INTERNATIONAL STANDARD

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Non-destructive testing — Qualification of personnel for limited applications of non-destructive testing

Essais non destructifs — Qualification du personnel pour des applications limitées en essais non destructifs

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 20807 was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 7, *Personnel qualification*.

Introduction

Since the effectiveness of any application of non-destructive testing depends upon the capabilities of the persons who perform or who are responsible for the test, a procedure has been developed to provide a means for evaluating and documenting the competence of personnel whose duties require the appropriate theoretical knowledge and practical competence of the non-destructive tests that they perform.

For this reason, ISO/TC 135 developed an International Standard, ISO 9712, to ensure that the certification of competence of NDT personnel could be performed to a consistent and high standard worldwide.

Recognizing, however, that the provisions of ISO 9712 were not necessarily appropriate in some instances, e.g., in limited applications of non-destructive testing, ISO TC135 SC 7 authorized a Working Group (WG 5) to draft proposals which would facilitate the standardization of the qualification of personnel carrying out such limited NDT applications. This document represents the result of the deliberations of ISO/TC 135/SC 7/WG 5.

As a provision outside the scope of ISO 9712 requirements, limited NDT is the practice of a test method for a particular application requiring specific training and experience, i.e., an application which is limited, repetitive or automated. It should be noted that, within ISO 9712, there is provision for a reduction in the duration of training and experience required for eligibility. Annex A serves to provide examples of syllabi for the training and examination of personnel seeking qualification to this International Standard.

The methodology set out in this International Standard may be applied to the qualification of personnel for any limited application of NDT. However, it is not intended that qualification for limited applications be substituted for qualification and certification under ISO 9712.

NOTE Wherever gender-specific words such as "his", "her", "he" or "she" appear in this International Standard the other gender is also applicable.

Non-destructive testing — Qualification of personnel for limited applications of non-destructive testing

1 Scope

1.1 This International Standard establishes a system for the qualification of personnel who perform NDT applications of a limited, repetitive or automated nature, such as:

a) eddy current and electromagnetic sorting of materials;

b) eddy current and electromagnetic testing of tubular products during manufacture;

c) normal beam ultrasonic testing of plate materials during manufacture;

d) ultrasonic thickness testing.

These examples are not intended to restrict the range of qualifications which could be covered by this International Standard.

1.2 This standard therefore does not provide for magnetic particle testing (MT) or liquid penetrant testing (PT).

NOTE The arrangements described in ISO 9712 provide sufficient flexibility to allow limited applications of these methods.

1.3 When the need for qualified non-destructive testing (NDT) personnel is defined in product standards, regulations, codes or specifications, and the nature of the testing to be carried out is limited in scope or automated such that the qualification requirements specified in ISO 9712 are considered inappropriate or excessive, it may be satisfied by qualification in accordance with this International Standard.

1.4 This International Standard is not intended to supplant the qualification and certification requirements detailed in sector-specific standards, such as ISO 11484:1994 *Steel tubes for pressure purposes — Qualification and certification of non-destructive testing (NDT) personnel.*

1.5 The requirements detailed herein apply only to NDT personnel qualified for specific applications, and no direct attempt should be made to equate this to the NDT levels defined in ISO 9712. However, it is recommended that qualified personnel defined in this International Standard be supervised by an appropriately certified NDT level 2 or 3 person as defined in ISO 9712:1999.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9712:1999, *Non-destructive testing — Qualification and certification of personnel*

ISO/IEC 17024, *Conformity assessment — General requirements for bodies operating certification of persons*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
candidate
individual seeking qualification and who gains experience under the supervision of suitably qualified personnel

3.2
certificate
document issued by the certification body under the provisions of this International Standard indicating that the named person has demonstrated the competence(s) defined on the certificate

3.3
certification body
body that administers procedures for qualification to the requirements of this International Standard

3.4
employer
organization for which the candidate works on a regular basis

3.5
examination centre
centre approved by the certification body, where qualification examinations are carried out

NOTE An examination centre may be situated at an employer's premises

3.6
examination invigilator
person authorized by the certification body to supervise examinations

3.7
examination, practical
examination of practical skills, in which the candidate demonstrates familiarity with, and the ability to operate the test equipment

3.8
examination question, multiple choice
wording of a question giving rise to four potential replies, only one of which is correct, the remaining three being incorrect or incomplete

3.9
examination question, short answer
written question that requires the candidate to respond using one or more sentences, or to provide a mathematical solution showing all calculations

NOTE A short answer examination question may provide some guidance on the matters to be included in the candidate's response.

