



CERTIFICATION SCHEME FOR PERSONNEL

**DOCUMENT No. CSWIP-ISO-NDT-11/93-R
Requirements for the Certification of Personnel Engaged in Non-Destructive Testing in accordance with the requirements of BS EN ISO 9712**

APPENDIX 1

Examination Format and Syllabus for the Certification of Personnel engaged in Non-Destructive Testing of Welded Joints and General Engineering Components

PART 2: Magnetic Particle Inspector, Level 1, 2 and 3

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Issued under the authority of the Governing Board for Certification
All correspondence should be addressed to:

TWI Certification Ltd
Granta Park, Great Abington, Cambridge CB21 6AL, UK
Telephone: +44 (0) 1223 899000
Fax: +44 (0) 1223 894219
Email: twicertification@twi.co.uk
Website: www.cswip.com

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These syllabi are applicable to candidates seeking certification in accordance with the current version of Document CSWIP-ISO-NDT-11/93-R 'Requirements for the Certification of Personnel Engaged in Non-Destructive Testing in accordance with the requirements of BS EN ISO 9712'.

MAGNETIC PARTICLE INSPECTOR

1 Level 1

1.1 General theory examination

- 30 multiple choice questions
- Time allowed 45 minutes
- Pass mark 70%

1.2 Specific theory examination

- 20 multiple choice questions (welds), time allowed 30 minutes
- 30 multiple choice questions (general engineering), time allowed 45 minutes
- Pass mark 70%

1.3 General practical examination

In the practical part of the examination the candidate is required to conduct and report on a function or control test on magnetic inks, permanent magnets, electromagnets, bench units and/or UV light intensity as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

1.4 Specific practical examination

Candidates for certification in magnetic particle inspection can seek qualification in either the welding or general engineering sectors. The latter of these encompasses welds, castings and wrought products. The specific practical examinations in these two sectors are as shown below.

1.4.1 Welds

The candidate is required to test and report on two specimens selected by the examiner from butt welds in plate, pipe or T-joint according to written instructions provided. The techniques used will be selected by the examiner from those shown below and may include both fluorescent and black inks.

Permanent magnets
Electromagnets
Flexible coils
Prods

- Time allowed 2 hours
- Pass mark 70%

1.4.2 General engineering

The candidate is required to test and report on three specimens selected by the examiner from welds (in plate, pipe or T- joint), casting and wrought products according to written instructions provided. The techniques used will be selected by the examiner from those shown below and may include both fluorescent and black inks.

Permanent magnets
Electromagnets
Flexible coils
Prods
Bench unit: Current flow, Magnetic Flow, Rigid Coil, Threading Bar

- Time allowed 3 hours
- Pass mark 70%

2 Level 2

2.1 General theory examination

The theory part consists of:

- 30 multiple choice questions
- Time allowed 45 minutes
- Pass mark 70%

2.2 Specific theory examination

The theory part consists of:

- 20 multiple choice questions (welds), time allowed 30 minutes
- 30 multiple choice questions (general engineering), time allowed 45 minutes
- Pass mark 70%

2.3 General practical examination

In the practical part the candidate is required to conduct and report on a function or control test on magnetic inks, permanent magnets, electromagnets, bench units and/or UV light intensity as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

2.4 Specific practical examination

Candidates for certification in magnetic particle inspection can seek qualification in either the welding or general engineering sectors. The latter of these encompasses welds, castings and wrought products. The specific practical examinations in these two sectors are as shown below.

2.4.1 Welds

The candidate is required to test and report on three specimens: butt weld in plate, butt weld in pipe and a T- joint, employing both fluorescent and black inks and using the most appropriate magnetisation techniques as selected from the list below for the component type:

Permanent magnets
Electromagnets
Flexible coils
Prods

- Time allowed 3 hours
- Pass mark 70%

2.4.2 Instruction writing

The candidate shall draft an NDT instruction suitable for Level 1 personnel as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

2.4.3 General Engineering

The candidate is required to test and report on three specimens selected by the examiner from welds (in plate, pipe or T-joint), castings and wrought products. The techniques used will be selected by the examiner from those shown below and may include both fluorescent and black inks.

