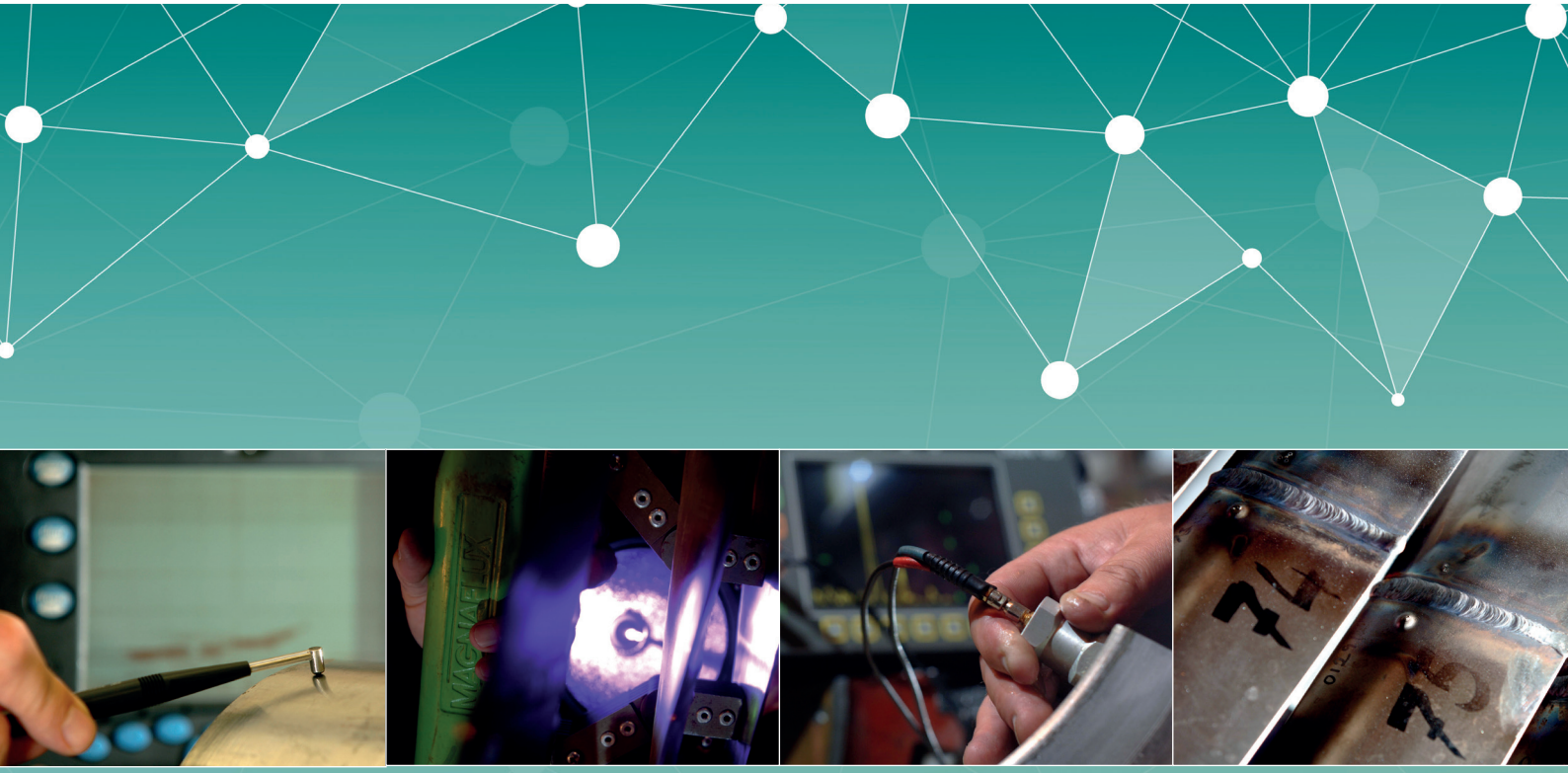
# PCN24/GEN/Appendix Z1

## NDT examination syllabi

*Issue 1 • February 2024*

A division of BINDT THE BRITISH INSTITUTE OF NON-DESTRUCTIVE TESTING



# Contents



*The British Institute of Non-Destructive Testing is an accredited Certification Body offering personnel and quality management systems assessment and certification against criteria set out in international and European standards through the PCN Certification Scheme.*

## Scope

This document gives requirements and recommendations for non-destructive testing (NDT) training syllabi with the intention of harmonising and maintaining the general standard of training of NDT personnel for industrial needs. It also establishes the minimum requirements for effective structured training of NDT personnel to ensure eligibility for qualification examinations leading to third-party certification according to recognised standards. This document provides guidelines for syllabi covering eddy current testing (ET), alternating current field measurement (ACFM), magnetic testing (MT), penetrant testing (PT), radiographic testing (RT), ultrasonic testing (UT), phased array ultrasonic testing (PAUT), time-of-flight diffraction (TOFD), visual testing (VT) and limited certification ultrasonic testing of manufactured wrought plate. Syllabus document developed in accordance with ISO/TS 25107 (2019) as per BS EN ISO 9712 (2022), Section 5.2.2, Subsection e). ISO/TS 25108 gives requirements and recommendations for NDT training organisations.

**PCN syllabus – Eddy current testing (ET)**

| Syllabus reference number | Title | Module subcontent | Eddy current testing (ET) | | |
|---|---|---|---|---|---|
| 1 | Terminology and history of ET | | Level 1 | Level 2 | Level 3 |
| 1.0 | History of ET | History of eddy current testing | X | X | X |
| 1.1 | Purpose of NDT | What is testing? | X | X | X |
| | | What is the purpose of NDT? | X | X | X |
| | | At what stage of life is NDT performed on a product? | X | X | X |
| | | How does it add value? | X | X | X |
| | | Who may carry out NDT? | X | X | X |
| | | Main NDT methods | X | X | X |
| 1.2 | Purpose of ET | Definition: | | | |
| | | • Electromagnetic interaction between a sensor and a test object conducting electricity | X | | |
| | | • Providing information on physical characteristics of the test object | X | | |
| | | Applicability and limitations | X | | |
| 1.3 | Terminology | Please refer to PCN24 standards document | X | X | X |
| 2 | Physical principles and associated knowledge | | Level 1 | Level 2 | Level 3 |
| 2.0 | Fundamentals | | X | X | X |
| 2.1 | Electricity: elements | Direct current: | X | X | X |
| | | • Current | X | X | X |
| | | • Voltage | X | X | X |
| | | • Resistance | X | X | X |
| | | • Conductance | X | X | X |
| | | • Ohm's Law | X | X | X |
| | | • Resistivity | X | X | X |
| | | • Conductivity | X | X | X |
| | | Units: | X | X | X |
| | | • Conductivity values for some metals | X | X | X |
| | | Alternating current: | X | X | X |
| | | • Sinusoidal current | X | X | X |
| | | • Voltage | X | X | X |
| | | • Amplitude | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 2.1 *(continued)* | | • Frequency | X | X | X |
| | | • Period | X | X | X |
| | | • Phase | X | X | X |
| | | • Vector representation | | X | X |
| | | Other periodic currents | | | X |
| 2.2 | Magnetism | Magnetic field | X | X | X |
| | | Lines of force | | X | X |
| | | Magnetic field strength | X | X | X |
| | | Permeability | X | X | X |
| | | Flux density (induction) | X | X | X |
| | | Flux | X | X | X |
| | | Hysteresis loop | X | X | X |
| | | Units | X | X | X |
| | | Diamagnetism | | X | X |
| | | Paramagnetism | | X | X |
| | | Ferromagnetism | | X | X |
| | | Reluctance | | X | X |
| | | Magnetomotive force | | X | X |
| 2.3 | Electromagnetism | Magnetic field created by a current (wire, coil) | X | X | X |
| | | Electromagnetic induction phenomenon | X | X | X |
| | | Inductance | X | X | X |
| | | Mutual inductance | | X | X |
| | | Electromagnetic coupling | X | X | X |
| | | Induced currents | X | X | X |
| | | Secondary field | X | X | X |
| | | Lenz's Law | X | X | X |
| | | Distribution in conducting materials: | X | X | X |
| | | • Planar wave | | X | X |
| | | • Depth of penetration | X | | |
| | | • Standard depth of penetration | | X | X |
| | | • Amplitude | X | X | X |
| | | • Phase | X | X | X |
| | | Cylindrical conductors: | X | X | X |
| | | • Characteristic frequency | X | X | X |
| | | Real (practical) depth of penetration | | X | X |
| | | Impedance: | X | X | X |
| | | • Complex plane representation | | X | X |
| | | • Impedance plane diagrams | | X | X |
| 2.4 | Alternative techniques | Pulsed eddy current | | | X |
| | | Magnetic field sensors | | | X |
| | | Alternating current field measurements | | | X |
| | | Remote field eddy currents | | | X |
| 2.5 | Simulation | Analytical calculation of eddy current tests | | | X |

