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 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 5c: Radiographic Inspector Levels 1, 2 and 3

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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.

RADIOGRAPHIC INSPECTOR EXAMINATION FORMAT

1 Level 1

1.1 General examination

- 40 multiple choice questions on general theory
- Time allowed 60 minutes
- Pass mark 70%

1.2 Specific examination

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

1.3 General practical examination

The candidate is required to conduct a test selected by the examiner from:

Check film for fog level
Check fix for clearing
Check safelight.

- 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 a plate butt weld and a pipe butt weld in materials selected by the examiner and to evaluate the quality of the radiographs produced.

- Time allowed 4 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 castings of simple form in materials selected by the examiner and to evaluate the quality of the radiographs produced.

- Time allowed 4 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 type of radiation.

2 Level 2

2.1 General examination

- 40 multiple choice questions on general theory
- Time allowed 60 minutes
- Pass mark 70%

2.2 Specific examination

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

Questions are related to specific theory and to the understanding and interpretation of procedures.

This part is open book – a procedure shall be provided.

2.3 Practical examination

2.3.1 Welds

In practical part of examination the candidate is required to:

- Produce a detailed NDT instruction, suitable for a Level 1 to follow, for one of the samples selected by the examiner.
- Interpret and evaluate a set of 12 radiographs.
- Test two (2) samples, chosen by the examiner, prepare detailed reports for each of the samples and evaluate the radiographs produced for acceptability and areas required further investigation.

Drafting of written instruction and interpretation of set of radiographs shall be completed prior to testing of samples.

Selection of samples

Candidate is required to be able to test following weld configurations:

- SWSI – Single Wall Exposure / Single Wall Image
- DWSI – Double Wall Exposure / Single Wall Image
- DWDI – Double Wall Exposure / Double Wall Image.

Additionally the candidate is required to be able to inspect a variety of materials.

This ability shall be demonstrated by testing of one (1) sample using DWSI configuration and one (1) sample using DWDI configuration.

It is suggested (not required) that samples are made of different materials.

If certification is awarded in X-ray and Gamma ray radiography together the both sources (X- and Gamma) shall be used.

Number of exposures

For both DWDI and DWSI configurations a minimum of two (2) exposures shall be done to demonstrate candidate's ability to maintain sufficient overlap between radiographs. These mean 4 exposures in total.

Selection of samples – Example 1:
DWDI: Aluminium pipe (76mm diameter, 6mm wall thickness) – 2 exposures using X-ray
DWSI: Steel pipe (168mm diameter, 12mm wall thickness) – 2 exposures using Ir192

Selection of samples – Example 2:
DWDI: Copper pipe (38mm diameter, 2.9mm wall thickness) – 2 exposures using X-ray
DWSI: Steel pipe (127mm diameter, 10mm wall thickness) – 2 exposures using Ir192

Set of 12 radiographs

The candidate is required to be able to read, mark up, interpret and report radiographic image.

This ability shall be demonstrated by interpreting of set of 12 radiographs.

A set of radiographs shall cover both Single Wall and Double Wall geometrical configuration. In set shall be at least 4 radiographs representing each geometrical configuration.

The set of radiographs must cover various materials (copper, aluminium, carbon steel and stainless steel must be represented by at least one radiograph in a set). Radiographs shall cover also X-ray and Gamma ray techniques. The requirement for the number of radiographs of any specific technique is not specified.

For each radiograph the candidate is required to define location, size and characterisation of defects and to comment upon radiographic technique and quality of the radiographs.

Candidates will be asked to complete seven multiple choice questions targeting key areas concerning each of the radiographs issued. Candidates will report on a set of 12 radiographs as defined above (84 questions in total).

Example of set composition:

Image no	Configuration	Material	Source
1	SWSI	carbon steel	X-ray
2	SWSI	carbon steel	X-ray
3	DWSI	carbon steel	X-ray
4	SWSI	aluminium	X-ray
5	DWSI	stainless steel	Gamma ray
6	SWSI	copper	X-ray
7	DWDI	carbon steel	X-ray
8	SWSI	carbon steel	Gamma ray
9	DWDI	carbon steel	X-ray
10	DWDI	stainless steel	X-ray
11	SWSI	aluminium	X-ray
12	SWSI	carbon steel	X-ray

- Written instruction (1 hour),
- Set of 12 radiographs – 84 multiple choice questions (3 hours)
- 2 samples (8 hours)
- Total time allowed (12 hours)
- Pass mark 70% per instruction, per sample or per set of 12 radiographs

2.4 Practical - castings

In practical part of examination the candidate is required to:

- Produce a detailed NDT instruction, suitable for a Level 1 to follow, for one of the samples selected by the examiner.
- Interpret and evaluate a set of 12 radiographs.
- Test two (2) samples, prepare a detailed report for each sample and evaluate the radiographs produced for acceptability and areas required further investigation.

Selection of samples

Candidate is required to be able to test various geometrical configurations. Additionally the candidate is required to be able to inspect a variety of materials. Two samples shall be selected by examiner for exam provided that:

- They will require different exposure configuration.
- It is suggested (not required) that samples are made of different materials.