Permanent magnets

Electromagnets

Flexible coils

Prods

Bench unit: Current flow, Magnetic Flow, Rigid Coil, Threader Bar

- Time allowed 3 hours
- Pass mark 70%

2.4.4 Instruction writing

The candidate shall draft an NDT instruction suitable for Level 1 personnel as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

3 Level 3

3.1 Basic Examination (Exempt if already holding a Level 3 ISO 9712 Certification)

Section A1

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

Section A2 Knowledge of the Certification Scheme

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

This section of the examination shall be open book.

Section B Level 2 Knowledge of other NDT methods

This section tests the knowledge of the candidate in at least four methods of NDT at a Level 2 standard. The methods shall be chosen by the candidate and shall include at least one volumetric method.

- 60 multiple choice questions
- Time allowed 90 minutes
- Pass mark 70%

N.B. Exemptions may apply, for this examination section to valid ISO 9712 or Level 2 certificate holders in the main NDT methods.

3.2 Main Method Examination

Section C1 Knowledge of the Method General Theory

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

- 30 multiple choice questions
- Time allowed 45 minutes
- Pass mark 70%

Section C2

This section of the examination may be open book in relation to codes standards and specifications.

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

Section C3

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

- Time allowed 4 hours
- Pass mark 70%

4 Ten Year Recertification Examination

Level 1 and Level 2 candidates whose certificates expire at the end of the maximum ten year period of validity will be required to undertake a recertification examination comprising practical tests only as detailed below.

Level 3 candidates should refer to CSWIP-ISO-NDT-11/93R, Section 7.5.3.

4.1 Level 1 Magnetic Particle Inspector

4.1.1 Welds

4.1.1.1 General practical examination

In the practical part the candidate is required to conduct and report on a function or control test on magnetic inks, permanent magnets, electromagnets, bench units and/or UV light intensity as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

4.1.1.2 Specific practical

The candidate is required to test and report on two specimens selected by the examiner from butt welds in plate, pipe or T joint according to written instructions provided. The techniques used will be selected by the examiner from those shown below and may include both fluorescent and black inks.

Permanent magnets
Electromagnets
Flexible coils
Prods

- Time allowed 2 hours
- Pass mark 70%

4.1.2 General engineering

4.1.2.1 General practical examination

In the practical part the candidate is required to conduct and report on a function or control test on magnetic inks, permanent magnets, electromagnets, bench units and/or UV light intensity as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

4.1.2.2 Specific practical

The candidate is required to test and report on three specimens selected by the examiner from welds (in plate, pipe or T joint), casting and wrought products according to written instructions provided. The techniques used will be selected by the examiner from those shown below and may include both fluorescent and black inks.

Permanent magnets
Electromagnets
Flexible coils
Prods

Bench unit: Current flow, Magnetic Flow, Rigid Coil, Threading Bar

- Time allowed 3 hours
- Pass mark 70%

4.2 Level 2 Magnetic Particle Inspector

4.2.1 Welds

4.2.1.1 General practical examination

In the practical part the candidate is required to conduct and report on a function or control test on magnetic inks, permanent magnets, electromagnets, bench units and/or UV light intensity as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

4.2.1.2 Specific practical

The candidate is required to test and report on three specimens: butt weld in plate, butt weld in pipe and a T joint, employing both fluorescent and black inks and using the most appropriate magnetisation techniques as selected from the list below for the component type:

Permanent magnets
Electromagnets
Flexible coils
Prods

- Time allowed 3 hours
- Pass mark 70%

4.2.1.3 Instruction writing

The candidate shall draft an NDT instruction suitable for Level 1 personnel as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

4.2.2 General engineering

4.2.2.1 General practical examination

In the practical part the candidate is required to conduct and report on a function or control test on magnetic inks, permanent magnets, electromagnets, bench units and/or UV light intensity as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

4.2.2.2 Specific practical

The candidate is required to test and report on three specimens selected by the examiner from welds (in plate, pipe or T joint), castings and wrought products. The techniques used will be selected by the examiner from those shown below and may include both fluorescent and black inks.