| 3 | Product knowledge and capabilities | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 3.1 | Defectology/product technology | Manufacturing-related discontinuities | X | X | X |
| | | Service-induced discontinuities | X | X | X |
| | | Material properties influencing eddy current testing: | X | X | X |
| | | • Conductivity | X | X | X |
| | | • Permeability | X | X | X |
| | | Product characteristics influencing eddy current testing: | | X | X |
| | | • Condition (surface, heat treatment, cold working) | | X | X |
| | | • Temperature | | X | X |
| | | • Shape | | X | X |
| | | • Wall thickness | | X | X |
| | | • Accessibility | | X | X |
| | | Products being tested: | | X | |
| | | • Semi-finished products | | X | |
| | | • Pipes | | X | |
| | | • Heat exchanger tubes | | X | |
| | | • Mechanical parts (for example cars, railway and aircraft industry) | | X | |
| | | • Welds (for example offshore) | | X | |
| | | • Characteristics of flaws affecting detection | | X | |
| | | • Width/depth ratio | | X | |
| 3.2 | Applications of eddy current testing | Material characterisation: conductivity, ferrite content, metal sorting, heat treatment sorting, thickness of thermochemical treatments (case hardening, nitriding), coating thickness (conductive or non-conductive) and derived information (hardness) | X | X | X |
| | | Detection of discontinuities: cracks (SCC, fatigue), wall thinning, corrosion, deposits, etc | X | X | X |
| 3.3 | Capabilities | Depth of penetration | X | X | X |
| | | Conductive materials | X | X | X |
| | | Non-contact | X | X | X |
| | | High speed | X | X | X |
| | | High temperature | X | X | X |
| | | Multiplexed arrays | X | | |
| | | Mechanised | X | X | X |
| 3.4 | Techniques | Single frequency | X | X | X |
| | | Multi-frequency | X | X | X |
| | | Multi-parameter | X | X | X |
| | | Pulsed current | | X | X |
| | | Multiplexed arrays | | X | X |
| | | Remote field | | X | X |
| | | Similarity rules for surface inspection and tube characteristic/ limit frequencies | | X | X |
| 3.5 | Codes and standards | Please refer to PCN24 standards document | | X | X |
| **4** | **Equipment** | | **Level 1** | **Level 2** | **Level 3** |
| 4.1 | Eddy current testing system | Instrument | X | X | X |
| | | General-purpose applications – essential functions | X | X | X |
| | | Specific applications: | | X | X |
| | | • Pulsed eddy current | | | X |
| | | • Magnetic field sensors | | | X |
| | | • Alternating current field measurement | | | X |

| | | | | | |
|---|---|---|---|---|---|
| 4.1 *(continued)* | | Mechanised equipment | | X | X |
| | | Probes: | X | X | X |
| | | • Combined | | X | X |
| | | • Separate transmit – receive | | X | X |
| | | • Surface | X | X | X |
| | | • Coaxial | X | X | X |
| | | • Designs | | X | X |
| | | • Array probes (description and operating principles) | | X | X |
| | | Measurements: | X | X | X |
| | | • Absolute | X | X | X |
| | | • Differential | X | X | X |
| | | • Impedance testing | X | X | X |
| 4.2 | Output and signal display | Signal-to-noise ratio | X | X | X |
| | | Distortion/non-linearity | X | X | X |
| | | Filters | X | X | X |
| 4.3 | Reference blocks | Material | X | X | X |
| | | Design | | X | X |
| | | Production | | X | X |
| | | Storage | | X | X |
| 4.4 | Codes and standards | Please refer to PCN24 standards document | | X | X |
| **5** | **Information prior to testing** | | **Level 1** | **Level 2** | **Level 3** |
| 5.1 | Information about the test object | Written instructions | X | | |
| | | Identification or designation material: | X | X | X |
| | | • Object to be tested | X | X | X |
| | | • Kind of manufacture | X | X | X |
| | | • Catalogue of defects | | X | X |
| | | • Extent of test coverage | | X | X |
| 5.2 | Test conditions and application of standard | Accessibility | | X | X |
| | | Temperature | | | X |
| | | Humidity | | | X |
| | | Availability | | | X |
| | | Unwanted interfering signals | | | X |
| | | Electric and/or magnetic disturbances | | | X |
| | | Infrastructure | | | X |
| | | Particular test conditions | | X | X |
| | | Application standard | | X | X |
| | | Stage of manufacture or service life when testing is to be carried out | | | X |
| | | Standards assigned to the test object | | X | X |
| | | Requirements of test personnel | | X | X |
| | | Acceptance criteria | | X | X |
| 5.3 | Technique and sequence of performing test | Surface condition | | X | |
| | | Surface preparation | | X | |
| | | Post-test documentation | | X | |
| | | Equipment to be used | | X | |
| | | Requirement for recording | | X | |
| 5.4 | Instructions | Preparation of written procedure | | | X |
| | | Preparation of written instruction | | X | |
| | | Performing inspection in accordance with written instruction | X | | |

