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 5b: Computed Radiographic Inspector/Interpreter Levels 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- Requirements for the Certification of Personnel engaged in Non-Destructive Testing in accordance with the requirements of BS EN ISO 9712'.

1 Level 1 Computed Radiographic Inspector

1.1 General theory examination

Not required for candidates who hold valid a or ISO 9712 or equivalent radiographic inspection certification at this level

- 40 multiple choice questions on general theory
- 20 multiple choice questions on basic radiation safety
- Time allowed 90 minutes
- Pass mark 70%

1.2 Specific theory examination

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

1.3 General practical examination

The candidate will be required to assess four phantom images and assess the digital measurements/quality as selected from the list below by the examiner.

- Scanner jitter
- CR plate erasure
- Scanner linearity
- Beam alignment
- SNR/BSR
- Shading

- Time allowed 30 minutes
- Pass mark 70%

1.4 Specific practical examination

1.4.1 Welds

In the practical part of the specific examination, the candidate is required to test two butt welds, one in plate and one in pipe as selected by the examiner to the procedure provided and to evaluate the quality of the digital images produced.

- Time allowed 5 hours
- Pass mark 70%

1.4.2 Castings

In the practical part of the specific examination, the candidate is required to test a minimum of two samples representative of the category as selected by the examiner to the procedure provided and to evaluate the quality of the digital images produced.

- Time allowed 5 hours
- Pass mark 70%

1.4.3 Profile and tangential

In the practical part of the specific examination, the candidate is required to test a minimum of two samples one sample by the profile method and one sample by the tangential method to the procedure provided and evaluate the quality of the digital images produced.

- Time allowed 5 hours
- Pass mark 70%

Note: Both written examinations and practical tests will be selected according to the category of certification being sought with particular reference to the material group(s) and type of radiation.

2 Level 2 Computed Radiographic Inspector

2.1 General theory examination

Not required for candidates who hold a valid Level 2 ISO 9712 or equivalent certification in the method.

- 40 multiple choice questions on general theory
- 20 multiple choice questions on basic radiation safety
- Time allowed 90 minutes
- Pass mark 70%

2.2 Specific theory examination

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

2.3 General practical examination

The candidate will be required to assess four phantom images and assess the digital measurements/quality as selected from the list below by the examiner.

- Scanner jitter
- CR plate erasure
- Scanner linearity
- Beam alignment
- SNR/BSR
- Shading

- Time allowed 30 minutes
- Pass mark 70%

2.4 Specific practical examination

2.4.1 Welds

In the practical part of the specific examination, the candidate is required to test two butt welds, one in plate and one in pipe as selected by the examiner and to evaluate the quality of the digital images produced.

Produce a detailed NDT instruction, suitable for a Level 1 to follow, for one of the samples selected by the examiner.

View, interpret and report on a total of five images, chosen by the examiner to represent the category of certification.

- Time allowed 8 hours
- Pass mark 70% for each sample examined, image interpreted and NDT Instruction

2.4.2 Castings

In the practical part of the specific examination, the candidate is required to test a minimum of two samples representative of the category as selected by the examiner and to evaluate the quality of the digital images produced.

Produce a detailed NDT instruction, suitable for a Level 1 to follow, for one of the samples selected by the examiner.

View, interpret and report on a total of five images, chosen by the examiner to represent the category of certification.

- Time allowed 8 hours
- Pass mark 70% for each sample examined, image interpreted and NDT Instruction

2.4.3 Profile and tangential

In the practical part of the specific examination, the candidate is required to test two samples, one sample by the profile method and one sample by the tangential method and evaluate the images produced for suitability for interpretation.

Produce a detailed NDT instruction, suitable for a Level 1 to follow, for one of the samples selected by the examiner.

View, interpret and report on a total of five images, chosen by the examiner to represent the category of certification.

- Time allowed 8 hours
- Pass mark 70% for each sample examined, image interpreted and NDT Instruction

Notes:

a) Both written examinations and practical tests will be selected according to the sector and categories of certification being sought.

b) Candidates requiring certification in the welds, castings and profile radiography sectors shall digitally radiograph one sample from each sector and interpret a total of two images of welds, castings and profile radiography. The time allowed shall be 12 hours in such cases. All other parts of the examination shall be attempted.

c) All Level 1 and Level 2 candidates will be required to complete a basic radiation safety question paper unless they hold a current basic radiation safety qualification recognised by CSWIP.

3 Level 2 Computed Radiographic Interpreter

3.1 Specific theory examination

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

3.2 Specific practical

3.2.1 Welds

The candidate shall perform the general practical examination as stated in Section 2.3.