Permanent magnets

Electromagnets

Flexible coils

Prods

Bench unit: Current flow, Magnetic Flow, Rigid Coil, Threader Bar

- Time allowed 3 hours
- Pass mark 70%

4.2.2.3 Instruction writing

The candidate shall draft an NDT instruction suitable for Level 1 personnel as selected by the examiner.

- Time allowed 1 hour
- Pass mark 70%

5 Examination Syllabus

5.1 Level 1 Magnetic Particle

5.1.1 General theory

a. Principles of Magnetism

General principles, magnetic poles, magnetic field, lines of force, longitudinal magnetisation, horse-shoe magnet, vector field, consequent poles, distorted field, leakage field. Curie Point to EN ISO 9934-1.

b. Magnetic Materials

Ferromagnetic, paramagnetic and diamagnetic materials. Simple definitions of permeability and reluctance.

c. Electrically induced Magnetic Fields

Generation of circumferential flux and longitudinal flux. Flux density and residual magnetism.

d. Hysteresis Loops

e. Magnetisation Methods

Permanent magnet, electro-magnet, contact current flow (includes prod testing), threading bar, coils, induced current flow.

f. Equipment

Fixed, transportable and portable installations. DC battery, AC mains, DC rectified half wave, DC rectified full wave. Ancillary equipment. Inspection lighting (including white and black light). Viewing aids. Marking devices. Demagnetisers. Contrast aids. Calibration of equipment and the use of meters. Performance checks. Test pieces and 'portable cracks.

g. Magnetic Detection Inks, Concentrates and Powders

Inks and concentrates: fluorescent and non-fluorescent. Water, hydrocarbon and quick drying based colours. Wetting agents and inhibitors. Dry powders: puffs, cabinets. Preparation and testing of materials: determination of solid content.

5.1.2 Specific theory - welds

a. Testing Procedures

Magnetising operation to be used, current or flux values, jigs or fixtures. Geometric shape of components. Methods of assessing sensitivity of techniques. Remanence technique.

b. Interpretation and Reporting of Indications

Types of discontinuity and their identification (surface and sub-surface indications). Non-relevant indications. Recording: transparent tape transfer, lacquer transfer, photographic (fluorescent and non-fluorescent). Reporting.

c. Demagnetisation and Post Test Procedures

Reasons for demagnetisation, AC and DC methods. Testing for demagnetisation. Cleaning.

d. Standards and Specifications

The standards and specifications to be used will be relevant to the region in which the examination is to be conducted and to the employment of the candidate.

e. Welding technology

Terminology for welds, welded joints, welding procedures.
Types of defect in welds and parent metals detectable by magnetic particle inspection.

5.1.3 Specific theory – general engineering

As for Level 1 welds but in addition candidates for General Engineering certification will be required to have a knowledge of:

a. Basic Casting Production Methods – Finished Products

Definition of casting and how it works.

Types of defect in castings detectable by magnetic particle.

b. Wrought Production Processes

Definition of rolling and how it works.

Types of defect in rolled material detectable by magnetic particle.

Definition of forging and how it works.

Types of defect in forged products detectable by magnetic particle.

5.2 Level 2 Magnetic Particle

5.2.1 General theory

The syllabus is the same as that for Level 1 but the questions will be more complex, and will include rectilinear conductors, long magnetic coils, flux passing in non-magnetic media, continuity of HT and BN, flux of a magnetic discontinuity, remarkable points, curve of first magnetisation, acceptance criteria and radiometers, influence of manufacture and material and document traceability.

5.2.2 Specific theory – welds

As for Level 1 but in addition:

a. Welding technology

Influence on techniques of geometry, size, surface condition, parent metal composition, weld metal structure. Influence of surface cladding, heat treatments and weld repairs.

Basic principles of fusion welding processes.

Types of defect associated with particular parent metal/welding process combinations. Types of defect in welds and parent metals detectable by magnetic particle inspection. Defect parameters which influence detectability.

5.2.3 Specific theory – general engineering

As for Level 1 but in addition:

a. Welding technology

Influence on techniques of geometry, size, surface condition, parent metal composition, weld metal structure. Influence of surface cladding, heat treatments and weld repairs.

Basic principles of fusion welding processes.

Types of defect associated with particular parent metal/welding process combinations. Types of defect in welds and parent metals detectable by magnetic particle inspection. Defect parameters which influence detectability.

b. Basic Production – Crude and Finished Products

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

Difference between ingot and concast production processes.

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

c. Basic Casting Production Methods – Finished Products

Methods of casting: sand casting, die casting, investment casting.

Basic defects associated with cast products, their appearance and how they are formed: shrinkage, inks, cold shuts, porosity, laps, hot tears, cracks.

d. Wrought Production Processes

Rolling process: primary rolling – blooms and slabs, secondary rolling, billets, sections and plates, cold rolling, sheets and strips, basic rolling defects, appearance and how they are formed.

Forging: open die forging and press forging, closed die forging.

Basic forging defects, their appearance and how they are formed: forging bursts, laps, seams, cracks.

Extrusion: definition of and how it works, why extrusion is used instead of rolling or forging.

e. Heat Treatment Processes

Annealing. How annealing is carried out and the results obtained, full anneal and definitions, sub critical anneal and definition.

Normalising: how it is carried out and the results obtained.

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

5.3 Level 3 Magnetic Particle

5.3.1 Basic examination

5.3.1.1 Materials, Processes and Product Technology

Material Technology

Properties of materials, origin of discontinuities and failure modes, statistical process control, probability of detection, ferrimagnetism, influence of temperature, effect of interface between magnetic medium and non-magnetic medium, behaviour of particle on flux, effects of work hardening, alloys (Invar, Inconel, permalloys), format of working procedures.

Basic Production – Crude and Finished Products

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

Difference between ingot and concast production processes.

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

Basic Casting Production Methods – Finished Products

Methods of casting: sand casting, die casting, investment casting.

Basic defects associated with cast products, their appearance and how they are formed: shrinkage, inclusions, cold shuts, porosity, laps, hot tears, cracks.

Wrought Production Processes

Rolling process: primary rolling – blooms and slabs, secondary rolling, billets, sections and plates, cold rolling, sheets and strips, basic rolling defects, appearance and how they are formed.

Forging: open die forging and press forging, closed die forging.

Basic forging defects, their appearance and how they are formed: forging bursts, laps, seams, cracks.

Extrusion: definition of extrusion and how it works; why extrusion is used instead of rolling or forging.

Heat Treatment Processes

Annealing. How annealing is carried out and the results obtained, full anneal and definitions, sub-critical annealing and definition.

Normalising: how normalisation is carried out and the results obtained.

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

Machining and material removal

Turning, boring, milling, grinding and electrochemical.

Surface finishing and corrosion protection.

Shot peening, grit blasting, painting, plating, chemical conversion coatings.

Non-metals and composite materials processing

Dimensional Metrology

5.3.1.2 Other NDT methods

Acoustic Emission

Principles, sources of acoustic emissions, equipment and materials, proper selection of technique.

Electromagnetic Testing

Principles, properties of eddy currents, effect of varying frequency, equipment, application and test results interpretation.

Infrared Thermographic testing

Principles, temperature measurement, technique selection, equipment, application and test results and interpretation.

Liquid Penetrant Inspection

Principles, technique selection, equipment, application and test results interpretation.

Radiographic Inspection

Principles, technique selection, equipment, application and test results interpretation.

Ultrasonic Inspection

Principles, technique selection, equipment, application and test results interpretation.

Visual and Optical Inspection

Principles, technique selection, equipment, application and test results interpretation.

5.3.1.3 Standards and documentation relating to the certification of NDT operators

BS EN ISO 9712, SNT-TC-1A

5.3.2 Main Method Examination

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

6 Recommended Reading

- Product Technology Classroom Training Handbook – The British Institute of Non-Destructive Testing.
- 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 Casting Research and Trade Association 1970.
- Basic Metallurgy for Non-Destructive Testing, Edited by J L Taylor. The British Institute of Non-destructive Testing, 1 Spencer Parade, Northampton NN1 5AA.
- ASNT Classroom Training Handbook originally published by General Dynamics.
- ASNT Self Study Handbook originally published by General Dynamics.
- ASNT Question and Answer Book.
- ASNT Level III Study Guide.
- NDT Handbook, second edition, volume 7 (1991).
- ASNT Student Package.
- ASNT Instructor Package (overheads for training).