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|---|---|---|---|---|---|
| 5.4 *(continued)* | | Documents | | | X |
| | | Presentation of the standards, codes and procedures | | | X |
| **6** | **Testing** | | **Level 1** | **Level 2** | **Level 3** |
| 6.1 | Probe selection as a result of information in **Section 5** | Product: | | | |
| | | • Grade | | X | X |
| | | • Metallurgical condition | | X | X |
| | | • Shape | | X | X |
| | | • Type of discontinuity sought | | X | X |
| | | • Location | | X | X |
| | | • Duty of the product | | X | X |
| | | • Extent of examination | | X | X |
| 6.2 | Operating conditions as a result of information in **Section 5** | Temperature | | X | X |
| | | Humidity | | X | X |
| | | Access | | X | X |
| | | Availability | | X | X |
| | | Interfering signals | | X | X |
| | | Electric and/or magnetic disturbances | | X | X |
| 6.3 | Parameters | Excitation frequency | X | X | X |
| | | Auxiliary frequencies | X | X | X |
| | | Probe speed | X | X | X |
| | | Probe clearance | X | X | X |
| | | Probe vibration | X | X | X |
| | | Probe centring | X | X | X |
| 6.4 | Adjustment curves | Adjustment curves | X | X | X |
| 6.5 | Settings | Data acquisition | X | X | X |
| | | Written procedure | | X | X |
| | | Written instruction | X | X | |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Reporting | Reporting level | | X | X |
| | | Examination report | X | X | X |
| 7.2 | Evaluation | Characterisation of the indications: | | X | X |
| | | • Single-frequency analysis | | X | X |
| | | • Multi-frequency analysis | | X | X |
| | | • Data analysis | | X | X |
| **8** | **Assessment** | | **Level 1** | **Level 2** | **Level 3** |
| 8.1 | Evaluation and confirmation of test reports | Acceptance criteria according to standards, codes and procedures | | X | X |
| | | Training of Level 1 and Level 2 of the acceptance criteria | | | X |
| **9** | **Quality aspects** | | **Level 1** | **Level 2** | **Level 3** |
| 9.1 | Factors affecting quality of testing | Personnel qualification: | X | X | X |
| | | • ISO 9712 | X | X | X |
| | | • Other NDT qualification and certification systems | | | X |
| | | Format and scope of working procedures | | | X |
| | | Qualification of NDT procedures | | | X |
| | | Authorisations (NDT instruction, procedures and personnel) | | | X |
| | | Developing written instruction | | X | |
| | | Working correctly to written instruction | X | | |
| | | Traceability of documents | | X | X |
| | | Reliability of measurements | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 9.2 | Knowledge of applicable NDT application and product standards | Correct technique selection | | X | |
| | | Use of correct test parameters | | X | |
| | | NDT method selection | | X | X |
| | | Job-specific training | X | X | X |
| | | Equipment verification | X | X | X |
| **10** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | General information | Non-inductive techniques: | | | X |
| | | • Magneto-optical imaging | | | X |
| | | • Superconducting quantum interference device (SQUID) | | | X |
| | | • Giant magnetoresistance | | | X |
| | | Imaging | | | X |
| | | Modelling | | | X |

**PCN syllabus – Alternating current field measurement (ACFM)**

| Syllabus reference number | Title | Module subcontent | Alternating current field measurement (ACFM) | | |
|---|---|---|---|---|---|
| **1** | **Terminology and history of ACFM** | | **Level 1** | **Level 2** | **Level 3** |
| 1.0 | History of electromagnetic testing | History of electromagnetic testing | X | X | X |
| 1.1 | Purpose of NDT | What is testing? | X | X | X |
| | | What is the purpose of NDT? | X | X | X |
| | | At what stage of life is NDT performed on a product? | X | X | X |
| | | How does it add value? | X | X | X |
| | | Who may carry out NDT? | X | X | X |
| | | Main NDT methods | X | X | X |
| 1.2 | Purpose of ACFM | Definition: | | | |
| | | • Electromagnetic interaction between a sensor and a test object conducting electricity | X | | |
| | | • Providing information on physical characteristics of the test object | X | | |
| | | Applicability and limitations | X | | |
| 1.3 | Terminology | Please refer to PCN24 standards document | X | X | X |
| **2** | **Physical principles and associated knowledge** | | **Level 1** | **Level 2** | **Level 3** |
| 2.0 | Fundamentals | | | | |
| 2.1 | Electricity: elements | Direct current: | X | X | X |
| | | • Current | X | X | X |
| | | • Voltage | X | X | X |
| | | • Resistance | X | X | X |
| | | • Conductance | X | X | X |
| | | • Ohm's Law | X | X | X |
| | | • Resistivity | X | X | X |
| | | • Conductivity | X | X | X |
| | | Units: | X | X | X |
| | | • Conductivity values for some metals | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 2.1 *(continued)* | | Alternating current: | X | X | X |
| | | • Sinusoidal current | X | X | X |
| | | • Voltage | X | X | X |
| | | • Amplitude | X | X | X |
| | | • Frequency | X | X | X |
| | | • Period | X | X | X |
| | | • Phase | X | X | X |
| | | • Vector representation | | X | X |
| | | Other periodic currents | | | X |
| 2.2 | Magnetism | Magnetic field | X | X | X |
| | | Lines of force | | X | X |
| | | Magnetic field strength | X | X | X |
| | | Magnetic fluid components *Bx*, *Bz* | X | X | X |
| | | Permeability | X | X | X |
| | | Flux density (induction) | X | X | X |
| | | Flux | X | X | X |
| | | Hysteresis loop | X | X | X |
| | | Units | X | X | X |
| | | Diamagnetism | | X | X |
| | | Paramagnetism | | X | X |
| | | Ferromagnetism | | X | X |
| | | Reluctance | | X | X |
| 2.3 | Electromagnetism | Magnetic field created by a current (wire, coil) | X | X | X |
| | | Electromagnetic induction phenomenon | X | X | X |
| | | Inductance | X | X | X |
| | | Electromagnetic coupling | X | X | X |
| | | Induced currents | X | X | X |
| | | Secondary field | X | X | X |
| | | Lenz's law | X | X | X |
| | | Distribution in conducting materials: | X | X | X |
| | | • Planar wave | | X | X |
| | | • Depth of penetration | X | | |
| | | • Standard depth of penetration | | X | X |
| | | • Amplitude | X | X | X |
| | | • Phase | X | X | X |
| | | Cylindrical conductors: | | | X |
| | | • Characteristic frequency | X | | X |
| | | • Real (practical) depth of penetration | | X | X |
| 2.4 | Alternative techniques | Pulsed eddy current | | | X |
| | | Magnetic field sensors | | | X |
| | | Conventional eddy current testing | | X | X |
| | | Remote field eddy currents | | | X |
| 2.5 | Simulation | Analytical calculation of eddy current tests | | | X |
| **3** | **Product knowledge and capabilities** | | **Level 1** | **Level 2** | **Level 3** |
| 3.1 | Defectology/product technology | Manufacturing-related discontinuities | X | X | X |
| | | Service-induced discontinuities | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 3.1 *(continued)* | | Material properties influencing eddy current testing: | | X | X |
| | | • Conductivity | | X | X |
| | | • Permeability | | X | X |
| | | Product characteristics influencing eddy current testing: | | X | X |
| | | • Condition (surface, heat treatment, cold working) | | X | X |
| | | • Temperature | | X | X |
| | | • Shape | | X | X |
| | | • Wall thickness | | X | X |
| | | • Accessibility | | X | X |
| | | • Permeability value and variability | | X | X |
| | | Products being tested: | | X | |
| | | • Semi-finished products | | X | |
| | | • Threads | | X | |
| | | • Mechanical parts (for example cars, railway and aircraft industry) | | X | |
| | | • Welds (for example offshore) | | X | |
| | | Flaw detection: | | X | |
| | | • Characteristics of flaws affecting detection | | X | |
| | | • Width/depth ratio | | X | |
| 3.2 | Applications of eddy current testing | Detection of discontinuities: cracks (SCC, fatigue), wall thinning, corrosion, deposits, etc | X | X | X |
| 3.3 | Capabilities | Depth of penetration | X | X | X |
| | | Conductive materials | X | X | X |
| | | Non-contact | X | X | X |
| | | High speed | X | X | X |
| | | High temperature | X | X | X |
| | | Multiplexed arrays | X | | |
| 3.4 | Techniques | Single frequency | X | X | X |
| | | Multiplexed arrays | | X | X |
| 3.5 | Codes and standards | | | X | X |
| **4** | **Equipment** | | **Level 1** | **Level 2** | **Level 3** |
| 4.1 | ACFM | Portable instrument | X | X | X |
| | | Underwater instrument | X | X | X |
| | | General-purpose applications – essential functions | | X | X |
| | | Specific applications: | | X | X |
| | | • Magnetic field sensors | | | X |
| | | • Alternating current field measurement equipment | | | X |
| | | Manual equipment | | X | X |
| | | Probes: | X | X | X |
| | | • Combined | | X | X |
| | | • Separate transmit – receive | | X | X |
| | | • Surface | | X | X |
| | | • Designs | | X | X |
| | | • Array probes (description and operating principles) | | X | X |
| | | Measurements: | X | X | X |
| | | • Absolute | X | X | X |
| | | • Differential | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 4.2 | Output and signal display | Signal-to-noise ratio | X | X | X |
| | | Filters | X | X | X |
| 4.3 | Reference blocks | Material | X | X | X |
| | | Design | | X | X |
| | | Production | | X | X |
| | | Storage | | X | X |
| 4.4 | Codes and standards | | | X | X |
| **5** | **Information prior to testing** | | **Level 1** | **Level 2** | **Level 3** |
| 5.1 | Information about the test object | Written instructions | X | | |
| | | Identification or designation material: | X | X | X |
| | | • Object to be tested (welds, threads, coated products) | X | X | X |
| | | • Kind of manufacture | X | X | X |
| | | • Catalogue of defects | | X | X |
| | | • Extent of test coverage | | X | X |
| 5.2 | Test conditions and application of standard | Accessibility | | X | X |
| | | Temperature | | | X |
| | | Humidity | | | X |
| | | Availability | | | X |
| | | Unwanted interfering signals | | | X |
| | | Electric and/or magnetic disturbances | | | X |
| | | Infrastructure | | | X |
| | | Particular test conditions | | X | X |
| | | Application standard | | X | X |
| | | Stage of manufacture or service life when testing is to be carried out | | | X |
| | | Standards assigned to the test object | | X | X |
| | | Qualification requirements of test personnel | | X | X |
| | | Acceptance criteria | | X | X |
| 5.3 | Technique and sequence of performing test | Surface condition | | X | |
| | | Surface preparation | | X | |
| | | Post-test documentation | | X | |
| | | Equipment to be used | | X | |
| | | Requirement for recording | | X | |
| 5.4 | Instructions | Preparation of written procedure | | | X |
| | | Preparation of written instruction | | X | |
| | | Performing inspection in accordance with written instruction | X | | |
| | | Documents | | | X |
| | | Presentation of the standards, codes and procedures | | | X |
| **6** | **Testing** | | **Level 1** | **Level 2** | **Level 3** |
| 6.1 | Probe selection as a result of information in **Section 5** | Product: | | | |
| | | • Grade | | X | X |
| | | • Metallurgical condition | | X | X |
| | | • Shape | | X | X |
| | | • Type of discontinuity sought | | X | X |
| | | • Location | | X | X |
| | | • Duty of the product | | X | X |
| | | • Extent of examination | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 6.2 | Operating conditions as a result of information in **Section 5** | Temperature | | X | X |
| | | Humidity | | X | X |
| | | Access | | X | X |
| | | Availability | | X | X |
| | | Interfering signals | | X | X |
| | | Electric and/or magnetic disturbances | | X | X |
| 6.3 | Parameters | Excitation frequency | X | X | X |
| | | Probe speed | X | X | X |
| 6.4 | Adjustment curves | Adjustment curves | X | X | X |
| 6.5 | Settings | Data acquisition | X | X | X |
| | | Written procedure | | X | X |
| | | Written instruction | X | X | |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Reporting | Reporting level | | X | X |
| | | Examination report | X | X | X |
| 7.2 | Evaluation | Characterisation of the indications: | | X | X |
| | | • Single-frequency analysis | X | X | X |
| | | • Data analysis | | X | X |
| | | • Defect sizing (length and depth) | X | X | X |
| | | • Analysing transverse defects | X | X | X |
| | | • Identification and analysis of 'bridging' | | X | X |
| | | • Identification of subsurface defects | | X | X |
| **8** | **Assessment** | | **Level 1** | **Level 2** | **Level 3** |
| 8.1 | Evaluation and confirmation of test reports | Acceptance criteria according to standards, codes and procedures | | X | X |
| | | Training of Level 1 and Level 2 of the acceptance criteria | | | X |
| **9** | **Quality aspects** | | **Level 1** | **Level 2** | **Level 3** |
| 9.1 | Factors affecting quality of testing | Personnel qualification: | X | X | X |
| | | • ISO 9712 | X | X | X |
| | | • Other NDT qualification and certification systems | | | X |
| | | Format and scope of working procedures | | | X |
| | | Qualification of NDT procedures | | | X |
| | | Authorisations (NDT instruction, procedures and personnel) | | | X |
| | | Developing written instruction | | X | |
| | | Working correctly to written instruction | X | | |
| | | Traceability of documents | | X | X |
| | | Reliability of measurements | | X | X |
| 9.2 | Knowledge of applicable NDT application and product standards | Correct technique selection | | X | |
| | | Use of correct test parameters | | X | |
| | | NDT method selection | | X | X |
| | | Job-specific training | X | X | X |
| | | Equipment verification | X | X | X |
| **10** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | General information | Non-inductive techniques: | | | X |
| | | • Magneto-optical imaging | | | X |
| | | • Superconducting quantum interference device (SQUID) | | | X |
| | | • Giant magnetoresistance | | | X |
| | | Imaging | | | X |
| | | Modelling | | | X |

