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PCN/GEN APPENDIX F3.1 ISSUE 2 Rev A

SPECIFIC REQUIREMENTS FOR THE CERTIFICATION OF PERSONNEL IN MAGNETIC PARTICLE TESTING OF RAILWAY RUNNING RAIL AND ASSOCIATED COMPONENTS

ASSOCIATED DOCUMENTS:

Appendix F3.2 to PCN/GEN

Examination Syllabus for the Certification of Personnel in Magnetic Particle Testing of Railway Running Rail and Associated Components

Appendix F3.3 to PCN/GEN

Specimen Examination Questions for the Certification of Personnel in Magnetic Particle Testing of Railway Running Rail and Associated Components

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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.



1. SCOPE

This document prescribes the specific requirements and procedures by which personnel may be examined and, if successful, certificated for the Magnetic Particle testing of railway running rail and associated components (steel sleepers, base plates, fastenings and fishplates). Requirements contained in this document are supplementary to those contained in the current edition of PCN General Requirements for Certification of Personnel engaged in Non-Destructive Testing.

The examinations described below are specific to the testing of rail installations using basic portable magnetic test equipment, typically hand held permanent and electromagnetic yokes and capacitive discharge (current flow equipment). Certification in accordance with this Appendix is specific to railway rail applications and may not be used in any other sector. Personnel already in possession of PCN magnetic particle testing certification in the multi sector shall be deemed to comply with this Appendix.

Further information concerning the PCN Scheme is available from the Certification Services Division, BINDT, Newton Building, St George's Avenue, Northampton NN2 6JB, United Kingdom. Tel: +44 (0)1604 893811. Fax: +44 (0)1604 893868. Email: pcn@bindt.org

2. EXAMINATION CONTENT

The examination format 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 Magnetic Particle NDT method. Thirty multiple choice questions to be answered in 45 minutes. Minimum pass mark 70%.

2.1.2 Sector Specific Theory of the application of the Magnetic Particle NDT method to railway rail and associated components. Twenty multiple choice questions to be answered in 30 minutes. Minimum pass mark 70%.

2.1.3 Sector Specific Practical examination comprising:

- (i) preparation of testing equipment for use (this may involve system sensitivity and control checks).
- (ii) testing two samples (selected by the examiner from typical rail samples containing a range of defects) in accordance with NDT instructions provided.
- (iii) reporting test results in a prescribed manner on proforma report sheets that will be supplied.

The total time allowed for the practical examination is 2 hours. *The minimum pass mark for the practical part is 70% per sample tested (failure to detect and report a reportable discontinuity in any one sample will result in failure of this examination part) and 70% overall.*

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 Magnetic Particle NDT method. Thirty multiple choice questions to be answered in 45 minutes. The minimum pass mark is 70%.

2.2.2 Sector Specific Theory of the application of the Magnetic Particle NDT method to the testing of railway running rail and associated components. Thirty multiple choice questions (ten of which will cover the basic casting, forging and welding processes and defects) associated with railway rail to be answered in 45 minutes. The minimum pass mark is 70%.

2.2.3 Sector Specific Practical examination comprising:

- (i) preparation of testing equipment for use (this may involve system sensitivity and control checks).
- (ii) testing 3 samples (selected by the examiner from typical rail samples containing a range of defects) in accordance with NDT procedures or instructions (two to be provided by the test centre and one to be generated by the candidate – see (iv) below) which will give, where appropriate, sensitivity levels and reporting thresholds.
- (iii) reporting the results on the forms provided. Each test report must indicate the location type and size of any flaws detected.
- (iv) preparation of a detailed NDT instruction (suitable for level 1 personnel to follow) for the testing of one of the above samples to a provided procedure, code, standard or specification, and prove the instruction by application.

The total time allowed for the sector specific practical examination is 4 hours. The minimum pass mark for the practical part is 70% per sample tested, 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) and 70% overall.

2.3 Level 3

Level 3 certification is not available for limited application magnetic particle testing as defined by this Appendix.

Level 3 certification requirements are covered by Appendix E1 (multi sector).

3. CERTIFICATION AVAILABLE

3.1 Level 1 Railway running rail and associated components

3.2 Level 2 Railway running rail and associated components

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.

4.2 Level 1 certificate holders seeking recertification will be required to undertake the practical examination detailed at Clause 2.1.3 above. The minimum pass mark for recertification is 80%.

4.3 Level 2 certificate holders seeking recertification will be required to undertake the practical examination detailed at Clause 2.2.3 above. The minimum pass mark for recertification is 80%.