3.10
examination, written
examination concerned with the principles of an NDT method and with the candidate's knowledge of procedures, codes, standards and specifications

3.11
examiner
person certified at level 3 in accordance with the provisions of ISO 9712 for the method and sector he is to examine, and authorized by the certification body to conduct, supervise and grade NDT qualification examinations

3.12
experience
period during which the candidate carried out, under supervision, the NDT application for which qualification is sought

3.13
NDT application
specific non-destructive test applied to a defined product or range of products

NOTE An NDT application will normally be restricted to the use of only one NDT method but may involve the use of more than one NDT technique.

3.14
NDT instruction
written description of the precise steps to be followed in testing to an established standard, code, specification or NDT procedure

3.15
NDT method
discipline applying a physical principle in non-destructive testing (e.g., ultrasonic testing)

3.16
NDT operator
individual qualified in accordance with this International Standard

3.17
NDT procedure
written description of all essential parameters and precautions to be observed when applying an NDT technique to a specific test, following an established standard, code or specification

NOTE An NDT procedure can involve the application of more than one NDT method or technique.

3.18
NDT technique
specific way of utilizing an NDT method (e.g., immersion ultrasonic testing)

3.19
NDT training
process of instruction in theory and practice in the NDT application for which qualification is sought, which takes the form of training courses covering an approved syllabus

3.20
operating authorization
written statement issued by the employer authorizing the individual to carry out the NDT application(s) detailed on the certificate of qualification

3.21
qualification
demonstration of physical attributes, knowledge, skill, training and experience required to properly perform NDT tasks

3.22
qualifying body
competent organization approved by the certification body to prepare and administer examinations aimed at qualifying NDT personnel

3.23
significant interruption
absence or a change of activity that prevents the qualified individual from practicing the duties corresponding to the level in the method and the sector(s) within the certified scope, for a) a continuous period in excess of 365 days or b) two or more periods for a total time exceeding two years

NOTE Legal holidays, periods of sickness or courses of less than thirty days are not taken into account when calculating the interruption.

3.24
specimen
sample used in practical examinations which should be representative of products typically tested in the NDT application for which qualification is sought and may include more than one area or volume to be tested

NOTE Samples should contain discontinuities typical of those found in the products concerned.

3.25
specimen master report
model answer, indicating the optimum result for a practical examination given a defined set of conditions (equipment type, settings, technique, specimen, etc.), against which the candidate's test report will be graded

3.26
supervision
act of directing the application of NDT performed by other NDT personnel, which includes the control of actions involved in the preparation of the test, performance of the test and reporting of the results

4 Responsibilities

4.1 Certification body

4.1.1 The certification body shall conform to the requirements of ISO/IEC 17024.

4.1.2 A certification body

a) shall accept ultimate responsibility for qualification as specified in this International Standard;

b) shall administer the procedures and operations for qualification in accordance with a documented procedure meeting the minimum requirements of this International Standard;

c) may delegate, under its direct responsibility, the detailed administration of the qualification procedure to other organizations which will act as qualifying bodies; the certification body shall publish its requirements for the approval of qualifying bodies. Where the qualifying body is also the employer, the certification body shall require additional controls to preserve impartiality;

d) shall authorize appropriately trained and qualified examiners to set, conduct and grade the examinations described in this International Standard;

e) shall approve, either directly or through a qualifying body, properly staffed and equipped examination centres;

f) shall, having reviewed the evidence of qualification, make and record its decision to authorize the issue of a certificate of qualification;

g) shall ensure that appropriate records are maintained and issue, or delegate the issuing of, certificates of qualification;

h) shall ensure that a databank of relevant examination questions is maintained;

1) for each multiple choice question this databank shall indicate the correct answer;

2) for other questions this databank shall include a model answer.

NOTE It is desirable that answers include a reference that validates the answer to the examination question.

4.2 Qualifying body

The qualifying body, where established, shall be authorized by the certification body to

a) apply a documented quality procedure;

b) establish and monitor examination centres with adequate qualified staff, premises and equipment to ensure satisfactory qualification examinations for the NDT applications concerned;

c) prepare and supervise qualification examinations;

d) if required by the certification body, create and maintain a collection of relevant examination materials, including specimens, questions and answers;

e) use only those examination questions and practical specimens approved by the certification body for examinations;

f) maintain qualification records as required by the certification body.

4.3 Examination centres

Examination centres shall

a) comply with the requirements of the certification body;

b) have test specimens, approved by the certification body, of difficulty comparable to those existant at other centres;

c) under no circumstances use test specimens for training purposes.

4.4 Employer

The employer shall

a) introduce the candidate to the certification body or qualifying body (if the candidate is self-employed, or presents himself alone, he shall assume all responsibilities described for the employer);

b) confirm the validity of the personal information provided, including the declaration of satisfactory vision, education, training and experience needed to establish the eligibility of the candidate;

c) be fully responsible for all that concerns the authorization to operate and the validity of the results of NDT operations;

d) ensure that NDT operators holding certificates of qualification issued conforming to this International Standard undergo an annual test of visual acuity.

