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PCN/GEN APPENDIX F4 ISSUE 2 rev B

SPECIFIC REQUIREMENTS FOR THE CERTIFICATION OF PERSONNEL IN LIQUID PENETRANT TESTING OF RAILWAY RUNNING RAIL AND ASSOCIATED COMPONENTS

ASSOCIATED DOCUMENTS:

Appendix F4 to PCN/GEN
Examination Syllabus for the Certification of Personnel in Liquid Penetrant Testing of Railway Running Rail and Associated Components

Appendix F4 to PCN/GEN
Specimen Examination Questions for the Certification of Personnel in Liquid Penetrant Testing of Railway Running Rail and Associated Components

CONTENTS: **PAGE**

1. SCOPE

This document prescribes the specific requirements and procedures by which personnel may be examined and, if successful, certificated for Liquid Penetrant Testing of Railway Running Rail and Associated Components (steel sleepers, baseplates, 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 only colour contrast aerosol dispensed non-aqueous liquid dye penetrants, cleaners and developers. Certification in accordance with this Appendix is specific to railway running rail applications and may not be used in any other sector. Personnel already in possession of PCN multi sector Liquid Penetrant certification 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 Liquid Penetrant 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 Liquid Penetrant NDT method to railway running 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 systems 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, and the minimum pass mark is 70% for each sample and 70% overall (failure to detect and report a reportable discontinuity in any one sample will result in failure of this examination part).

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 Liquid Penetrant 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 Liquid Penetrant 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 associated defects) to be answered in 45 minutes. The minimum pass mark is 70%.

2.2.3 Sector Specific Practical examination comprising:

(i) preparation of testing systems 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 test results on the forms provided, characterising any discontinuities detected.

(iv) preparing 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 to prove the instruction by application.

The total time allowed for the sector specific practical examination is 4 hours, and the minimum pass mark is 70% in each sample (failure to detect and report a reportable discontinuity in any one specimen will result in failure of this examination part), and 70% for the NDT instruction.

2.3 Level 3

Level 3 certification is not available for the limited range of liquid dye penetrant testing techniques defined by this Appendix.

Level 3 certification requirements are covered by Appendix E2 (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

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 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 70%.

4.3 Level 2 certificate holders seeking recertification will be required to undertake the practical examination detailed in Clause 2.2.3 above. The minimum pass mark for recertification is 70%.

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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PCN/GEN APPENDIX F4 ISSUE 2 rev A

EXAMINATION SYLLABUS FOR THE CERTIFICATION OF PERSONNEL IN LIQUID PENETRANT TESTING OF RAILWAY RUNNING RAIL AND ASSOCIATED COMPONENTS

ASSOCIATED DOCUMENTS:

Appendix F4.1 to PCN/GEN

Specific Requirements for the Certification of Personnel in Liquid Penetrant Testing of Railway Running Rail and Associated Components

Appendix F4.3 to PCN/GEN

Specimen Examination Questions for the Certification of Personnel engaged in Liquid Penetrant Testing of Railway Running Rail and Associated Components

CONTENTS: ..... PAGE1. SCOPE 2

1. LEVEL 1 SYLLABUS - GENERAL THEORY

1.1 Principles of Penetrant Inspection

1.1.1 Basic principles of liquid penetrant testing: surface tension, viscosity, volatility, capillary action and their relevance to penetrating fluids.

1.1.2 Properties and requirements of emulsifiers, spirit remover and of a developer. Terminology associated with penetrant flaw detection.

1.2 Equipment and Materials

1.2.1 Penetrant: colour contrast, fluorescent, combined colour contrast and fluorescent.

1.2.2 Penetrant removers: solvents in liquid form, water only, water soluble, oil soluble emulsifiers.

1.2.3 Developers: dry powders, aqueous suspensions, aqueous solutions, non-aqueous developers.

1.2.4 Fixed installations, portable inspection kits and auxiliary equipment.

1.3 Methods of Assessing Sensitivity and Control Testing

Chromium plated and aluminium test blocks, defective components. Colour, fluorescent intensity and comparator checks of penetrants. Efficiency of penetrant removers. Fluorescence, coverage and concentration checks on developers.

2. LEVEL 1 SYLLABUS - SPECIFIC THEORY

2.1 Preparation for Testing

Surface preparation, cleaning methods, effect of surface finish and contaminants. Compatibility of materials.

2.2 Testing Technique

2.2.1 Selection of appropriate technique.

2.2.2 Method of application of penetrant, significance of temperature, drainage and self-drying, removal of excess penetrant, contact time.

2.2.3 Penetrant removal: liquid solvents, aqueous washes, post emulsifiers, contact times.

2.2.4 Drying of components. Application of developers; dry powders, liquid developers (aqueous and non-aqueous).

2.2.5 Viewing conditions: white light and UV(A) radiation and their assessment.

2.2.6 Types of discontinuity and their identification, false indications and their cause.

2.2.7 Preservation of indications: transparent tape transfer and other coating transfers, photographic (fluorescent and colour contrast).

