



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 Syllabuses for the Certification of Personnel Engaged in Non-Destructive Testing of Welded Joints and General Engineering Components

PART 7: ACFM Inspector, Level 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-11/93R 'Requirements for the Certification of Personnel engaged in Non-Destructive Testing in accordance with the requirements of BS EN ISO 9712'.

ACFM INSPECTOR – EXAMINATION FORMAT

1 Level 1 ACFM Inspector

1.1 General theory examination

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

1.2 Specific theory examination

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

1.3 General practical

In the practical part, the candidate is required to set up and conduct operational and function checks on equipment and probes; record function check data and print out a hard copy.

- Time allowed 30 minutes
- Pass mark 70%

1.4 Specific practical

Candidates for certification in ACFM inspection can seek qualification in general engineering, rails or welds. General engineering encompasses welds, castings and wrought products (including forgings). The specific practical examinations in these two sectors are as shown below.

1.4.1 General engineering

The candidate is required to carry out inspections following written procedures as specified by an NDT Level 2 operator. The candidate is required to test and report on two specimens selected by the examiner; carry out sizing for length and depth; record inspection data in accordance with accepted conventions; transfer inspection data files to long term storage.

- Time allowed 1 hour
- Pass mark 70%.

1.4.2 Rails

The candidate is required to carry out inspections following written procedures as specified by an NDT Level 2 operator. The candidate is required to test and report on two specimens selected by the examiner; carry out sizing for length and depth; record inspection data in accordance with accepted conventions; transfer inspection data files to long term storage.

- Time allowed 1 hour
- Pass mark 70%.

1.4.3 Welds

The candidate is required to carry out inspections following written procedures as specified by an NDT Level 2 operator. The candidate is required to test and report on two specimens selected by the examiner; carry out sizing for length and depth; record inspection data in accordance with accepted conventions; transfer inspection data files to long term storage.

- Time allowed 1 hour
- Pass mark 70%.

2 Level 2 ACFM Inspector

2.1 General theory examination

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

2.2 Specific theory examination

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

2.3 General Practical Examination

In the practical part, the candidate is required to choose the necessary probes and equipment to conduct the test; conduct operational and function checks on equipment and probes; record function check. Data and print out hard copy.

- Time allowed 30 minutes
- Pass mark 70%

2.4 Specific practical examination

Candidates for certification in ACFM inspection can seek qualification in general engineering, rail or welds. General Engineering encompasses welds, castings and wrought products (including forgings). The specific practical examinations are as shown below:

2.4.1 General engineering

To test and report on three specimens selected by the examiner; carry out sizing for length and depth on a fatigue crack specified by the examiner; record inspection data in accordance with accepted conventions; transfer inspection data files to long term storage.

- Time allowed 1 hour 30 minutes
- 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 Rails

To test and report on three specimens selected by the examiner; carry out sizing for length and depth on a fatigue crack specified by the examiner; record inspection data in accordance with accepted conventions; transfer inspection data files to long term storage.

- Time allowed 1 hour 30 minutes
- 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%

2.4.5 Welds

To test and report on three specimens selected by the examiner; carry out sizing for length and depth on a fatigue crack specified by the examiner; record inspection data in accordance with accepted conventions; transfer inspection data files to long term storage.

- Time allowed 1 hour 30 minutes
- Pass mark 70%

2.4.6 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 ACFM Inspector – Welds, Plates, Castings, Forgings, Bars and Rails made of Ferritic Steel (or Electromagnetically Similar Material)

3.1 Basic examination (exempt if already a holding Level 3 ISO 9712 certification)

Section A1 Material Science and Processes

- 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 Level 2 certificate holders in the main NDT methods.

3.2 Main method examination

Section C1 - Knowledge of the Method General Theory

- 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 with respect to codes, standards and specifications.

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

Section C3 - NDT 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 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 ACFM Inspector

4.1.1 General Practical Examination

In the practical part, the candidate is required to choose the necessary probes and equipment to conduct the test; conduct operational and function checks on equipment and probes; record function check. Data and print out a hard copy.