5 Domains of competence

NDT operators qualified in accordance with this International Standard may, within the scope and limitations of the qualification concerned

a) set up and verify equipment settings;

b) perform the tests in accordance with NDT instructions produced by appropriately qualified personnel such as those certified Level 2 or Level 3 in accordance with ISO 9712:1999;

c) record, classify, interpret and evaluate the test results in accordance with written criteria;

d) organize and report test results.

6 Vision requirements

6.1 The candidate shall provide documented evidence of satisfactory vision in accordance with the following requirements:

a) near-vision acuity shall permit reading a minimum of Times Roman N4,5 or equivalent letters (Times New Roman of 4,5 points where 11 point = 1/72 inch or 0,352 8 mm) at not less than 30 cm with one or both eyes, either corrected or uncorrected;

b) colour vision shall be sufficient that the candidate can distinguish contrast between the colours used in the NDT method concerned as specified by the employer.

6.2 Subsequent to qualification, the tests of visual acuity shall be carried out annually and be verified by the employer.

7 Eligibility

7.1 Eligibility for examination

To be eligible for examination, the candidate shall provide evidence acceptable to the qualifying body or to the certification body, of completion of a course of NDT training appropriate to the scope of qualification sought.

NOTE 1 Training providers should issue documentary proof of completion of training.

NOTE 2 Information in Annex A may be used as guidance for the development of training and education syllabi, and duration of training.

7.2 Eligibility for the award of a certificate of qualification

7.2.1 The candidate shall have satisfactorily completed an appropriate written and practical examination.

7.2.2 The candidate shall have gained experience as required by the certification body, taking into account the guidance provided in A.1 to A.4.

7.2.3 The candidate shall provide documentary evidence of satisfactory vision in accordance with Clause 6.

8 Examinations

8.1 General

The qualification examination shall comprise a written examination and a practical examination. A guide to the construction of a written examination syllabus and practical tests to be carried out is given in Annex A.

8.2 Written examination

8.2.1 The written examination shall include an evaluation of the candidate's understanding of the NDT application, as well as the theory of the NDT method. Questions shall be selected from the certification body's or the qualifying body's collection of questions valid on the date of examination. The candidate shall be required, as a minimum, to give answers to thirty questions, which may be multiple choice and/or short answer questions.

8.2.2 The time allowed to the candidates for completion of each examination shall be based upon the level of difficulty of the questions. The average time allowed for multiple choice questions shall be no longer than three minutes per question. The average time allowed for written questions shall be determined by the certification body.

8.3 Practical examination

8.3.1 The practical examination shall require that the candidate demonstrate competence in the application of the NDT method and technique to products appropriate to the NDT application for which qualification is sought.

8.3.2 Specimens shall contain discontinuities characteristic of those that occur during manufacturing or in service. Discontinuities may be natural, artificial or implanted. Each practical examination specimen shall be uniquely identified and have a master report that gives details of all the relevant properties of, and flaws in the test specimen. The master report should include all relevant equipment settings used to prepare the master report (see Annex B). The master report for use in grading examinations shall be compiled based upon at least two independent tests conducted by appropriately qualified personnel, and shall be authorized by an examiner.

8.3.3 The number of areas or volumes to be tested shall be adequate to the application concerned, and shall be documented by the certification or qualification body.

8.4 Conduct of examination

8.4.1 All examinations shall be conducted in centres approved and monitored by the certification body, either directly or through a qualifying body.

8.4.2 Before commencement of the examination, the candidate shall present to the examiner or invigilator valid proof of identification.

8.4.3 Written and practical examinations shall be approved by an examiner.

8.4.4 Examinations shall be invigilated by an examiner, or by one or more authorized invigilators placed under the examiner's responsibility.

8.4.5 The examiner shall not be the only examiner for any candidate he has personally trained for that particular examination or who is employed by or belongs to the same organization as the examiner.

8.4.6 A candidate for a practical examination may use his own apparatus. In this case, the examiner shall establish that the apparatus is covered, where applicable, by a valid certificate of calibration, and is serviceable for the purpose of the examination.

8.5 Grading

8.5.1 An examiner shall be responsible for grading the examinations in accordance with procedures approved by the certification body.

8.5.2 The written and practical examinations shall be graded separately.

8.5.3 To be successful in the examinations, a candidate shall obtain a grade of at least 70 % in the written examination and 80 % in the practical examination (suggested weighting factors for practical examination elements is given in informative Annex B).

9 Qualification

9.1 General

The certification body shall, in all cases, review evidence of qualification and, where competence is proven, issue or authorize the issue of a certificate and corresponding wallet card.