View, interpret and report on a total of five images, chosen by the examiner to represent the categories of certification.

- Time allowed 90 minutes
- Pass mark 70% per image assessed and reported

3.2.2 Castings

The candidate shall perform the general practical examination as stated in Section 2.3.

View, interpret and report on a total of five images, chosen by the examiner to represent the categories of certification.

- Time allowed 75 minutes
- Pass mark 70% per image assessed and reported

3.2.3 Profile and tangential

The candidate shall perform the general practical examination as stated in Section 2.3.

View, interpret and report on a total of five images, chosen by the examiner to represent the categories of certification.

- Time allowed 90 minutes
- Pass mark 70% per image assessed and reported

3.2.4 Welds, castings and profile and tangential digital radiographic image

The candidate shall perform the general practical examination as stated in Section 2.3.

View, interpret and report on a total of six images, chosen by the examiner to represent the categories of certification.

- Time allowed 110 minutes
- Pass mark 70% per image assessed and reported
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4 Level 3

4.1 Basic examination (exempt if already holding a Level 3 ISO 9712 Certification)

4.2 Section A1 - Materials and Process Technology

- 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 is open book.

Section B - Level 2 Knowledge of the 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 Level 2 certificate holders in the main NDT methods.

4.3 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 - Application of the NDT method

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

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

Section C3 - Procedure writing

Candidates are required to produce a comprehensive procedure for the radiography of a weld type selected by the examiner and utilising either standard or computed radiographic techniques. This examination part is open book, in that applicable codes and standards are to be made available to the candidate.

- Time allowed 4 hours
- Pass mark 70%

5 Ten Year 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.

The recertification examination shall include both the specific practical and also the general practical as listed for initial candidates as per the level and sector of certification sought. Additionally a written instruction for one sample shall also be produced for those attempting Level 2 computed radiographic inspector.

Candidates attempting computed radiographic inspector, Level 1 or 2 recertification shall hold a current BRS (Basic Radiation Safety) certificate before certification can be granted. This does not apply to those attempting the computed radiographic interpreter certification.

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

6 Examination Syllabus

6.1 Level 1 Computed Radiographic Inspector (Welds) Syllabus

6.1.1 General theory

a. Nature and properties of X and/or Gamma Radiation

Penetration, absorption, scatter, diffraction, transmission. Rectilinear propagation. Photographic, fluorescent and ionising effects. Physiological properties. Descriptions of film, CR and RTR image collection systems

b. Image production aspects

Dark room procedures: layout, processing units, safe-lights and ancillary equipment. Handling and processing of films, temperature control. Handling of imaging plates, scanning and erasure procedures.

Sensitometry: types of film, paper, and imaging plates used in industrial radiography.

The use of differing types of screens in conventional & CR radiography.

c. Fundamental aspects of radiographic quality

Quality of radiation. Optimum working densities. Radiographic contrast. Objective and subjective contrast. Methods of controlling radiographic contrast. Effects of scattered radiation. Use of filters, screens, masking and blocking media. Brief reference to grids. Influence of processing conditions and viewing conditions on contrast.

Radiographic definition: objective and subjective, unsharpness, geometric unsharpness, inter-relationship of dimensions of focal spot or source, focus (source) – object and focus (source) – film distances. Inherent unsharpness. Movement. Film screen contact. The summation of factors controlling definition. Control of radiographic sensitivity and its assessment by the use of image quality indicators. The control of CR radiographic quality by the use of, phantoms, duplex & wire IQI's, line pair IQI's, BAM alignment indicators, contrast sensitivity indicators and S/N ratios.

d. X-ray equipment

Generation of X-rays, their characteristics and selection. Handling equipment.

e. Geometry of image formation

Control of focus (source) – object distance, object – film distance, focus (source) – film distance. Selection of beam angle.

f. Safety

An understanding of working practices including safety precautions (see recommended reading).

6.1.2 Specific theory

a. Exposure calculations

Effect of distance on exposure. Use of exposure charts and calculators for X and gamma radiography using either film or imaging plates.

b. Geometric considerations of radiography for welds and castings and profile RT

- Flaw depth determination in a specimen by the tube or source shift method.
- Geometric unsharpness and its control.
- Principles and practices for profile radiography
- Measurement comparators for CR profile radiography.

c. Viewing of images

Spurious indications relating to film radiography: light (and safe-light) fogging, chemical fog, strains, air bubbles, reticulation, pressure marks, static marks, drying marks, defective screens, incomplete fixing, film manufacturing faults.
Artefacts and fading of CR imaging media.