- Time allowed 30 minutes
- Pass mark 70%

The candidate is required to carry out inspections following written procedures as specified by NDT Level 2 operator. The candidate is required to test and report on two specimens selected by the examiner; carry out sizing for length and depth; record inspection data in accordance with accepted conventions; transfer inspection data files to long term storage.

- Time allowed 1 hour
- Pass mark 70%

4.2 Level 2 ACFM Inspector

4.2.1 General Practical Examination

In the practical part, the candidate is required to choose the necessary probes and equipment to conduct the test; conduct operational and function checks on equipment and probes; record function check. Data and print out hard copy.

- Time allowed 30 minutes
- Pass mark 70%

4.3 Specific practical

The candidate is required to test and report on three specimens selected by the examiner; carry out sizing for length and depth on a fatigue crack specified by the examiner; record inspection data in accordance with accepted conventions; transfer inspection data files to long term storage.

- Time allowed 90 minutes
- Pass mark 70%

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%

5 Examination - Syllabus

5.1 Level 1 ACFM Inspector

5.1.1 General theory

a) Overview of NDT techniques

Visual inspection; MPI; History of electromagnetic testing.

b) Electricity

Formation of electrical current; current and voltage; resistance and Ohm's law; alternating current.

c) Magnetism

Line of force and force fields; residual magnetism; effect of material geometry on magnetic fields.

d) Electromagnetism

Induction and magnetic fields; magnetic permeability; induced magnetic flux; magnetic field produced by a current.

e) Eddy Currents

Eddy current induced by a magnetic field; fields created by eddy currents; eddy current distribution; standard depth of penetration; factors affecting penetration; theory of deflection of currents by defects.

5.1.2 Specific ACFM Theory

a) ACFM Theory

Uniform fields; interaction of field with defects; effects of field curvature; Bx and Bz field components; typical displays; Bx and Bz time base; butterfly plot; ACFM defect models.

b) ACFM Equipment

Equipment design and construction; equipment set up and basic operation; basic maintenance; potential equipment faults, causes and corrective actions.

c) ACFM Manual and Array Probes

Simple probes; field generation; Bx and Bz sensors; multiple coil configurations; advantages and limitations of array probes; position encoders; X and Y field direction switching; optical encoder; identity chip; multiple Bz coil pencil probes.

d) ACFM Software

Role of individual package components; task based operation; importance of component identification; software set up; operation of main inspection screen.

e) Defect Sizing

Manual software sizing; automatic sizing and limitations, defect sizing limits defect detection limits; minimum detectable defect size and measurement.

f) Basic Signal Interpretation

Signals influenced by geometry and material variations; defect shape and orientation; edge effects; influence of attachments; material changes; surface finish; effects of non-conductive coatings; false indications and causes.

g) Basic scanning techniques

Function checks; probe deployment including A / C / T direction; software operation to start and stop scan; operation of markers.

h) Detailed Signal interpretation

Relationship between Bx, Bz and butterfly plot; typical signals from spark eroded slot; general strategies for crack identification; effect on signal from, lift off, plate edges, welds, bolt holes, other general geometry effects, inclined defects, transverse defects.

i) Defect sizing

Use of ACFM model; data required to size using models; sizing problems.

j) Data

Storage of data; retrieval of data.

k) Reporting

Marking the product under test; individual data print outs; creating standard reports; retrieval of information.

l) Standards

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.

5.1.3 Specific Theory

5.1.3.1 General Engineering

a) Welding technology

Terminology for welds, welded joints, welding procedures; types of defects in welds and parent metals detectable by ACFM inspection methods.

b) Basic Casting Production Methods – Finished Products

Definition of casting how it works; types of defect in castings detectable by ACFM inspection methods.

c) Wrought Production Processes

Definition of rolling and how it works; types of defects in rolled material detectable by ACFM inspection methods; definition of forging and how it works; types of defect in forged products detectable by ACFM inspection methods.

5.1.3.2 Rails

a) Rails

Stress areas; types of defect and their related signals; sizing different defect types.

b) Wheel sets

Axles; wheels.