9.2 Certificates and wallet cards

9.2.1 When authorized to do so, the qualifying body may issue certificates and corresponding wallet cards.

9.2.2 Certificates of qualification and/or corresponding wallet card shall, between them, include:

a) the full name of the qualified individual;

b) the date of qualification;

c) the date upon which qualification expires;

d) the name of the certification body;

e) the scope of the qualification, including specific applications covered;

f) a unique personal identification number;

g) the signature of the qualified individual;

h) a photograph of the qualified individual in the case of the wallet card;

i) a device to prevent falsification;

j) the signature on the certificate of a designated representative of the certification body or qualification body;

k) the signature(s) of the employer(s).

NOTE By issuing the certificate of qualification and/or corresponding wallet card, the certification body attests to the qualification of the NDT operator but does not give any operating authorization. The signature of the employer on the certificate of qualification may provide evidence that the employer is authorizing the certificate holder to operate within the scope defined on the certificate.

9.3 Validity

The period of validity of the certificate of qualification shall not exceed five years from the date of qualification indicated on the certificate and/or wallet card.

The certificate of qualification shall be invalid:

a) for any specific applications other than that for which it was issued;

b) at the discretion of the certification body after reviewing evidence of unethical behaviour or incompetence;

c) if the NDT operator fails to meet the vision requirements;

d) if a significant interruption takes place in the NDT operator's work within the scope of the certificate of qualification.

10 Renewal

10.1 Upon completion of the first 5-year period of validity, a certificate of qualification may be renewed by the certification body or qualifying body for a new period of five years, provided the certificate holder supplies, in a form acceptable to the certification body, documentary evidence of:

a) satisfactorily meeting the vision requirements of this International Standard during the preceding 12 months;

b) continued satisfactory work activity relevant to the certificate of qualification without significant interruption.

10.2 If the criteria for renewal are not met, the individual shall follow the same rules as for initial qualification.

11 Re-qualification

11.1 Upon completion of each second period of validity (every ten years), or following a significant interruption, a new certificate of qualification shall be issued by the certification body for a period of five years on the basis of the following requirements:

a) the candidate provides evidence of meeting the vision requirements of this International Standard;

b) the candidate is successful in a practical examination, which includes the competences covered by the scope of the qualification.

11.2 If the NDT operator fails to achieve a grade of at least 70 % for each specimen attempted (weighted according to the guidance given in Annex B), two retests of the whole requalification examination shall be allowed within 6 months. In the event of failure in the two permissible retests, the certificate of qualification shall not be issued and in order to regain qualification, the individual shall follow the same rules as for initial qualification.

12 Files

12.1 The certification body shall create and maintain an updated list of all certificates of qualification awarded.

12.2 The certification body or qualifying body shall maintain individual files for each qualified NDT operator, including those whose certificate of qualification has lapsed, containing:

a) application forms;

b) examination documents, such as questionnaires, answers, description of specimens, records, results of test, written procedures, grade sheets;

c) renewal documents, including evidence of visual acuity and continuous activity.

12.3 Individual files shall be kept under suitable conditions of safety and confidentiality for as long as the certificate of qualification remains valid and for at least ten years after the lapse of the certificates of qualification to which they relate.

Annex A
(informative)

Example syllabi and competencies

IMPORTANT — This annex contains four modules, A.1 to A.4, which provide example syllabi and competencies which may be used directly or adapted to specific situations. These examples are not intended to restrict the range of qualifications which could be developed by individual countries to satisfy national requirements.

The training provided to the candidate will be derived from the following syllabus, and will be appropriate to the scope of the qualification to be awarded.

A.1 Eddy current and electromagnetic sorting of materials

A.1.1 Duration of training and experience prior to authorization

It is anticipated that a candidate will achieve the full module purpose in 24 h to 40 h of training and not less than 160 h of supervised experience.

It is anticipated that a candidate will achieve the module purpose for use of simple instruments measuring only one parameter in 8 h to 24 h of training and not less than 40 h of supervised experience.

A.1.2 Purpose of the module

To enable candidates to describe the basic principles of materials sorting using electromagnetic techniques as applied to eddy current sorting of materials, and to undertake material sorting using eddy current equipment.

A.1.3 Content

Basic principles of eddy currents and electromagnetism

Electricity

— direct current, amperage, voltage

Ohm's law and resistance, conductivity and resistivity

— alternating current

Electromagnetic induction

— field generated by a current

— field/induction relationship

— effect of fill factor

— effect of frequency

— influence of magnetic field

- Magnetism
  - magnetic data
  - induction and magnetic fields
  - magnetic permeability
  - coercive force
  - saturation magnetism
  - iron magnetisation
  - induced magnetic flux
  - lines of force and force fields
- Electromagnetism
  - magnetic field produced by a current
  - inductive current – eddy current
  - skin effect
    - effect of test frequency

Reactance (field produced by eddy current)