5. GRADING

The method for composite grading of initial examinations, and the grading of supplementary examinations will be as specified in the current edition of PCN General Requirements.

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THE BRITISH INSTITUTE OF
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PCN/GEN APPENDIX F3.2 ISSUE 2 Rev A

EXAMINATION SYLLABUS FOR THE CERTIFICATION OF PERSONNEL IN MAGNETIC PARTICLE TESTING OF RAILWAY RUNNING RAIL AND ASSOCIATED COMPONENTS

ASSOCIATED DOCUMENTS:

Appendix F3.1 to PCN/GEN

Specific Requirements for the Certification of Personnel in Magnetic Particle Testing of Railway Running Rail and Associated Components

Appendix F3.3 to PCN/GEN

Specimen Examination Questions for the Certification of Personnel in Magnetic Particle Testing of Railway Running Rail and Associated Components

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1. LEVEL 1 SYLLABUS – GENERAL THEORY

1.1 Principles of Magnetic Particle Inspection

1.1.1 Basic principle - magnetisation, leakage field, attraction of ferromagnetic particles, production of indication.

1.1.2 Requirements for MPI - component, field, defect orientation and detecting media etc.

1.1.3 Terms and definitions - field, flux, field strength, flux density, poles.

1.1.4 Magnetic fields - bar magnet, horseshoe magnet, fields produced by straight conductor and coil.

1.1.5 Magnetic materials - recognise terms i.e. permeability, soft and hard, brief description of hysteresis.

1.1.6 Magnetising currents - description of AC, DC, HWR, FWR.

1.2 Methods of Magnetisation

1.2.1 General - description of methods showing directions of current, field and flaw, calculation of magnetising current.

1.2.2 Contact current flow.

1.2.3 Rigid coil (flexible cables for level 2).

1.2.4 Threading bar.

1.2.5 Prods.

1.2.6 Magnets and electromagnets.

1.2.7 Magnetic flow.

1.3 Inspection and Detection of Indications

1.3.1 Detecting media - types and standard requirements.

1.3.2 Illumination - white light, UV(A), viewing conditions.

1.4 Checks and Calibrations

1.4.1 General - reasons for checks, frequency and recording.

1.4.2 Sensitivity - portable flux indicators, field strength meter, brief descriptions.

1.4.3 Functional tests - CF and flux flow test pieces.

1.4.4 Equipment checks - ammeter, illumination, detecting media, electromagnet.

1.5 Equipment

Types of equipment - description and correct use of portable and fixed units, prods, electromagnets, coils, contact heads.

2. LEVEL 1 SYLLABUS - SPECIFIC THEORY

2.1 Test Procedure

2.1.1 Safety - electrical, fire, toxicity and UV(A) hazards and their minimisation.

2.1.2 Surface preparation – pre-cleaning, contrast aid paint.

2.1.3 Correct application of field and detecting media.

2.1.4 Demagnetisation - reasons for, when and methods.

2.1.5 Indications - preservation and reporting.

2.2 Detectability of Defects

2.2.1 General - advantages and limitations of the test method with regard to defect detection.

2.2.2 Characteristics of indications.

2.2.3 Factors affecting indications - surface preparation, detecting medium and application, magnetising current.

2.3 Standards and Specifications

BS 6072, BS 4489, BS 4069, BS 5044 and BS 3683.

3. LEVEL 1 SYLLABUS - SPECIFIC PRACTICAL

Refer to PCN/GEN Appendix F3.1.

4. LEVEL 2 SYLLABUS - GENERAL THEORY

The level 2 candidate will be examined on the syllabus for level 1 but the examination questions will be more complex.

5. LEVEL 2 SYLLABUS - SPECIFIC THEORY

As level 1, but in addition:

5.1 Testing Procedures

Preparation and selection of magnetisation techniques to provide complete coverage with respect to geometry of specimen. Selection of current or flux values and methods of assessing sensitivity of technique.

5.2 Detectability of Defects

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

5.3 Interpretation and Reporting

Types of discontinuity and their identification (surface and sub-surface indications). False indications and their cause. Preservation of indications: transparent tape transfer and after coating transfers, magnetic silicone rubber, photographic (fluorescent and non-fluorescent).

5.4 Post Test Procedures

Post test cleaning and the need for restoration of preservation coatings.