If certification is awarded in X-ray and Gamma ray radiography together then both sources (X- and Gamma) shall be used.

Number of exposures

- Areas of interest shall be defined individually for each casting by examiner.

Set of 12 radiographs

The candidate is required to be able to read, mark up, interpret and report radiographic image.

This ability shall be demonstrated by interpreting of set of 12 radiographs.

A set of radiographs shall cover variety of castings. The radiographs may cover various materials (e.g. copper, aluminium carbon steel or stainless steel). The requirement for number of radiographs from a given material is not specified.

For each radiograph the candidate is required to define location, size and character of defect and to comment upon radiographic technique and quality of the radiographs.

Candidates will be asked to complete seven multiple choice questions targeting key areas concerning each of the radiographs issued. Candidates will report on a set of 12 radiographs as defined above.

- Written instruction (1 hour),
- Set of 12 radiographs – 84 multiple choice questions (3 hours)
- 2 samples (8 hours)
- Total time allowed (12 hours)

Note: Both theory examinations and practical tests will be selected according to the sector and category of certification being sought with particular reference to the type of radiation.

3 Level 3

3.1 Basic examination (exempt if already holding Level 3 EN ISO 9712 Certification)

Section A1 – Material Science 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 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, (either ultrasonic or radiographic inspection).

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

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

3.2 Main Method Examination

Section C1 – Knowledge of the Method

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 specifications.

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

Section C3 – Procedure Writing

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 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-11/93-R, Section 7.5.3.

4.1 Level 1 Radiographic Inspector

4.1.1 Welds

The candidate is required to test a plate butt weld and a pipe butt weld in materials selected by the examiner and to evaluate the quality of the radiographs produced.

- Time allowed 4 hours
- Pass mark 70%.

4.1.2 Castings

The candidate is required to test a minimum of two castings of simple form in materials selected by the examiner and to evaluate the quality of the radiographs produced.

- Time allowed 4 hours
- Pass mark 70%.

Note: Tests will be selected according to the category of certification being recertified with particular reference to the type of radiation.

4.2 Level 2 Radiographic Inspector

4.2.1 Welds

The candidate is required to:

- Interpret and evaluate a set of 12 radiographs.
- Test one (1) sample, chosen by the examiner, prepare detailed reports for each of the samples and evaluate the radiographs produced for acceptability and areas required further investigation.

Same rules for sample selection as in case of initial exam shall be applied.

- Set of 12 radiographs – 84 multiple choice questions (3 hours)
- One sample (4 hours)
- Total time allowed (7 hours)
- Pass mark 70% per sample or per set of 12 radiographs

4.2.2 Castings

The candidate is required to:

- Interpret and evaluate a set of 12 radiographs.
- Test one (1) sample, chosen by the examiner, prepare detailed reports for each of the samples and evaluate the radiographs produced for acceptability and areas required further investigation.

Same rules for sample selection as in case of initial exam shall be applied.

- Set of 12 radiographs – 84 multiple choice questions (3 hours)
- One sample (4 hours)
- Total time allowed (7 hours)
- Pass mark 70% per sample or per set of 12 radiographs

5 Examination Syllabus

5.1 Level 1 Radiographic Inspector (Welds)

5.1.1 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, origin of gamma radiation

b. Photographic aspects

Dark room procedures: layout, light traps and entrance, wet and dry benches, film-pass hatches, processing units, safe-lights and ancillary equipment. Handling and processing of films, temperature control.

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

The use of screens

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, influences on detectability.

d. X-ray and gamma ray equipment

Generation of X-rays, their characteristics and selection, design and operation of X-ray machines and gamma ray devices. 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).

5.1.2 Specific Theory

a. Exposure calculations

Effect of distance on exposure. Use of exposure charts and calculators for X and gamma radiography.

b. Geometric considerations of radiography for welds and castings

Flaw depth determination in a specimen by the tube or source shift method.

Geometric unsharpness and its control

c. Viewing of radiographs

Spurious indications: light (and safe-light) fogging, chemical fog, strains, air bubbles, reticulation, pressure marks, static marks, drying marks, finger marks, defective screens, incomplete fixing, film manufacturing faults.

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

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.

5.2 Level 2 Radiographic Inspector (Welds)

5.2.1 General theory

As for Level 1 but the examination questions will be more complex, including basics of evaluation and classification of imperfections, document traceability and alternative detectors to film.

5.2.2 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, special techniques including 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.

5.3 Level 2 Radiographic Inspector (Castings)

5.3.1 General Theory

As for Level 1 but the examination questions will be more complex, including basics of evaluation and classification of imperfections, document traceability and alternative detectors to film..

5.3.2 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. Special techniques including 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.

5.4 Level 3 Radiographic Inspection

5.4.1 General Theory

5.4.1.1 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.

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

EN ISO 9712, SNT-TC-1A

5.4.1.2 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.

5.4.2 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

6 Reference Literature

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- The Physics of Industrial Radiography by R Halmshaw. Heywood.
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- 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).
- IRR 1999