Theory of eddy currents

Distribution of eddy currents

Plane conductors

- depth of standard penetration
- defect reaction according to its position

Cylindrical bars

- depth of standard penetration
- defect reaction according to its position

Tubes

- depth of standard penetration
- defect reaction according to its position

Characteristics of eddy current and electromagnetic sorting probes and coils

Induction and reception functions

Absolute and differential measure

Types of probes, encircling, internal, surface, hybrid

— field from an empty coil

Effect of coupling

— EC distribution related to coil position

Eddy current equipment

Working principles

— transmission, reception, data presentation

— Equipment controls

— oscillator – frequency control

— magnetizing current control

— energizing devices and measurement

— balancing the system – sensitivity

— amplifier, filter, modulation/demodulation

— phase rotation

— CRT Display – ellipse, A-scan, vector point

— analogue display – digital/meter

— gain control

Properties of materials

Physical properties — Ferromagnetic and non-ferromagnetic materials

— electrical conductivity – effect of chemical analysis, temperature, hardness, grain structure, texture, cold work, structure

— magnetic permeability – effect of chemical analysis, temperature, hardness, grain structure, texture, cold work, structure

Influence of various parameters on eddy current measurement

— defect position and orientation

— EC path, penetration depth, zone of probe action

— material temperature

— structure and geometry of test part

Choice of frequency, phase discrimination, noise filtering, magnetic saturation

— coupling influence

— vibrations, centering, fill factor, sensitivity, compensation

— relative speed

— testing frequencies according to speed

A.1.4 Learning outcome details

On completion of this module, the candidate will be able to

Learning outcome 1

describe the basic principles of eddy currents and electromagnetism.

Assessment criteria

a) Explain the physics of electricity and magnetism as it applies to eddy current and electromagnetic sorting.

b) Explain the physics of electromagnetism.

c) Describe how eddy currents are distributed in sheet, plate, bars and tubes.

Learning outcome 2

describe the characteristics of probes and coils used for eddy current and electromagnetic sorting.

Assessment criteria

a) Describe the induction and reception functions of eddy current probes.

b) Discuss the features and applications of absolute and differential probes.

Learning outcome 3

demonstrate the principles and set-up, calibrate and use eddy current and electromagnetic sorting equipment.

Assessment criteria

a) Describe the principles of the operation of eddy current and electromagnetic sorting equipment.

b) Set up and calibrate the various types of eddy current and electromagnetic sorting equipment.

c) Use eddy current equipment and electromagnetic sorting equipment for sorting of materials and components.

Learning outcome 4

describe the material properties that can affect eddy currents, and assess the influence of various parameters on material sorting.

Assessment criteria

a) Describe how material properties can affect electrical conductivity and permeability of a material.

b) Describe how parameters such as defect orientation and position, structure, shape, coupling and test speed may influence the technique and outcome of material sorting.

c) Assess and report on the effect of various parameters on the test outcomes.

A.1.5 Delivery of the module

This module is practical in nature and may be taught by active participation, illustration, demonstration and description. The practical skills should be reinforced by instruction covering the relevant theory.

A.2 Eddy current and electromagnetic testing of tubular products during manufacture

A.2.1 Duration of training and experience prior to authorization

It is anticipated that a candidate will achieve the full module purpose in 24 h to 40 h of training and not less than 160 h of supervised experience.

A.2.2 Purpose of the module

To enable candidates to describe the basic principles of eddy current non-destructive testing as applied to tubular products during manufacture, and to set up, calibrate and operate eddy current tubular product test equipment.

A.2.3 Content

Basic principles of eddy currents and electromagnetism

Electricity

— direct current, amperage, voltage

Ohm's law and resistance, conductivity and resistivity

— alternating current

Electromagnetic induction

— field generated by a current

— field/induction relationship

— effect of fill factor

— effect of frequency

— influence of magnetic field

- Magnetism
  - magnetic data
  - induction and magnetic fields
  - magnetic permeability
  - coercive force
  - saturation magnetism
  - iron magnetization
  - induced magnetic flux
  - lines of force and force fields
- Electromagnetism
  - magnetic field produced by a current
  - inductive current – eddy current
  - skin effect
    - effect of test frequency

Reactance (field produced by eddy current)

Theory of eddy currents

Distribution of eddy currents in tubular products

- depth of standard penetration
- defect reaction according to its position

Characteristics of eddy current coils

Induction and reception functions

Differential mode

Encircling coils

- field from an empty coil

Effect of coupling

- eddy current distribution related to coil position

Eddy current equipment

Working principles

- Transmission, reception, data presentation

— Equipment controls

  — oscillator – frequency control

  — magnetizing current control

  — energizing devices and measurement

  — balancing the system — sensitivity

  — amplifier, filter, modulation/demodulation

  — phase rotation

  — CRT Display — ellipse, A-scan, vector point

  — analogue/digital display

  — gain control

Properties of materials

Physical properties — Ferromagnetic and non-ferromagnetic materials

— electrical conductivity and magnetic permeability – effect of temperature, structure, cold work

Influence of various parameters on eddy current measurement

— defect position and orientation

— eddy current path, penetration depth, zone of probe action

— material temperature

— structure and geometry of test part

Choice of frequency, phase discrimination, noise filtering, magnetic saturation

— coupling influence

— vibrations, centering, fill factor, sensitivity, compensation

— relative speed

  — testing frequencies according to speed

A.2.4 Learning outcome details

On completion of this module, the candidate will be able to

Learning outcome 1

describe the basic principles of eddy currents and electromagnetism.

Assessment criteria

a) Explain the physics of electricity and magnetism as it applies to eddy current testing of tubular products.

b) Explain the physics of electromagnetism.

c) Describe how eddy currents are distributed in tubular product.

Learning outcome 2

describe the characteristics of coils used for eddy current testing of tubular product.

Assessment criteria

a) Describe the induction and reception functions of eddy current coils.

b) Discuss the features and applications of differential coils.

Learning outcome 3

set up, calibrate and use tubular product eddy current test equipment.

Assessment criteria

a) Describe the principles of the operation of tubular product eddy current test equipment.

b) Set up and calibrate tubular product eddy current test equipment.

c) Use eddy current equipment for the testing of tubular products.

Learning outcome 4

describe the material properties that can affect eddy currents, and assess the influence of various parameters upon eddy current test equipment related to testing tubular product.

Assessment criteria

a) Describe how material properties can affect electrical conductivity and permeability of a material.

b) Describe how parameters such as defect orientation and position, structure, shape, coupling and test speed may influence the technique and outcome of eddy current testing of tubular product.

c) Assess and report on the effect of various parameters on the test outcomes.

A.2.5 Delivery of the module

This module is practical in nature and may be taught by active participation, illustration, demonstration and description. The practical skills should be reinforced by instruction covering the relevant theory.

A.3 Normal beam ultrasonic testing of plate materials during manufacture

A.3.1 Duration of training and experience prior to authorization

It is anticipated that a candidate will achieve the full module purpose in 24 h to 40 h of training and not less than 160 h of supervised experience.

A.3.2 Purpose of the module

To enable candidates to describe the principles and procedures of ultrasonic testing of plate products by contact or immersion techniques during manufacture, and to undertake ultrasonic testing of rolled plate during manufacture.

A.3.3 Content/Syllabus

Basic principles of acoustics

— nature of sound waves

— modes of sound wave generation

— velocity, frequency and wavelength of sound waves

— attenuation of sound waves

— acoustic impedance

— reflection

— refraction and mode conversion

— Fresnel and Fraunhofer effects

Equipment

— basic and pulse-echo instrumentation (A, B and C scan and computerized systems)

— electronics; time base, pulser, receiver and various monitor displays

— control functions

— calibration

— basic instrument calibration

— calibration blocks

— transducer operation and theory

— piezoelectric effect

— types of crystals

— frequency (crystal thickness relationship)

— near and far fields

— beam spread

— construction; materials and shapes

— types

— beam intensity characteristics

— sensitivity resolution and damping

— mechanical vibration into test material

— couplants

— purpose and principles

— materials and efficiency

Basic testing methods

— contact

— immersion

— multiple transducer

— transducer in water

— water column; wheels, etc.

— submerged test part

— sound beam path – transducer to part

— focussed transducers

— comparison of contact and immersion techniques

Calibration (electronic and functional)

— equipment

— monitor displays

— recorders

— alarms

— automated and semi-automated systems

— distance amplitude correction (DAC/DGS)

— transducers

— calibration of equipment electronics

— variable effects

— transmission accuracy

— calibration requirements

— calibration reflectors

— inspection calibration

— comparison with reference blocks

— pulse echo variables

— reference for planned tests

— transmission factors

— transducer

— couplants

— materials

Straight beam examination to specific procedures

— selection of parameters

— test standards

— evaluation of results

— test reports

Evaluation of product forms

— ingots

  — process review

  — types and origins of discontinuities

— plate

  — rolling process

  — types and origins of discontinuities

— response of discontinuities to ultrasound

— applicable codes, standards and specifications

Discontinuity detection

— sensitivity to reflections

— size, type and locations of discontinuities

— techniques used in detection

— resolution

— standard reference comparisons

— probability of type of discontinuity

— effects of ultrasonic frequency

— damping effects

— determination of discontinuity size

— monitor displays

— transducer movement versus display

— signal patterns

— location of discontinuity

— amplitude and linear time

— search technique

Evaluation

— comparison procedures

— standards and references

— amplitude, area and distance

— object appraisal

— history of part

— existing and applicable code interpretation

— type of discontinuity and location

A.3.4 Learning outcome details

On completion of this module, the candidate will be able to

Learning outcome 1

describe the fundamental properties and behaviour of ultrasound.