6. LEVEL 2 SYLLABUS - PRODUCT TECHNOLOGY THEORY

Product technology is only applicable to level 2 candidates. The depth of knowledge required for this examination is given in the following syllabus but, briefly, the examination will cover:

- an understanding of the basic production process;
- the terms used in the production process;
- the terms, origin and nature of flaws related to the production process.

6.1 Basic Production - Crude and Finished Products

6.1.1 Ingot types: narrow end up and wide end up. Concast methods (continuous casting process). Definition used in the production of ingots and casting.

6.1.2 Difference between ingot and concast production processes.

6.1.3 Ingot casting for further hot working, rolling, forging and extrusion.

6.2 Basic Casting Production Methods - Finished Products

6.2.1 Methods of casting:

- i) sand casting
- ii) die casting
- iii) investment casting

6.2.2 Basic defects associated with cast products, their appearance and how they are formed:

- i) shrinkage
- ii) sinks
- iii) cold shuts
- iv) porosity
- v) laps
- vi) hot tears
- vii) cracks

6.2.3 Stress relieving. What stress relieving is and why it is carried out.

6.3 Wrought Products Forming Processes

6.3.1 Rolling process:

- i) primary rolling - blooms and slabs
- ii) secondary rolling - billets, sections and plates
- iii) cold rolling - sheets and strips, basic rolling defects, appearance and how they are formed

6.3.2 Forging:

- i) open forging and press forging
- ii) closed die forging

6.3.3 Basic forging defects, their appearance and how they are formed:

- i) forging bursts
- ii) laps
- iii) seams
- iv) cracks

6.3.4 Extrusion:

- i) definition of and how it works
- ii) why extrusion is used instead of rolling or forging

6.3.5 Annealing:

- i) full anneal and definitions
- ii) sub critical anneal and definition

Explanation of how annealing is carried out and the results obtained.

6.3.6 Stress relieving. What stress relieving is and why it is carried out.

6.4 Basic Welding Processes

6.4.1 Schematic lay out and general method of producing welds:

- i) MMA
- ii) TIG
- iii) MIG/MAG
- iv) SAW
- v) electroslag
- vi) alumino thermic
- vii) flash butt
- viii) gas pressure welding

6.4.2 Basic types of welds:

- i) fillet welds
- ii) butt welds in plate, pipe, nozzle and nodes

6.4.3 Welding defects:

- i) lack of fusion (all types)
- ii) porosity; worm holes, gas pores
- iii) cracks; centre line, HAZ
- iv) visual defects including weld mismatch etc.
- v) lack of penetration
- vi) slag

Explanation of how the above defects are formed.

6.4.4 In-service defects:

- i) fatigue cracks
- ii) stress corrosion cracks
- ii) grinding cracks

6.4.5 Welding terms. Definition of welding terms, part of the weld and adjacent parent plate.

6.4.6 Stress relieving. What stress relieving is and why it is carried out.

6.4.7 Normalising. Definition of normalising and the differences to annealing.

7. LEVEL 2 SYLLABUS - SPECIFIC PRACTICAL

Refer to PCN/GEN Appendix F3.1.

8. LEVEL 2 SYLLABUS - SPECIFIC PRACTICAL - INSTRUCTION WRITING

Refer to PCN/GEN Appendix F3.1. PCN publishes a document, CP25, for the information of candidates for this examination.

9. REFERENCE LITERATURE

Essential Reading

BS 3683: Part 2 - Glossary of terms used in NDT - Magnetic particle flaw detection.

BS 4069: Magnetic flaw detection inks and powders.

BS 6072: Method for magnetic particle flaw detection.

BS EN ISO 3059: Non-destructive testing. Penetrant testing and magnetic particle testing. Viewing conditions

BS EN ISO 9934-2: Non-destructive testing - Magnetic particle testing. Part 2 : Detection media

PD 6513: Magnetic particle flaw detection.

Product Technology Classroom Training Handbook. Obtainable from the Certification Services Division, The British Institute of Non-Destructive Testing, Newton Building, St George's Avenue, Northampton NN2 6JB.

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.

Recommended Reading

Classroom Training Handbook CT-6-3, Magnetic particle testing - General Dynamics, Convair Division.

Electrical, Magnetic and Visual Methods of Testing Materials. J Blitz, W.G. King and D.G. Rogers, Butterworth 1969.

Non-Destructive Testing Handbook, edited by Robert G McMaster, The Ronald Press, New York.

Principles of Magnetic Particle Testing, C E Betz, Magnaflux Corp., Chicago. 1967.

Recommended Procedure for Surface Flaw Detection of Steel Castings, by Magnetic Particle Examination. Steel Castings Research and Trade Association 1970.

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.

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 II Study Guide.

NDT Handbook, second edition, volume 6: Magnetic Particle Testing (ASNT 1989).

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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PCN/GEN APPENDIX F3.3 ISSUE 2 Rev A

SPECIMEN EXAMINATION QUESTIONS FOR THE CERTIFICATION OF PERSONNEL IN MAGNETIC PARTICLE TESTING OF RAILWAY RUNNING RAIL AND ASSOCIATED COMPONENTS

ASSOCIATED DOCUMENTS:

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1. LEVEL 1

The level 1 written examination is in two compulsory parts: General Theory and Sector Specific Theory. Except where exemptions apply (refer to PCN/GEN), all parts must be attempted.

Level 1 General Theory of the Magnetic Particle Method

1. A fundamental requirement of magnetic particle flaw detection is that the material tested:
 - a) can be any type
 - b) must be diamagnetic
 - c) must be ferromagnetic
 - d) must be paramagnetic

2. A part should normally be tested with a magnetic field in at least:
 - a) four directions
 - b) one direction
 - c) two directions
 - d) three directions

3. Indicate the unit used in the measurement of magnetic field strength?
 - a) amps per meter
 - b) tesla
 - c) volt
 - d) watt

Level 1 Sector Specific Theory of the Application of the Magnetic Particle Method

1. Consumables of a toxic nature may:
 - a) not be used at any time
 - b) be used on site work only
 - c) be used in accordance with the manufacturer's instructions
 - d) be used in small amounts

2. All surfaces to be examined by magnetic particle flaw detection should be initially:
 - a) welded
 - b) painted
 - c) clean
 - d) sandblasted

3. Which of the following items of equipment would be used to determine that ambient lighting conditions are suitable for magnetic testing?
 - a) radiometer
 - b) lux meter
 - c) magnetometer
 - d) spectrometer

2. LEVEL 2

The level 2 written examination is in two compulsory parts: General Theory and Sector Specific Theory. Except where exemptions apply (refer to PCN/GEN), all parts must be attempted.

Level 2 General Theory of the Magnetic Particle Method

1. The technique which involves the application of the detecting medium after magnetisation has ceased is the:
 - a) re-applying technique
 - b) residual technique
 - c) continuous technique
 - d) collective technique

2. When applying a magnetic field to an item, the term flux density refers to the:
 - a) concentration of lines of flux generated in the sample
 - b) magnitude of flux leakage detected
 - c) observable magnetic furring that occurs
 - d) concentration of flux adjacent to the defect

3. When testing a component using a coil, the magnetic field is:
 - a) transverse
 - b) circular
 - c) diametrical
 - d) longitudinal

Level 2 Sector Specific Theory of the Application of the Magnetic Particle Method

1. Indications caused by magnetic leakage fields which result from the geometry of the component, i.e., keyways, splines etc., are referred to as:
 - a) magnetic writing
 - b) non-relevant indications
 - c) boundary zones
 - d) relevant indications

2. When using the threading bar technique to test a bolt hole, the direction of the magnetic field will be:
 - a) longitudinal
 - b) transverse
 - c) circular
 - d) at 45° to the axis of the bar

3. The field strength of an electro-magnetic yoke will be dependent on:
 - a) pole spacing
 - b) contact of the poles with the test surface
 - c) the number of windings in the coil
 - d) all the above

Level 2 Wrought Product Technology Theory

1. Poor forging temperature or too great a reduction in section can give rise to rupturing of the material, this is called a:

- a) lap
- b) seam
- c) burst
- d) inclusion

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

- a) tup and anvil
- b) cope and drag
- c) head and foot
- d) hammer and anvil

Level 2 Casting Product Technology Theory

3. Large smooth voids or porosity in a casting results from:

- a) turbulent flow of metal during pouring
- b) segregation of alloy constituents
- c) gas evolved before and during solidification
- d) hot tearing in the thick sections of the casting

4. Discontinuities which originate in the cast ingot can often be reduced by a process which closes and welds the voids, as well as breaking up inclusions, this process is:

- a) machining
- b) welding
- c) forging
- d) cold extrusion

Level 2 Welding Product Technology Theory

5. Gross worm hole porosity which breaks the surface of a submerged arc weld is most likely caused by:

- a) damp flux
- b) poor current connection
- c) work oxide films
- d) variation in joint fit-up

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