2.3 Post Test Procedures Cleaning

2.4 Safety Precautions

Fire hazards, electrical safety, ventilation, toxic materials and safe use of UV(A) radiation.

2.5 Standards, codes and specifications

BS ISO 3452 Parts 1, 2, 3 and 4, BS EN ISO 3059; BS EN ISO 12706.

3. LEVEL 1 SYLLABUS - SPECIFIC PRACTICAL

Refer to PCN/GEN Appendix F4.1.

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

Selection of the penetrant and developer for optimum sensitivity with due regard to inspection criteria, surface condition and ambient light levels.

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. False indications and their cause. Preservation of indications: Lacquer developers, photographic (fluorescent and colour contrast).

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 die 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. How annealing is carried out and the results obtained:

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

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) SA welding
v) electroslag 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 and how they are formed:

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

6.4.4 In-service defects:

i) fatigue cracks
ii) stress corrosion cracks
iii) 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 F4.1.

8. LEVEL 2 SYLLABUS - SPECIFIC PRACTICAL - INSTRUCTION WRITING

Refer to PCN/GEN Appendix F4.1. PCN publishes a document, CP25, for the information of candidates for this examination.

9. REFERENCE LITERATURE

Essential Reading

BS EN ISO 3452-1: Non-destructive testing. Penetrant testing. General principles.

BS EN ISO 3452-2: Non-destructive testing. Penetrant testing. Testing of penetrant materials.

BS EN ISO 3452-3: Non-destructive testing. Penetrant testing. Reference test blocks.

BS EN ISO 3452-4: Non-destructive testing. Penetrant testing. Equipment.

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

BS EN ISO 12706: Non-destructive testing. Terminology. Terms used in penetrant 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.

Recommended Reading

Penetrant Testing: A practical guide. D Lovejoy. Chapman & Hall, 1991.

Principles of Penetrants. C. E. Betz, Magnaflux Corp., Chicago 1969.

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**.**

Materials and Processes for NDT Technology, ASNT, 1981.

Liquid Penetrant Testing Classroom Training Book, ASNT, 1996.

Liquid Penetrant Testing programmed instruction book, ASNT, 1977.

Question and Answer Book, Levels 1, 2 and 3, Liquid Penetrant Testing, ASNT, 1980.

Level II Study Guide, Liquid Penetrant Testing, ASNT, 1997.

NDT Handbook, third edition, volume 2 Liquid Penetrant Testing (1999), ASNT.

Liquid Penetrant Testing, Student Package, ASNT.

Liquid Penetrant Testing, Instructor Package (overheads for training) ASNT.

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

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PCN/GEN APPENDIX F4 ISSUE 2 rev A

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

ASSOCIATED DOCUMENTS:

Appendix F4.1 to PCN/GEN

Specific Requirements for the Certification of Personnel in Liquid Penetrant Testing of Railway Running Rail and Associated Components

Appendix F4.2 to PCN/GEN

Examination Syllabus for the Certification of Personnel in Liquid Penetrant Testing of Railway Running Rail and Associated Components CONTENTS: PAGE

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.

General Theory of the Liquid Penetrant Method

1. Which of the following would assist the penetrant to enter sub-surface cracks in a component?

a) the material's surface finish
b) the penetrant viscosity
c) the inherent surface tension
d) none of the above

2. The only discontinuities which penetrant testing can detect are:

a) sub-surface
b) surface breaking
c) internal
d) contaminant filled

3. The term used to define the period of time that a developer has been applied is:

a) attraction time
b) development time
c) dwell time
d) drain time

Sector Specific Theory of the Application of the Liquid Penetrant Method to Railway Running Rail and Associated Components

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 using penetrant flaw detection should be initially:

a) welded
b) painted
c) clean
d) sandblasted

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.

General Theory of the Liquid Penetrant Method

1. 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

2. The corrosivity of a liquid penetrant is usually assessed by:

a) actual component testing
b) the manufacturer of the penetrant
c) samples of material left in contact for 24 hours and examined
d) samples of material left in contact for 16 hours and examined

3. If fluorescent penetrant is applied after an acid precleaning treatment:

a) the penetrant should dwell for twice the time specified
b) marking of the test piece may be evident
c) a decrease in brilliance of the penetrant may occur
d) an increase in brilliance of the penetrant may occur

Sector Specific Theory of the Application of the Liquid Penetrant Method to Railway Running Rail and Associated Components

1. The British Standard to be referred to for penetrant flaw detection is:

a) BS 6072
b) BS 4069
c) BS 4489
d) BS EN 571-1

2. To avoid the risk of fire, penetrants in cans should:

a) be stored away from direct sunlight
b) not be sprayed near or onto hot components
c) kept away from incandescent surfaces
d) be handled so as to avoid all of the above situations

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. The failure of turbine blades at the junction of the blade and larger section where it will be attached to the rotor, can often be ascribed to cyclical stresses which are concentrated in this region. The failure mechanism is called:

a) stress rupture

b) intergranular fretting corrosion

c) fatigue

d) hot tearing

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

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. Which of the following will not be found in a TIG welded joint?

a) porosity
b) slag
c) crater cracking
d) incomplete penetration