## PCN syllabus – Magnetic testing (MT)

| Syllabus reference number | Title | Module subcontent | Magnetic testing (MT) | | |
|---|---|---|---|---|---|
| 1 | **Terminology and history of MT** | | Level 1 | Level 2 | Level 3 |
| 1.0 | History of MT | History of magnetic particle testing | X | X | X |
| 1.1 | Purpose of NDT | What is testing? | X | X | X |
| | | What is the purpose of NDT? | X | X | X |
| | | At what stage of life is NDT performed on a product? | X | X | X |
| | | How does it add value? | X | X | X |
| | | Who may carry out NDT? | X | X | X |
| | | Main NDT methods | X | X | X |
| 1.2 | Purpose of MT | Definition | X | X | X |
| | | Applicability and limitations | X | X | X |
| 1.3 | Terminology | Please refer to PCN24 standards document | X | X | X |
| 2 | **Physical principles and associated knowledge** | | Level 1 | Level 2 | Level 3 |
| 2.1 | Basic physical phenomena | Electric circuits: | X | X | X |
| | | • Typical values | X | X | X |
| | | • Units | X | X | X |
| | | Magnetic circuits: | X | X | X |
| | | • Typical values | X | X | X |
| | | • Units | X | X | X |
| | | Magnetic field: | X | X | X |
| | | • Characterisation | X | X | X |
| | | • Measurements | X | X | X |
| | | • Magnetic field (*H*) | X | X | X |
| | | • Magnetic induction (*B*) | X | X | X |
| | | • Designation of alloys (classification of material types) | X | X | X |
| | | Magnetic field created by electric circuits: | X | X | X |
| | | • Indefinite rectilinear conductor | X | X | X |
| | | • Long magnetic coil | X | X | X |
| | | • Short or flat magnetising coil | X | X | X |
| | | • Influences of the flux of a magnetic field in a non-magnetic media | X | X | X |
| | | • Continuity of $H_t$ | X | X | X |
| | | • Continuity of $B_n$ | X | X | X |
| | | • Passage and distribution of flux from a magnetic medium (ferromagnetic) to a non-magnetic medium (paramagnetic) | X | X | X |
| | | Distribution of flux around material discontinuities: | X | X | X |
| | | • Influence of depth | X | X | X |
| | | • Influence of orientation | X | X | X |
| 2.2 | Properties of materials | Non-magnetic materials | X | X | X |
| | | Magnetic materials: | X | X | X |
| | | • Influence of temperature on the magnetic properties | X | X | X |
| | | Diamagnetism | X | X | X |
| | | Paramagnetism | X | X | X |
| | | Ferromagnetism | X | X | X |
| | | Ferrimagnetism | | | X |