Optimum viewing conditions. Checking for acceptable density, contrast and freedom from spurious indications.

Monitor types and resolutions for viewing of CR images. Optimum viewing conditions for CR images. Measurements using CR images, Image manipulation techniques.

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 radiographic inspection.

f. Casting technology

Types of castings: sand casting, investment castings, pressure die- castings.

Typical defects in cast materials

6.2 Level 2 Computed Radiographic Inspector (Welds)

6.2.1 General theory

As for Level 1 but the examination questions will be more complex.

6.2.2 Specific theory

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. Defect parameters which influence detectability.

6.3 Level 2 Computed Radiographic Inspector (Castings) Syllabus

6.3.1 General Theory

As for Level 1 but the examination questions will be more complex.

6.3.2 Specific theory

As for Level 1 but in addition:

a. Casting technology

Influence on techniques of geometry, size, surface condition, parent metal composition, feeding and cooling effects on defect formation. Influence of heat treatments and weld repairs.

Basic principles of casting processes.

Types of defect associated with particular materials and casting process combinations. Defect parameters and their influence on detection.

6.4 Level 2 Computed Radiographic Inspector (Profile and Tangential Digital Radiographic Image)

6.4.1 General theory

As for Level 2 but the examination questions will be targeted toward image analysis and assessment.

6.4.2 Specific theory

As for Level 2 but the examination questions will be targeted toward image analysis and assessment.

6.4.3 Specific practical

The production and assessment of CR images for, corrosion, erosion, pitting and the techniques for measurement of the same.

6.5 Level 2 Computed Radiographic Inspector

6.5.1 General theory

As for Level 2 but the examination questions will be targeted toward image analysis and assessment.

6.5.2 Specific theory

As for Level 2 but the examination questions will be targeted toward image analysis and assessment.

6.5.3 Specific practical

The assessment of CR images for, corrosion, erosion, pitting and the techniques for measurement of the same, defect recognition and assessment of welds and castings.

7 Level 3

7.1.1 General theory

7.1.1.1 Section A

1. Materials, Processes and Product Technology

Material Technology

Properties of materials, origin of discontinuities and failure modes, statistical process control and probability of detection.

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, inks, 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 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 anneal and definition.

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

Stress relieving. Why stress relieving is 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

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 interpretation.

Magnetic Particle Inspection

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

3. Standards and Documentation Relating to the Certification of NDT Operators

BS EN ISO 9712EN 473, SNT-TC-1A

7.1.2 Section B

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.

7.1.2.1 Specific theory

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. Candidates will in addition require a knowledge of the following:

Alternative forms of imaging

Fluoroscopy, Real time radiography, digital imaging

Alternative Equipment

Micro focus X-ray equipment, linear accelerators, neutron radiography

8 Recommended Reading

- Product Technology Classroom Training Handbook – The British Institute of Non-Destructive Testing.
- An introduction to Industrial Radiology Techniques by R Halmshaw. Wykeham Publications.
- Basic Metallurgy for NDT. British Institute of NDT.
- Data Sheets for Industrial Radiography. Kodak Limited, London.
- Handbook of Radiographic Apparatus and Techniques, a concise guide to the radiography of welds. The Welding Institute.
- Industrial Radiography. Agfa-Gevaert Limited. Brentford, Middlesex.
- Industrial Radiography. Kodak Limited, London.
- Non-Destructive Testing (second edition, 1991) by R Halmshaw. Edward Arnold.
- Recent Developments in Non-Destructive Testing. The Welding Institute.
- The Physics of Industrial Radiography by R Halmshaw. Heywood.
- 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.
- ASNT Student Package.
- ASNT Instructor Package (overheads for training).

Reference Literature

- BS EN 444 Non-Destructive testing - General Rules for the radiographic Examination of Metallic Materials using X-Rays and Gamma Rays.
- BS EN 462 Non-Destructive testing - Part 5, Image Quality Indicators (duplex wire type) for the Determination of Image Quality values.
- BS EN 584 Non-Destructive testing - Part 1, Classification of Film Systems for Industrial Radiograph.
- Pr EN 14784 Non-Destructive testing Part 1, Industrial Computed Radiography with Phosphor Imaging Plates - Classification of Systems.
- Pr EN 14784 Non-Destructive testing Part 2, General principles for testing of metallic materials using X-rays and gamma rays using storage phosphor imaging plates.
- ASTM E1647 - 2009 Standard Practice for Determining Contrast Sensitivity in Radioscopy.