5.1.3.3 Welds

a) Welding technology

Terminology for welds, welded joints, welding procedures; types of defects in welds and parent metals detectable by ACFM inspection methods.

5.2 Level 2 ACFM Inspector

5.2.1 General theory

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

5.2.2 Specific theory

As for Level 1, plus:

a) ACFM Specific Theory

Probe characteristics and selection.

b) Defect Sizing

Limitations of ACFM model; advanced manual sizing.

c) Safety Precautions

Fire hazards; electrical safety.

d) Conduct of Test

Test procedures and reasons for NDT instructions; briefing of the remote probe operator; minimum qualifications for remote probe operator; supervision of Level 1 personnel; production of probe files; computer file handling.

e) Detailed Signal Interpretation

Types of discontinuity and their identification; relevant and non-relevant indications and their cause; identification of crack features; capabilities and limitations of other NDT methods in terms of detection; characterisation and confirmation of defects.

f) Reporting

Responsibilities for reporting; origination and authentication of NDT reports; content and layout of report; presentation of the inspection results of an NDT report; hard copy computer generated reports; maintenance and retention of records.

5.2.3 Specific Theory

5.2.3.1 General Engineering

As for Level 1 plus:

a) Welding and Wrought Product Technology

Terminology of welds; basic principles of fusion welding processes; methods of producing welds including, MMA, TIG, MAG, Submerged Arc, and Electro slag; rail weld types.

Basic types of welds including, fillet welds, butt welds. Variable configuration welds including, 'T's nozzles and nodes.

Terminology for wrought products including, forging, hammer forging and press forging. Methods of casting.

Influence on techniques of geometry, size, surface condition, parent metal composition; influence of non – conductive and conductive paint coatings and weld repairs; types of defect in welds and parent metals including lack of fusion, porosity, worm holes and cracks.

b) Equipment maintenance

Probe care; trouble shooting; instrument and battery care.

c) Reporting

Configuring customers reports; emailing reports; incorporating results into reports; searching for and emailing data records.

5.2.3.2 Rails

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

5.2.3.3 Welds

As for Level 1 plus:

Terminology of welds; basic principles of fusion welding processes; methods of producing welds including, MMA, TIG, MAG, Submerged Arc, and Electro slag; rail weld types.

Basic types of welds including, fillet welds, butt welds. Variable configuration welds including, 'T's nozzles and nodes.

Terminology for wrought products including, rolling, forging, and casting.

Influence on techniques of geometry, size, surface condition, parent metal composition; influence of non – conductive and conductive paint coatings and weld repairs; types of defect in welds and parent metals including lack of fusion, porosity, worm holes and cracks.

b) Equipment maintenance

Probe care; trouble shooting; instrument and battery care.

c) Reporting

Configuring customers reports; emailing reports; incorporating results into reports; searching for and emailing data records.

5.3 Level 3 ACFM Inspector

5.3.1 General theory

5.3.1.1 Section A1

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. What 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 Section A2 - Standards and Documentation Relating to the Certification of NDT Operators

BS EN ISO 9712, SNT-TC-1A

3 Section B - Other NDT Methods:

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.

5.3.2 Sections C1 and C2 – Level 3 General Theory and Application of the Test Method

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 Reference Literature

- Product Technology Classroom Training Handbook – The British Institute of NDT 1995.
- 'Ultrasonic Testing of Materials' by J and H Krautkramer. George Allen & Unwin Limited, London, 1990 ISBN 0387512314.
- 'Principles and practice of non-destructive testing' edited by Dr J H Lambie. Heywood and Company, London, 1962.
- Non-Destructive Testing (second edition, 1991) by R Halmshaw. Edward Arnold, London 1991 ISBN 0340545216.
- TWI Training Hand Book for electromagnetic inspection using ACFM (July 2000).
- ASNT Level III Study Guide.
- NDT Handbook, volume 7 Ultrasonic Handbook, ASNT 1991, Columbus, Ohio ISBN 0931403049.
- TSC Handbook and operating instructions manuals. Technical Software Consultants Ltd, 6 Mill Square, Featherstone Road, Wolverton Mill, Milton Keynes, MK12 5RB.