Assessment criteria

a) Describe the nature of sound waves as particle motion associated with energy.

b) Describe the relationship between velocity, frequency and wavelength.

c) Outline the method of propagation of compression waves.

d) Describe the behaviour of sound as it strikes an interface between two media.

e) Define "Acoustic Impedance" and state its importance in ultrasonic testing.

f) List the factors that affect attenuation of ultrasonic energy as it passes through a medium and the practical outcome of attenuation.

Learning outcome 2

describe how ultrasonic waves are generated and detected.

Assessment criteria

a) Describe piezoelectric effect and types of crystals.

b) Describe briefly the components used in the construction of an ultrasonic transducer.

c) Describe the characteristics of transducers, such as frequency - crystal thickness relationship, conversion efficiencies of various crystals, damping and resolution, beam intensity characteristics, near field, far field and beam divergence.

d) List desirable steps for the care of transducers.

Learning outcome 3

describe the basic parts of pulse-echo instruments and the functions of various controls.

Assessment criteria

a) Describe the functions of the various parts and demonstrate how the various controls can be used to calibrate and operate the equipment for optimum performance.

b) Outline the principles of A-, B- and C-scan displays.

c) Describe different couplants used and desirable characteristics for ultrasonic testing, and list their advantages and limitations.

Learning outcome 4

describe various types of ultrasonic testing equipment used for plate testing during manufacture, and set up test equipment.

Assessment criteria

a) Describe straight beam testing techniques using compression wave probes.

b) Set up ultrasonic equipment.

c) Correctly adjust the controls of display units.

d) Select test parameters including frequency, transducer size and type.

Learning outcome 5

discuss the material technology for the product sector.

Assessment criteria

a) Describe the casting process and the type and formation of typical discontinuities.

b) Describe the production of plate and the type and formation of typical discontinuities.

c) Interpret applicable codes, standards and/or specifications.

Learning outcome 6

calibrate ultrasonic test equipment using reference standards, and use the equipment to test plate.

Assessment criteria

a) Calibrate ultrasonic test equipment using standard calibration blocks.

b) Test plate using the calibrated equipment.

Learning outcome 7

evaluate indications.

Assessment criteria

a) Interpret test results.

b) Evaluate discontinuities against codes, standards or specifications.

c) Report the location and size of discontinuities detected.

A.3.5 Delivery of the module

This module is practical in nature and may be taught by active participation, illustration, demonstration and description. The practical skills should be reinforced by instruction covering the relevant theory.

A.4 Ultrasonic thickness testing

A.4.1 Duration of training and experience prior to authorization

It is anticipated that a candidate will achieve the full module purpose in 24 h to 40 h of training and not less than 160 h of supervised experience.

It is anticipated that a candidate will achieve the module purpose for use of digital instruments only in 16 h to 24 h of training and not less than 40 h of supervised experience.

A.4.2 Purpose of module

To enable candidates to describe the principles and procedures of ultrasonic testing as they relate to ultrasonic thickness testing by A-scan and/or digital techniques and to undertake ultrasonic thickness testing of material with parallel surfaces.

A.4.3 Content/Syllabus

Properties and behaviour of ultrasound

— frequency, velocity, wavelength, amplitude

— continuous and pulsed waves

— modes of vibration

— acoustic impedance pressure, energy, intensity

— reflection, refraction and mode conversion

— diffraction, dispersion and attenuation

— generation of ultrasound

— piezoelectricity and types of crystal

— construction of ultrasonic search units

— characteristics of search units; frequency — crystal thickness relationship

— conversion efficiencies of various crystals

— damping and resolutions

— beam intensity characteristics — near field, far field divergence

— normal and angle probes

— flat and contoured probes

— single crystal and twin crystal probes

— care of search units

Ultrasonic testing equipment

— description of basic pulse-echo instrument

— time-base (synchronizer) circuit

— pulser circuits

— receiver or echo-amplifier circuit

— A-scan display circuit

— horizontal linearity

— digital instruments

— care of equipment

— types of couplants, desirable characteristics

— probe selection

— single crystal probes

— single crystal probes with spacers

— twin crystal probes

Testing methods

— contact testing — straight beam

Calibration

— types and uses of calibration blocks for thickness testing

— secondary calibration

Test application

— selection of test parameters

— frequency

— probe type, size and shape

— methods of measurement

  — single spot

  — double spot

  — grid

Interpretation of results

— recording and reporting

— job records

— routine reports

Codes and standards

— use of correction factors and charts

— order of accuracy

Variables affecting test results

— instrument performance variables

— transducer performance variables

— inspected part variables

— entry surface conditions

— part size and geometry

Metallurgical structure

— material temperature

— surface coatings

— corrosion

Abnormal values

— nil readout

— half anticipated thickness readout

— double anticipated thickness readout

A.4.4 Learning outcome details

On completion of this module, the candidate will be able to

Learning outcome 1

describe the fundamental properties and behaviour of ultrasound.