| | | | | | |
|---|---|---|---|---|---|
| 2.2 *(continued)* | | Influence of work hardening | | | X |
| | | Influence of heat treating | | | X |
| | | Particular alloys: | | X | X |
| | | • Permalloys | | X | X |
| | | • Invar | | X | X |
| | | • Inconel | | X | X |
| 2.3 | Characteristics of magnetic particle testing | Characteristics of magnetic discontinuities affecting their detection: | X | X | X |
| | | • Depth | X | X | X |
| | | • Thickness | X | X | X |
| | | • Orientation | X | X | X |
| | | Magnetic properties: | X | X | X |
| | | • Principal ferromagnetic alloys | X | X | X |
| | | Non-magnetic properties | X | X | X |
| | | Magnetic materials: | X | X | X |
| | | • Field of application | X | X | X |
| | | • Curie point | X | X | X |
| | | • Curve of the first magnetisation | X | X | X |
| | | • Hysteresis cycle and remarkable points | X | X | X |
| | | • Magnetic properties of steel | X | X | X |
| | | Behaviour of a magnetic particle in the vicinity of a magnetic flux: | X | X | X |
| | | • Magnetic field ($H$) | | X | X |
| | | • Magnetic induction ($B$) | | X | X |
| | | • Relative magnetic permeability, $\mu_r$ | | X | X |
| | | • Coercive force, $H_c$ | | X | X |
| | | • Electrical resistivity, $\rho$ | | X | X |
| | | Influence of composition | X | X | X |
| **3** | **Product knowledge and capabilities** | | **Level 1** | **Level 2** | **Level 3** |
| 3.1 | Processing | Test conditions | X | X | X |
| | | Preparation of parts | X | X | X |
| | | Viewing conditions: | X | X | X |
| | | • Visual ergonomics | | | X |
| | | • Modulation (increase) of lighting and adaption period in darkened environment according to age of inspector | | | X |
| | | Light sources: | X | X | X |
| | | • Physiological human factor knowledge of aspects related to lighting | | | X |
| | | • Quality of light sources products | | | X |
| | | Application of medium | X | X | X |
| | | Technique selection | | X | X |
| | | Factors affecting indications | | X | X |
| | | Metrological uncertainties | | | X |
| 3.2 | Typical discontinuities | Typical discontinuities according to the production process: | X | X | X |
| | | • Castings | X | X | X |
| | | • Forgings | X | X | X |
| | | • Welds | X | X | X |
| | | • Wrought products | X | X | X |

| 4 | Equipment | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 4.1 | Magnetising equipment | Permanent magnets | X | X | X |
| | | Portable electromagnets | X | X | X |
| | | Coils | X | X | X |
| | | Threading bars | X | X | X |
| | | Prods | X | X | X |
| | | Magnetic benches: | X | X | X |
| | | • Fixed and portable | X | X | X |
| | | • Automatic | | X | X |
| | | • Robotised | | X | X |
| | | Clamps | X | X | X |
| | | Cable wraps | X | X | X |
| | | Swinging field | | X | X |
| | | Mobile | | X | X |
| 4.2 | Measurement and adjustment | Field indicators | X | X | X |
| | | Hall probe | | X | X |
| 4.3 | Demagnetisation | Accessories: | X | | |
| | | • Field indicators | | X | |
| | | • Field strength measuring devices | | X | |
| | | • Flux indicators | | X | |
| 4.4 | Detection media | Contrast paint | X | X | X |
| | | Particles | X | X | X |
| 4.5 | Viewing conditions | Light sources: | X | X | X |
| | | • Quality of LED products | | | X |
| | | Human factors: | X | X | X |
| | | • Adaptation to darkened environment | | X | X |
| | | • Transition from bright/darkened lighting conditions | | X | X |
| | | • Role of adaptation for darkened environment | | X | X |
| | | Conditions of illumination: | | X | X |
| | | • Photometers and radiometers | | X | |
| **5** | **Information prior to testing** | | **Level 1** | **Level 2** | **Level 3** |
| 5.1 | Information about the test object | Identification or designation material: | X | X | X |
| | | • Object to be tested | X | X | X |
| | | • Kind of manufacture | X | X | X |
| | | • Catalogue of defects | | X | X |
| | | • Extent of test coverage | X | X | X |
| 5.2 | Test conditions and application of standard | Accessibility | | X | X |
| | | Infrastructure | | | X |
| | | Particular test conditions | | X | X |
| | | Application standard | | X | X |
| | | Stage of manufacture or service life when testing is to be carried out | | | X |
| | | Standards assigned to the test object | | X | X |
| | | Requirements of test personnel | | X | X |
| | | Acceptance criteria | | X | X |
| 5.3 | Technique and sequence of performing test | Surface condition | | X | |
| | | Surface preparation | | X | |
| | | Post-test documentation | | X | |

| | | | | | |
|---|---|---|---|---|---|
| 5.4 | Instructions | Preparation of written procedure | | | X |
| | | Preparation of written instruction | | X | |
| | | Documents | | | X |
| | | Presentation of the standards, codes and procedures | | | X |
| **6** | **Testing** | | **Level 1** | **Level 2** | **Level 3** |
| 6.1 | Testing according to the written instructions | Performing inspection in accordance with written instruction | X | | |
| | | Supervision of testing personnel | | X | X |
| 6.2 | Parameters | Preparation of the parts and influence of the surface quality: | X | X | |
| | | • Surface preparation | X | X | |
| | | Demagnetisation | X | X | X |
| | | Cleaning, machining | X | X | |
| | | Magnetisation: | X | X | |
| | | • Equipment | X | X | |
| | | • Current type | X | X | |
| | | • Type | X | X | |
| | | • Time of application | X | X | |
| | | Control of magnetisation conditions: | X | X | X |
| | | • Values of the magnetising parameters | | X | |
| | | • Continuous or simultaneous technique | | X | X |
| | | • Remanence technique | | X | |
| | | • Use of flux indicators and magnetometers | | X | |
| | | Technique: | X | X | X |
| | | • Correct use | X | X | |
| | | • Selection | | X | X |
| | | • Magnetic field strength | | X | X |
| | | • Orientation | X | X | X |
| | | Planning of the test: | X | X | X |
| | | • Grids | | X | X |
| | | • Coverage | | X | X |
| | | Detecting medium: | | X | |
| | | • Correct use | X | X | X |
| | | • Correct selection | | X | X |
| | | • Wet medium | X | X | |
| | | • Dry medium | X | X | |
| | | • Contrast paint | X | X | |
| | | Viewing conditions: | X | X | X |
| | | • Adaptations to darkened environment | | X | |
| | | • Cleanliness | | X | |
| | | Observation and indications | X | X | X |
| | | Recording of discontinuities | | X | X |
| | | Reporting | X | X | |
| | | Interpretation of indications | | X | |
| | | Labelling and disposition of tested product | | X | |
| 6.3 | Treatment of components | Residual field: | X | X | |
| | | • Condition requiring demagnetisation | | X | |
| | | • Level of residual | | X | |
| | | • Influence on later use of material | | | X |

| | | | | | |
|---|---|---|---|---|---|
| 6.3 *(continued)* | | Demagnetisation: | X | X | X |
| | | • Basic principles | X | X | |
| | | • Industrial methods | X | X | |
| | | • Influence of terrestrial magnetic field | | X | X |
| | | • Minimal value of the magnetic field of demagnetisation principles | X | X | |
| | | • Frequency | X | X | |
| | | • Effect of skin | X | X | |
| | | • Calculation of magnetising coil | | X | X |
| 6.4 | Cleaning of components | | X | X | X |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Classification of indications | • Welding | | X | X |
| | | • Casting | | X | X |
| | | • Forging | | X | X |
| | | • FE tubes | | X | X |
| 7.2 | Inspection conditions | Viewing according to reference block | X | X | X |
| | | Use of other reference blocks | | X | X |
| | | Verification of the indication quality (ISO 3059) | X | X | X |
| | | Adjustment of test units | | X | X |
| | | Batch test report | | X | |
| 7.3 | Test report | Basics of evaluation | | | X |
| | | Test report: | X | X | X |
| | | • Check test report | | X | |
| | | • In accordance with written procedure | | | X |
| | | Report of imperfections | X | X | |
| | | Evaluation of the indication quality | | X | X |
| | | Preservation of indications | | X | |
| **8** | **Assessment** | | **Level 1** | **Level 2** | **Level 3** |
| 8.1 | Assessment of indications | Relevant and non-relevant | X | | |
| 8.2 | Assessment of discontinuities | Influence of manufacture | | X | |
| | | Influence of material | | X | |
| | | Influence of depth | | X | X |
| | | Influence of shape | | X | X |
| | | Influence of position | | X | X |
| | | Influence of orientation | | X | X |
| **9** | **Quality aspects** | | **Level 1** | **Level 2** | **Level 3** |
| 9.1 | Personnel qualification | ISO 9712 | X | X | X |
| | | Other NDT qualification and certification systems | | | X |
| 9.2 | Documentation | Format and scope of working procedures | | | X |
| | | Qualification of NDT procedures | | | X |
| | | Authorisations (NDT instruction, procedures and personnel) | | | X |
| | | Developing written instruction | | X | |
| | | Working correctly to written instruction | X | | |
| | | Traceability of documents | | X | X |
| | | Reliability of measurements | | X | X |
| 9.3 | Knowledge of applicable NDT application and product standards | Correct technique selection | | X | |
| | | Use of correct test parameters | | X | |
| | | NDT method selection | | X | X |
| | | Job-specific training | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 9.3 *(continued)* | | Equipment verification: | X | X | X |
| | | • Medium concentration | X | | |
| | | • Medium contamination | X | | |
| | | • Ammeter adjustment | X | | |
| | | • Lift test | X | | |
| **10** | **Environmental and safety conditions** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | Human factors | Extended stay in dark areas | | X | X |
| | | Role of breaks | | X | X |
| | | Role of anti-UV glasses | | | X |
| 10.2 | Chemicals | Proper handling (aerosols/propellants) | X | X | X |
| | | Disposal of effluents | | X | X |
| | | Environmental conditions | | X | X |
| | | Treatment and rejection of the effluents | | | X |
| | | Toxicity of lead contact pads | | X | |
| | | Toxicity of products | | | X |
| | | Risks related to the products | X | X | X |
| | | Material safety data sheet | X | X | |
| | | Review of applicable NDT application and product standard | | | X |
| | | Fire hazards | | | X |
| 10.3 | Accessories | UV radiation hazards | X | X | X |
| | | Hazards of white light | | | X |
| | | Electrical hazards | X | X | X |
| | | UV filters | X | X | |
| | | Vision considerations: | X | X | X |
| | | • Protective glasses | X | X | X |
| **11** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 11.1 | Developments | Special installation and equipment | | X | |
| | | Actinic blue (alternative wavelengths) | | X | X |
| | | New techniques | | | X |
| | | Creative and innovative special installations | | | X |

## PCN syllabus – Penetrant testing (PT)

| Syllabus reference number | Title | Module subcontent | Penetrant testing (PT) | | |
|---|---|---|---|---|---|
| 1 | **Terminology and history of PT** | | Level 1 | Level 2 | Level 3 |
| 1.0 | History of PT | History of penetrant testing | X | X | X |
| 1.1 | Purpose of NDT | What is testing? | X | X | X |
| | | What is the purpose of NDT? | X | X | X |
| | | At what stage of life is NDT performed on a product? | X | X | X |
| | | How does it add value? | X | X | X |
| | | Who may carry out NDT? | X | X | X |
| | | Main NDT methods | X | X | X |
| 1.2 | Purpose of PT | Definition | X | X | X |
| | | Applicability and limitations | X | X | X |
| 1.3 | Terminology | Please refer to PCN24 standards document | X | X | X |
| 2 | **Physical principles and associated knowledge** | | Level 1 | Level 2 | Level 3 |
| 2.1 | Penetrant systems | Penetrant types: | X | X | X |
| | | • Fluorescent | X | X | X |
| | | • Visible | X | X | X |
| | | Basis of fluorescent and absorption principles used in dye penetrants | | X | |
| | | Interactions between different dyes | | | X |
| | | Penetrant techniques: | X | X | X |
| | | • Water washable | X | X | X |
| | | • Post emulsifiable | X | X | X |
| | | • Solvent removeable | X | X | X |
| | | Emulsifiers | X | X | X |
| | | Cleaner | X | X | X |
| | | Developer: | X | X | X |
| | | • Wet (aqueous and non-aqueous) | X | X | X |
| | | • Dry | X | X | X |
| 2.2 | Properties and characteristics | Physical basics of the method | X | X | X |
| | | Penetrant: | X | X | X |
| | | • Viscosity | X | X | X |
| | | • Flashpoint | X | X | |
| | | • Bleed out | X | X | |
| | | • Capillarity | X | X | |
| | | • Superficial tension | X | X | X |
| | | • Contact angle | X | X | X |
| | | • Vapour pressure | X | X | X |
| | | Influence of material roughness: | | X | X |
| | | • Variable values of roughness ($R_a + R_z$) | | | X |
| | | • Components with multiple roughness (*ie* foundry with machining) | | | X |
| | | • Signal-to-noise ratio concept | X | X | X |
| | | • Residual background noise (over/under washing risks) | X | X | X |
| | | • Emulsification of penetrant | X | X | X |
| | | • Cleaner | X | X | X |
| | | • Developer | X | X | X |

| 3 | Product knowledge and capabilities | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 3.1 | | Test conditions: | X | X | X |
| | | • Lighting in work and surrounding areas | | X | |
| | | • Adaption to black light environment | | X | |
| | | • Transition between bright and darkened areas | | X | |
| | | Viewing conditions: | X | X | X |
| | | • Performance of penetrant based on temperature | | X | |
| | | • Role of adaptation to darkened environment | | X | |
| | | • Cleanliness | | X | |
| | | • Modulation (increase) of lighting and adaptation period to darkened environment according to age of inspector | | | X |
| | | Technique selection | | X | X |
| | | Technique application | X | X | X |
| 3.2 | Typical defects according to the production process | Castings | X | X | X |
| | | Forgings | X | X | X |
| | | Welding | X | X | X |
| | | Wrought products | X | X | X |
| **4** | **Equipment** | | **Level 1** | **Level 2** | **Level 3** |
| 4.1 | Design and operation of penetrant installations and units | Aerosol spray cans: | X | X | X |
| | | • Compressed gas, liquefied gas, 'atomisation' | | | X |
| | | Dip tanks | X | X | X |
| | | Electrostatic systems, fluidised bed | | X | X |
| | | Semi-automatic systems | | X | X |
| | | Automatic systems | | X | X |
| | | Application | X | X | X |
| | | Light sources: | X | X | |
| | | • Introduction to actinic blue | | X | |
| | | • Physiological human factor knowledge of aspects related to lighting | | | X |
| | | • Quality of LED products | | | X |
| | | Measuring units: | X | X | |
| | | • Basics of metrology | | X | |
| | | • Metrological uncertainties | | | X |
| | | Reference blocks: | X | X | |
| | | • Minimum quality required for a reference photo | | X | X |
| | | Viewing conditions | X | X | |
| **5** | **Information prior to testing** | | **Level 1** | **Level 2** | **Level 3** |
| 5.1 | Information about the test object | Identification or designation material: | X | X | X |
| | | • Object to be tested | X | X | X |
| | | • Kind of manufacture | X | X | X |
| | | • Catalogue of defects | | X | X |
| | | • Extent of test coverage | X | X | X |
| 5.2 | Test conditions and application of standard | Accessibility | | X | X |
| | | Infrastructure | | | X |
| | | Particular test conditions: | | X | X |
| | | • Actinic blue | | | X |
| | | Application standard | | X | X |
| | | Stage of manufacture or service life when testing is to be carried out | | | X |

| | | | | | |
|---|---|---|---|---|---|
| 5.2 *(continued)* | | Standards assigned to the test object | | X | X |
| | | Requirements of test personnel | | X | X |
| | | Acceptance criteria | | | X |
| 5.3 | Technique and sequence of performing test | Surface condition | | X | |
| | | Surface preparation: | | X | |
| | | • Differences between aqueous alkaline degreaser and water based/solvent | | X | |
| | | • Danger of borates and silicate in water-based cleaners – soaps | | | X |
| | | Post-test documentation | | X | |
| 5.4 | Instructions | Preparation of written procedure | | | X |
| | | Preparation of written instruction | | X | |
| | | Documents | | | X |
| | | Presentation of the standards, codes and procedures | | | X |
| **6** | **Testing** | | **Level 1** | **Level 2** | **Level 3** |
| 6.1 | Preparation and performance of the test | Performing inspection in accordance with written instruction | X | | |
| | | Supervision of personnel | | X | X |
| 6.2 | Parameters | Preparation of the parts and influence of the surface quality: | X | X | X |
| | | • Surface preparation | X | X | |
| | | • Cleaning | X | X | |
| | | Technique: | | X | X |
| | | • Selection | | X | X |
| | | • Correct use | X | X | X |
| | | Planning of the test: | | X | |
| | | • Grids | | X | |
| | | • Coverage | | X | |
| | | Detecting medium: | X | X | X |
| | | • Correct use | X | X | |
| | | • Correct selection | | X | X |
| | | Viewing conditions | X | X | X |
| | | Observation and indications | X | X | |
| | | Recording of discontinuities | X | X | |
| | | Reporting (including length and breadth of indications) | X | X | |
| | | Interpretation of indications | | X | X |
| | | Labelling and disposition of tested product | | X | X |
| | | Cleaning of components | X | X | |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Test report | Viewing conditions | X | X | X |
| | | Reference block No 1 | | X | X |
| | | Reference block No 2: | X | X | X |
| | | • Differences between progressive and non-progressive panels | | | X |
| | | Statistical aspects of analysed parameters to revalidate penetrant use | | | X |
| | | Verification of indication quality: | X | X | X |
| | | • Use of reference photographs to validate visual conditions | | X | |
| | | Report of simple welding, forging rolled products and casting imperfections | X | | |
| | | Other reference blocks used | | X | X |
| | | Adjustment of test units batch test report | | X | X |
| 7.2 | Evaluation | Report of discontinuities | | X | |

| 8 | Assessment | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 8.1 | Assessment of discontinuities | Influence of manufacture and material | | X | X |
| | | Depth | | X | X |
| | | Width | | X | X |
| | | Shape | | X | X |
| | | Position | | X | X |
| | | Orientation | | X | X |
| **9** | **Quality aspects** | | **Level 1** | **Level 2** | **Level 3** |
| 9.1 | Personnel qualification | ISO 9712 | X | X | X |
| | | Other NDT qualification and certification systems | | | X |
| 9.2 | Documentation | Format and scope of working procedures | | | X |
| | | Qualification of NDT procedures | | | X |
| | | Authorisations (NDT instruction, procedures and personnel) | | | X |
| | | Developing written instruction | | X | |
| | | Working correctly to written instructions | X | | |
| | | Traceability of documents | | X | X |
| | | Reliability of documents | | X | X |
| 9.3 | Knowledge of applicable NDT application and product standards | Correct technique selection | | X | |
| | | Use of correct test parameters | | X | X |
| | | NDT method selection | | X | X |
| | | Job-specific training | X | X | X |
| | | Equipment verification | X | X | X |
| 9.4 | Relevant standards | Please refer to PCN24 standards document | | | X |
| **10** | **Environmental and safety conditions** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | Chemicals | Chemical handling (aerosols/propellants) | X | X | X |
| | | Disposal: | X | X | X |
| | | • Penetrant | X | X | X |
| | | • Developer | X | X | X |
| | | • Emulsifier | X | X | |
| | | • Soluble remover | | | X |
| | | • Material of process excess removal | X | X | |
| | | • Active carbon method | | X | |
| | | • Ultrafiltration method | | X | |
| | | Material safety data sheet | X | | |
| | | Review of applicable NDT application and product standard | | | X |
| 10.2 | Accessories | Violet and UV radiation hazards | X | X | X |
| | | Dangers of white lights | X | X | X |
| | | Electrical hazards | X | X | X |
| | | UV filters | X | X | |
| | | Vision considerations | X | X | X |
| | | Protective glasses | X | X | X |
| 10.3 | Human factors | Extended stay in dark areas | | | X |
| | | Role of breaks | | | X |
| **11** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 11.1 | Developments | Special installations | | X | |
| | | Automotive installations | | X | |
| | | Creative and innovative special installations | | | X |
| | | Tube installations | | | X |

## PCN syllabus – Radiography (RT-F – Film)

| Syllabus reference number | Title | Module subcontent | Film radiography (RT-F) | | |
|---|---|---|---|---|---|
| 1 | **Terminology and history of RT** | | Level 1 | Level 2 | Level 3 |
| 1.1 | History | History and discovery of radiographic materials, X-rays | X | X | X |
| 1.2 | Purpose of NDT | What is testing? | X | X | X |
| | | What is the purpose of NDT? | X | X | X |
| | | At what stage of life is NDT performed on a product? | X | X | X |
| | | How does it add value? | X | X | X |
| | | Who may carry out NDT? | X | X | X |
| | | Main NDT methods | X | X | X |
| 1.3 | Purpose of RT | Definition | X | X | X |
| | | Applicability and limitations | X | X | X |
| 1.4 | Terminology | Electromagnetic radiation | X | X | X |
| | | Energy | X | X | X |
| | | Dose | X | X | X |
| | | Dose rate | X | X | X |
| | | Wavelength | X | X | X |
| | | Intensity | X | X | X |
| | | Dose rate constant | X | X | X |
| | | Activity | X | X | X |
| 1.5 | Relevant standards | Please refer to PCN24 standards document | | X | X |
| 2 | **Physical principles and associated knowledge** | | Level 1 | Level 2 | Level 3 |
| 2.1 | General | Structure of the atom | X | X | X |
| | | Electromagnetic spectrum | X | X | X |
| | | Sources of radiation and its properties: | | | |
| | | • X-rays | X | X | X |
| | | • Gamma rays | X | X | X |
| | | • Neutrons | | | X |
| | | X-ray and gamma ray spectrum | X | X | X |
| | | Essential radiographic parameters: | | | |
| | | • Voltage | X | X | X |
| | | • Current | X | X | X |
| | | • Activity | X | X | X |
| | | Radiation filters | | X | X |
| | | Focal spot | X | X | X |
| | | Dose | X | X | X |
| | | Dose rate | X | X | X |
| | | Dose rate constant | X | X | X |
| 2.2 | Attenuation of radiation | General mechanism of interaction: | | | |
| | | • Photoelectric effect | X | X | X |
| | | • Compton effect | X | X | X |
| | | • Pair production | X | X | X |
| | | HVL, TVL and attenuation law | X | X | X |
| | | Hardening of radiation | X | X | X |
| | | Scattered radiation and build-up factor | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 2.2 *(continued)* | | Filtering and collimation | X | X | X |
| | | X-ray fluorescence | | X | X |
| | | Attenuation of neutrons and electrons | | | X |
| 2.3 | Radiation contrast and noise | Contrast, noise, granularity | X | X | X |
| | | Specific contrast | | X | X |
| | | Scatter influence | X | X | X |
| | | Unsharpness | X | X | X |
| 2.4 | Optimisation of image quality | Scatter protection | X | X | X |
| | | Maximum/optimum X-ray voltage | | X | X |
| 2.5 | Geometrical projection conditions | Geometrical and inherent unsharpness | X | X | X |
| | | Geometrical magnification | | X | X |
| | | Effect of magnification | | X | X |
| | | Optimum magnification | | | X |
| | | Difference between radiography and radioscopy | | X | X |
| | | Law of the squared distance | X | X | X |
| 2.6 | Image quality indicators | Wire type | X | X | X |
| | | Step hole type | X | X | X |
| | | Plate hole type | X | X | X |
| | | Duplex wire type | X | X | X |
| | | Measurement of basic spatial resolution | | X | X |
| | | Measurement of total unsharpness | | X | X |
| | | Converging line pairs | | | X |
| | | Line pair gauges (MTF) | | | X |
| **3** | **Product knowledge and capabilities** | | **Level 1** | **Level 2** | **Level 3** |
| 3.1 | General defects | Processes overview: | | | |
| | | • Casting | | X | X |
| | | • Forging | | X | X |
| | | • Welding | | X | X |
| | | • Tubes and pipes | | X | X |
| | | • Wrought products | | X | X |
| | | • Corrosion assessment | | X | X |
| | | • Composite materials | | X | X |
| | | Types of discontinuity | X | X | X |
| | | Fracture mechanics | | | X |
| | | Working load | | | X |
| | | Material properties | | X | X |
| | | Origin of defects | | X | X |
| | | Evaluation | | X | X |
| 3.2 | Influence on detectability | Type of defect | X | X | X |
| | | Size | X | X | X |
| | | Orientation | X | X | X |
| | | Number of exposures | | X | X |
| | | Beam direction | X | X | X |
| | | Increase in wall thickness | | X | X |
| | | Thickness ranges for X- and gamma rays | | X | X |
| | | Number of exposures *versus* distortion angle (tubes and pipes) | | X | X |

| 4 | Equipment | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 4.1 | Radiation sources – X-ray sources | Standard sources: | | | |
| | | • Types of source | X | X | X |
| | | • Stationary *versus* mobile | X | X | X |
| | | • Construction and function of X-ray tubes | X | X | X |
| | | • Unipolar *versus* bipolar | | X | X |
| | | Special sources | | X | X |
| | | Generation of high voltage | | X | X |
| | | Cooling | X | X | X |
| | | Handling | X | X | X |
| | | Parameters: | | | |
| | | • kV | X | X | X |
| | | • mA | X | X | X |
| | | • Focal spot size | X | X | X |
| | | Measurement of parameters | | X | X |
| 4.2 | Radiation sources – gamma sources | Container: | | | |
| | | • Shielding | X | X | X |
| | | • Classes of containers | | | X |
| | | Transportation | X | X | X |
| | | Source holder and capsule: | | | |
| | | • Handling and projection | X | X | X |
| | | • Special design | | X | X |
| | | • Collimation | X | X | X |
| | | Parameters: | | | |
| | | • Isotope type | X | X | X |
| | | • Spectrum | X | X | X |
| | | • Energy | X | X | X |
| | | • Activity | X | X | X |
| | | • Source size | X | X | X |
| | | • Half life | X | X | X |
| 4.3 | Film | Construction: | X | X | X |
| | | • Latent image information origin | X | X | X |
| | | • Base, emulsion, silver bromide, grain size, grain form | X | X | X |
| | | • Photo process | X | X | X |
| | | Processing: | | | |
| | | • Properties of film systems | X | X | X |
| | | • Characteristic curve | X | X | X |
| | | • Film gradient, film contrast, speed | X | X | X |
| | | • Influence of film processing | X | X | X |
| | | • Sensitivity | X | X | X |
| | | • Granularity | X | X | X |
| | | • Detail perceptibility | | X | X |
| | | Classification of film systems | X | X | X |
| | | Quality assurance with film test strips | | X | X |
| | | Film screens: | | | |
| | | • Types of screen | X | X | X |
| | | • Inherent unsharpness | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 4.3 *(continued)* | | • Intensifying effect | X | X | X |
| | | • Effect of filtering | X | X | X |
| | | • Screens for Cobalt 60 and LINAC | X | X | X |
| | | Working with exposure charts | X | X | X |
| 4.4 | Film development and darkroom conditions | Darkroom design | X | X | X |
| | | Manual *versus* machine development | X | X | X |
| | | Baths: | | | |
| | | • Different baths | X | X | X |
| | | • Quality assurance in the darkroom | X | X | X |
| | | Developing process: | | | |
| | | • Principles | X | X | X |
| | | • Processing equipment, adjustment | X | X | X |
| | | • Checking | X | X | X |
| | | • Storage of unexposed films | X | X | X |
| | | • Darkroom light test | X | X | X |
| | | • Fog test | X | X | X |
| | | • Clearing time | X | X | X |
| | | • Tally sheet | X | X | X |
| | | Use of test film strips | | X | X |
| 4.5 | Film digitisation | Scanner design: | | | |
| | | • Camera based | | X | X |
| | | • Line scanners | | X | X |
| | | • Laser scanners | | X | X |
| | | Quality assurance (phantom) | | X | X |
| | | Handling, archiving | | X | X |
| | | System selection | | | X |
| | | Classification | | X | X |
| 4.6 | Accessories | Equipment: | | | |
| | | • Lead letters and tape | X | X | X |
| | | • Holding magnets | X | X | X |
| | | • Lead shielding, collimation, masking | X | X | X |
| | | • Rubber bands | X | X | X |
| | | • Radiation protection equipment | X | X | X |
| **5** | **Information prior to testing** | | **Level 1** | **Level 2** | **Level 3** |
| 5.1 | Information about the test object | Identification or designation material: | | | |
| | | • Object to be tested | X | X | X |
| | | • Kind of manufacture | X | X | X |
| | | • Catalogue of defects | | X | X |
| | | • Extent of test coverage | X | X | X |
| 5.2 | Test conditions and application of standard | Accessibility | | X | X |
| | | Infrastructure | | X | X |
| | | Particular test conditions | | X | X |
| | | Application standard | | X | X |
| | | Stage of manufacture or service life when testing is to be carried out | | X | X |
| | | Standards assigned to the test object | | X | X |
| | | Requirements of test personnel | | X | X |
| | | Acceptance criteria | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 5.3 | Technique and sequence of performing test | Surface condition | | X | X |
| | | Surface preparation | | X | X |
| | | Post-test documentation | | X | X |
| 5.4 | Instructions | Preparation of written procedure | | | X |
| | | Preparation of written instruction | | X | X |
| | | Performing inspection in accordance with written instruction | X | | |
| | | Presentation of the standards, codes and procedures | | | X |
| **6** | **Testing** | | **Level 1** | **Level 2** | **Level 3** |
| 6.1 | Standard practice and evaluation standards | Selection of technique: | | | |
| | | • Different exposure geometries | | X | X |
| | | • Interpretation of images | | X | X |
| | | • Evaluation of flaws | | X | X |
| | | • Use of catalogues | | X | X |
| | | