducer (piezo-electric, magnetostrictive and electro-dynamic). Properties of the transducer, (nominal and working frequency, band width). Effect of different transducer materials.

3.1.8 Sound field. Calculation and estimation of near field, far field and beam spread.

3.1.9 Influence on specimen material properties on sound propagation, attenuation, cause, effect and measurement, attenuation coefficient. Surface shape and condition. Sound velocity, cause, effect and measurement.

3.2 Equipment

3.2.1 Probe construction and mode of operation. Special probes, double crystal angle probes, focused probes, probes with different damping.

3.2.2 Measurement of resolving power of angle probes. Correlation between resolution, frequency, penetrating power and damping.

3.2.3 Amplifier characteristics, broad and narrow band, logarithmic, saturation, linearity, suppression, DAC correction.

3.2.4 Signal presentation. Deeper knowledge of automatic test systems.

4. Sector Specific Theory

4.1 Calibration of Testing Systems

4.1.1 Timebase calibration - projected distance, Effect of different materials.

4.1.2 Calibration for sensitivity with reference to back-wall echo, and flat bottomed holes.

4.2 Detectability of Defects

4.2.1 Advantages and limitations of the test method with regard to defect detection.

4.3 Factors affecting the Performance of the Ultrasonic Test

4.3.1 Relationship of material properties and surface condition with attenuation and sound velocity.

4.3.2 Selection of probe type, frequency and angle.

4.3.3 Preparation of test surface.

4.3.4 Selection of couplant and testing technique.

4.3.5 Influence of defect type, position and orientation on detection.

4.4 Codes of Practice and Standards

See essential reading list.

4.4.1 Establishing of testing instructions considering application, equipment, technique, probes, calibration, operation of test, recording of test results.

4.5 Conducting and Recording the Test

4.5.1 Procedure to be adopted to carry out the test.

4.5.2 Information to be recorded on the report.

4.5.3 Flaw assessment and reporting.

4.6 Interpretation of Test Results

Interpretation of test results to acceptance standards.

5. Product Technology Theory

Product technology is applicable only to level 2 and level 3 candidates.

5.1 Basic Production - Crude and Finished Products

5.1.1 Grades of steel; steel making processes. Ingot types (narrow end up and wide end up), concast methods (continuous casting process). Definition used in the production of ingots and casting.

5.1.2 Difference between ingot and concast production processes. Ingot casting for further hot working, rolling, forging and extrusion.

5.2 Forging Processes and Basic Forging Defects

5.2.1 The appearance of defects and how they are formed:

i) forging bursts;

ii) laps;

iii) seams;

iv) cracks.

5.3 Heat Treatment

5.3.1 What stress relieving is and why it is carried out.

5.3.2 Explanation of how annealing is carried out and the results obtained; Full anneal and definitions; Sub critical anneal and definition.

5.3.3 Rectification.

5.4 Inspection

5.4.1 Brand marks, surface condition, dimensional checks and protection in transit.

5.5 Defects Arising in Service

Causes and Rectification

5.6 Rail joining Processes

Thermit welds, and fish plated joints.

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

Candidates will be required to be familiar with all the content of the theoretical and practical syllabi for level 2 and, in addition:

6.1 Alternative Methods of Data Presentation

6.1.1 Brief knowledge of the principles of 'B' 'C' and 'D' scan systems, and Time of Flight Diffraction (TOFD).

6.1.2 Methods of digital data-processing.

6.2 Alternative Probe Arrangements

6.2.1 The purpose, construction and performance of twin crystal probes.

6.2.2 Special arrays for detection of near surface defects.

6.2.3 Probes with focused crystals.

6.2.4 Probes with wide band frequency reception.

6.2.5 The effective range of the above probes, comparative sensitivity to given reflectors and establishment of principal characteristics of beam spread, distance amplitude response curves and sensitivity settings to achieve standard reflector equivalents.

7. General Theory of NDT Methods at Level 2

7.1 General theory at level 2, including limitations and applications, of four NDT methods. The examination syllabi are detailed in appendices to PCN General Requirements and are obtainable from PCN or any of its test centres.

7.2 In detail, the level 3 candidate will be required to demonstrate a knowledge of the level 2 general theory syllabus covering the NDT method in which level 3 certification is sought and, in addition, three others selected by the candidate from RT, UT, PT, MT, ET and VT.

8. Knowledge of PCN Requirements

A thorough understanding of the PCN criteria for certification of all levels of personnel as applied in the current edition of the PCN General Requirements for the Certification of Personnel engaged in NDT.

9. Sector Specific Theory

All of the combined syllabus for PCN ultrasonic practitioner (rail testing) levels 1 and 2, and in addition:

9.1 Flaw Sizing and Recording Systems

Knowledge of the currently used systems for defect sizing in rail. Knowledge of current systems for flaw recording. Recording echo height comparisons from actual defects and their equivalent reflectors from the test block used.

9.2 Sensitivity

Methods of setting sensitivity for normal probes. Methods of setting sensitivity for angle probes to obtain 'grain interference level' (or 'grass') and the recording of the equivalent calibration block echoes, and comparison with a standard calibration block.

9.3 Accuracy and Limitation

A thorough knowledge of the effective range of all types of probe beams, both of maximum and minimum path distances. Determination of the repeatability and accuracy of the cross section of simulated defects and of their length. Tabulation of the results achieved.

10. Materials Technology Theory

This examination part will cover the product technology syllabus given earlier under level 2, but the level 3 candidate will also require an understanding of the casting and forging processes and associated defects.

11. Sector Specific Practical Level 2

For level 3 candidates not holding a valid PCN level 2 ultrasonic rail testing certificate, the level 2 practical examination must be passed. Refer to PCN/GEN Appendix F2.1.

12. NDT Instruction Writing

For level 3 candidates not holding a valid PCN level 2 ultrasonic rail testing certificate, the level 2 NDT instruction writing examination must be passed. Refer to PCN/GEN Appendix F2.1. PCN publishes a document, CP25, for the information of candidates in this examination.

13. NDT Procedure Writing

13.1 The candidate will be required to produce a comprehensive test procedure for a specific ultrasonic rail inspection to a provided standard or code. PCN publishes a guidance document on the drafting of NDT procedures for information and for use by candidates in this open book examination.

13.2 The procedure must include acceptance levels to specified applications standards, ultrasonic operator approvals, techniques, equipment and its calibration, reference documentation, the use of complementary NDT methods, the timing of ultrasonic inspection in relation to procedures, surface condition of the rail, special contractual requirements, action to be taken in case of non-compliance, reporting instructions (implementation of the procedure). techniques, PCN publishes a document, CP25, for information and for use by candidates in this open book examination.

NOTE: Codes and standards of other national (or international) origins may be proposed by candidates, if appropriate to their job responsibilities, for use in this examination module. Candidates should notify the test centre of their choice on the enrolment form and will be permitted to bring a copy of the chosen code or standard to the test centre for use in this open book examination.

REFERENCE LITERATURE

Essential Reading

LEVEL 1:

- ❑ BS EN 1330-2 Non-destructive testing – Terminology – Part 2: Terms common to the non-destructive testing methods
- ❑ BS EN 12668-1 Non-destructive testing – Characterisation and verification of ultrasonic examination equipment – Part 1: Instruments
- ❑ BS EN 12668-3 Non-destructive testing – Characterisation and verification of ultrasonic examination equipment – Part 3 combined equipment
- ❑ BS EN 583-1 Non-destructive testing – Ultrasonic examination – Part 1: General principles
- ❑ BS EN 583-3 Non-destructive testing – Ultrasonic examination – Part 3: Transmission technique
- ❑ BS EN 583-5 Non-destructive testing –Ultrasonic examination – Part 5: Characterisation and sizing of discontinuities
- ❑ BS EN 1330-1: Non-destructive testing-Terminology – Part 1 List of general terms
- ❑ BS EN 1330-4 Glossary of terms used in non-destructive testing. Ultrasonic flaw detection
- ❑ BS EN 10228-3 Non-destructive testing of steel forgings. Ultrasonic testing of ferritic or martensitic steel forgings
- ❑ BS EN 10228-4 Non-destructive testing of steel forgings. Ultrasonic testing of austenitic-ferritic stainless steel forgings.
- ❑ BS EN 12223 Calibration block No.1 for ultrasonic examination
- ❑ BS 11: Specification for railway rails.
- ❑ RT/CE/5/055 Railtrack line specification -
- ❑ Ultrasonic rail test procedures U1 to U14
- ❑ BS EN ISO 9000: Quality Systems (for level 3 candidates only).
- ❑ Product Technology Classroom Training Handbook – The British Institute of Non-Destructive Testing.
- ❑ Training Course Notes. PCN requires candidates to have attended an approved course of training. Accredited Training Establishments are required to provide trainees with an up-to-date set of training course notes. These are considered essential reading.

NOTE: National or international standards equivalent to the above may be used as alternatives.

Recommended Reading

- Basic Metallurgy for Non-Destructive Testing. Edited by J L Taylor. The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.
- '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.
- 'Principles and Practice of Non-Destructive Testing' edited by Dr J H Lamble. Heywood and Co 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, Newton Building, St George's Avenue, Northampton NN2 6JB.
- 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 3 (1985).
- ASNT Student Package.
- ASNT Instructor Package (overheads for training).

NOTE: Some of the above are available only in reference libraries. For information on sources of the above recommended reading, contact, The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.

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SPECIMEN EXAMINATION QUESTIONS FOR THE CERTIFICATION OF PERSONNEL IN ULTRASONIC TESTING OF RAILWAY RAIL

ASSOCIATED DOCUMENTS:

Appendix F2.1 to PCN/GEN

Specific Requirements for the Certification of Personnel in Ultrasonic Testing of Railway Rail.

Appendix F2.2 to PCN/GEN

Examination Syllabus for the Certification of Personnel in Ultrasonic Testing of Railway Rail.

CONTENTS

LEVEL 1

General Theory of the Ultrasonic Method

1. The depth of a discontinuity cannot be determined when using the:

a) straight beam testing method

b) through transmission method

c) angle beam testing

d) paint brush testing

2. A term used to describe the ability of ultrasonic testing equipment to detect discontinuities close to the scanning surface of the material is:

a) sensitivity

b) penetration

c) segregation

d) resolution

3. Which of the following wave forms has the greatest velocity

a) shear wave

b) transverse wave

c) surface wave

d) longitudinal wave

4. The process of comparing an instrument with a standard is called:

a) angulation

b) calibration

c) attenuation

d) correlation

5. When the motion of the particles of a medium are parallel to the direction of motion of the wave, the wave transmitted is called:

a) longitudinal

b) shear

c) surface

d) Lamb

Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Rail

1. A possible reason for a total loss of back-wall echo when measuring rail depth using a zero degree compression wave probe with the beam passing between holes 1 and 2 is:

a) an S & T hole

b) a horizontal flaw

c) a bonding hole

d) piping

2. The primary purpose of the calibration block is to:

a) aid the operator in obtaining maximum back reflections

b) obtain the greatest possible sensitivity from the instrument

c) obtain a reproducible signal

d) none of the above

3. The process of comparing an instrument with a standard is called:

a) angulation

b) calibration

c) attenuation

d) correlation

LEVEL 2

General Theory of the Ultrasonic Method

1. The angle at which the shear component of an incident beam is refracted at 90 degrees to the normal is called:

a) the normal angle of incidence

b) the first critical angle

c) the angle of maximum reflection

d) the second critical angle

2. As frequency increases in ultrasonic testing the angle of beam divergence of a given diameter crystal:

a) decreases

b) remains constant

c) increases

d) varies uniformly through each wavelength

3. The fundamental frequency of a piezo-electric crystal used in ultrasonic probes is a function of:

a) its thickness

b) the velocity of sound in the crystal material

c) both A and B above

d) its diameter

4. Shear waves are generally more sensitive to fine discontinuities for a given frequency than longitudinal waves because:

a) the wavelength is shorter

b) shear waves are not as easily dispersed in the material

c) the direction of particle vibration of shear is more sensitive

d) the wavelength of shear waves is longer

5. A linear time base is achieved when the electron beam in the CRT:

a) is deflected with constant velocity

b) is deflected with constant acceleration

c) is deflected with the same velocity as the probe movement

d) produces four echoes on the screen

Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Rail

1. When testing number 1 bolt hole for a 'D' flaw, a signal appears on the time base at a short range. You would suspect:

a) a miss-shapen bolt hole

b) a horizontal reflector

c) half a hole

d) a bonding hole

2. In the ultrasonic testing of thermit welds, what flaw in the weld can the tandem rig readily identify?

a) lack of fusion

b) porosity

c) horizontal inclusion

d) isolated pores

3. When scanning towards a welded rail joint, the ultrasonic `A' scan presentation displays an echo-dynamic pattern in which the signal amplitude rises smoothly to a plateau, which is held with minor variations, before falling smoothly to zero. This describes the typical echo-dynamic pattern of:

a) a smooth planar reflector at oblique incidence

b) a point reflector

c) a smooth planar reflector at normal incidence

d) an irregular reflector at normal incidence

Product Technology Theory

1. Rails are made from steel and are produced by:

a) forging

b) extrusion

c) pultrusion

d) rolling

2. The height of the branding marks on the web of a rail must be at least:

a) 5mm

b) 10mm

c) 15mm

d) 20mm

3. What, during the manufacture of rail, forms the nucleus of a tache ovale?

a) water entrapment

b) hydrogen flakes

c) shatter cracks

d) stress

LEVEL 3

General Theory of the Ultrasonic Method

1. For piezo-electric transducers, the general relationship between frequency and transducer thickness states:

a) frequency and transducer thickness are independent

b) thicker transducers generate lower ultrasonic frequencies

c) thinner transducers generate lower ultrasonic frequencies

d) none of the above

2. The half-angle calculation of beam spread to one tenth of the beam centre-line intensity is calculated from:

a) $\sin\theta/2 = 1.08v/Df$

b) $\sin\theta = 1.08D/vf$

c) $\sin\theta/2 = 0.56v/Df$

d) $\sin\theta/v = 1.22v/fD$

3. The principal reason for damping the transducer in an ultrasonic probe is to:

a) reduce the applied voltage

b) enhance resolving power

c) modify sensitivity

d) reduce bandwidth

4. When using focused probes, non-symmetry in a propagated sound beam may be caused by:

a) backing material variations

b) lens centering or misalignment

c) porosity in lenses

d) all of the above

5. The 6dB drop sizing technique should only be applied to which of the following types of discontinuity:

a) those which are larger than the ultrasonic beam width

b) those of similar dimensions to the ultrasonic beam width

c) those which are smaller than the ultrasonic beam width

d) any size of discontinuity

6. Which of the following displays can be used to produce a plan view of a defect?

a) A scan

b) B scan

c) C scan

d) D scan

General Theory of Other NDT Methods at Level 2

The examination will test the candidate's understanding of the General Theory at level 2 of four out of the radiographic, ultrasonic, electromagnetic, magnetic particle and liquid penetrant NDT methods to enable him/her to recognise correct application but not necessarily to specify techniques.

1. Thin sheets of lead foil in intimate contact with radiographic film increase film density because they:

a) fluoresce and emit visible light which helps expose the film

b) absorb the scattered radiation

c) prevent back-scattered radiation from fogging the film

d) emit electrons which help darken the film

2. The fact that gases, when bombarded with radiation, ionise and become electrically conductive make them useful in:

a) X-ray transformers

b) X-ray tubes

c) masks

d) monitoring equipment

3. The most effective method of demagnetisation is:

a) AC aperture coil

b) reversing and decreasing DC

c) stroking with AC yokes

d) hammering along the length of the part

4. For fine, surface breaking cracks the best magnetic particle inspection medium is:

a) dry powder, black

b) dry powder, fluorescent

c) magnetic ink, black

d) magnetic ink, fluorescent

5. Water washable penetrants require longer dwell times than solvent removable versions because of the presence of:

a) emulsifier

b) stabiliser

c) penetrant remover

d) contaminants

6. The property of a liquid which affects the speed of flow is:

a) surface tension

b) viscosity

c) contact angle

d) a combination of all the above

7. In eddy current test systems where encircling coils are used, coupling efficiency is referred to as:

a) lift-off

b) edge factor

c) fill factor

d) phase differentiation

8. When the voltage applied to a circuit and the current through the circuit both reach their maximums at the same time the voltage and current are:

a) additive

b) in phase

c) regenerate

d) out of phase

9. The angle at which the shear component of an incident beam is refracted at 90 degrees to the normal is called:

a) the normal angle of incidence

b) the first critical angle

c) the angle of maximum reflection

d) the second critical angle

10. As frequency increases in ultrasonic testing the angle of beam divergence of a given diameter crystal:

a) decreases

b) remains constant

c) increases

d) varies uniformly through each wavelength

Knowledge of the Requirements for PCN Certification

1. The minimum period of experience required to be eligible for the Level 2 Ultrasonic Tester examination is:

a) 3 months

b) 12 months

c) 9 months

d) 6 months

2. Candidates who fail to achieve 70% in one section of the examination but who achieve a composite grade of 80% or more are eligible for:

a) one retest of the failed part

b) two retests of the failed part

c) one retest of any two parts selected by the test centre

d) one retest of any two parts selected by the candidate

3. PCN candidates shall have near distance acuity, corrected or uncorrected, in at least one eye, such that the candidate is capable of reading:

a) Jaeger number 1 letters at not less than 30cm

b) Jaeger number 1 letters at not more than 30cm

c) Jaeger number 2 letters at not more than 30cm

d) Jaeger number 2 letters at not less than 30cm

Sector Specific Theory of the Application of the Ultrasonic Method in the Testing of Rail

1. When balancing the 070 system, the signal from the zero degree probe is set to FSH, and the signal from the seventy degree probe is set at:

a) 20% FSH

b) 40% FSH

c) 50% FSH

d) 60% FSH

2. When testing jointed rail, an echo signal may not be received from one of the fish-plate holes because:

a) it is not round

b) the bolt is an interference fit

c) the hole has been 'burnt in'

d) the bolt is missing

Materials Technology Theory

1. A common cause of solidification cracking in welds made with high deposition rate processes is:

a) hydrogen entrapment

b) contaminated flux or shielding gas

c) weld preparation has an unsatisfactory depth to width ratio

d) operator error

2. A casting discontinuity which is caused by gas release or the evaporation of moisture during solidification is:

a) microshrinkage

b) porosity

c) porous segregation

d) hydrogen induced porosity

3. The heat treatment process which is employed to give a soft ductile product, by recrystallisation of the material, is termed:

a) tempering

b) hardening

c) stress relieving

d) annealing

4. Poor through thickness ductility in rolled plate, often associated with non-metallic inclusions, gives rise to:

a) lamellar tearing

b) reheat cracking

c) uniform porosity

d) hydrogen cracking

5. The welding process which would be chosen for its rapid deposition rates, high welding speeds and deep penetration quality joints is:

a) electroslag

b) manual metal arc

c) submerged arc

d) TIG

6. Hydrogen cracking, due to the break down of water molecules creating hydrogen which dissolves in the weld metal and HAZ, is most likely to occur in which of the following welding processes?

a) TIG

b) MIG

c) sub-arc

d) MMA

7. In open die forging the top and bottom dies are called, respectively, the:

a) tup and anvil

b) cope and drag

c) head and foot

d) hammer and anvil