Assessment criteria

a) Describe the nature of sound waves as particle motion associated with energy.

b) Describe the relationship between velocity, frequency and wavelength.

c) Outline the method of propagation of compression waves.

d) Describe the behaviour of sound as it strikes an interface between two media resulting in reflection, refraction and mode conversion.

e) Define "acoustic impedance" and state its importance in ultrasonic testing.

f) List the factors that affect attenuation of ultrasonic energy as it passes through a medium and the practical outcome of attenuation.

Learning outcome 2

describe how ultrasonic waves are generated and detected.

Assessment criteria

a) Define piezoelectricity and the type of crystals.

b) Describe briefly the components used in the construction of an ultrasonic transducer.

c) Describe the characteristics of transducers, such as frequency - crystal thickness relationship, conversion efficiencies of various crystals, damping and resolution, beam intensity characteristics, near field, far field and beam divergence.

d) List desirable steps for the care of transducers.

Learning outcome 3

describe the basic parts of pulse-echo instrument and the functions of various controls.

Assessment criteria

a) Describe the functions of the various parts and demonstrate how the various controls can be used to calibrate and operate the equipment for optimum performance.

b) Outline the principles of A-scan display.

c) Outline the principles used in digital thickness instruments.

d) Describe different couplants used and desirable characteristics for ultrasonic testing and list their advantages and limitations.

Learning outcome 4

describe various types of ultrasonic testing equipment used for thickness testing and demonstrate competence in setting up the instrument.

Assessment criteria

a) Describe straight beam contact testing techniques using compression wave probes.

b) Describe the setting up and use of A-scan equipment for thickness testing.

c) Describe the setting up and use of digital thickness testing equipment.

d) Demonstrate ability to adjust the controls of A-scan display units and digital ultrasonic thickness meters.

Learning Outcome 5

calibrate ultrasonic thickness test equipment using standard thickness calibration blocks and carry out secondary thickness calibrations.

Assessment criteria

a) Demonstrate competency in calibrating ultrasonic A-scan and digital thickness testing equipment using standard calibration blocks and secondary calibrations.

b) Demonstrate ability in the selection of test parameters including frequency, transducer size and type.

Learning outcome 6

demonstrate proficiency in carrying out thickness testing of various materials in the wrought and cast condition.

Assessment criteria

a) Demonstrate competency in thickness testing of various materials using A-scan and digital instruments.

b) Prepare preliminary test reports on ultrasonic thickness testing of selected materials and components.

Learning outcome 7

show awareness of various variables affecting the test results.

Assessment criteria

a) Describe briefly the instrument performance variables and their effect on the A-scan and digital displays.

b) Describe briefly transducer performance variables and their effect on the test results.

c) Describe briefly the inspected part variables such as contour and corrosion and their effect on test results.

d) Describe briefly the effect of specimen temperature on test results.

e) Demonstrate the preparation and use of conversion factors and charts.

f) Describe the procedures required if readouts vary significantly from anticipated results.

A.4.5 Delivery of the module

This module is practical in nature and may be taught by active participation, illustration, demonstration and description. The practical skills should be reinforced by instruction covering the relevant theory.

Annex B
(informative)

Weighting of the practical elements

Subject	Weighting
Part 1: Knowledge of the NDT apparatus	
a. System control and functional checks	10
b. Verification of settings	10
Total (Part 1)	**20**
Part 2: Application of the NDT method	
a. Preparation of the test piece (e.g., surface condition), including visual examination	5
b. Setting up of the NDT apparatus and determination of operating conditions	15
c. Performance of the test	10
d. Post test procedures (e.g., cleaning, preservation)	5
Total (Part 2)	**35**
Part 3: Detection of discontinuities, non-conformities and reporting	
a. Detection of mandatory reportable discontinuities or non-conformities	15
b. Characterization within permissible tolerances (type, position, orientation, apparent dimensions, etc.)	10
c. Evaluation against written procedure	10
d. Preparation of the test report	10
Total (Part 3)	**45**
Overall grade for practical specimen (= sum of the part totals in boldface)	**100**

NOTE 1 The candidate failing to report a discontinuity specified on the specimen master report as 'mandatory for candidates to report' when performing the test in the conditions specified in the master report should be awarded zero marks for part 3 of the practical examination related to the specimen tested.

NOTE 2 Marks should be deducted from the candidate's part 3 score for reporting non-existent discontinuities.

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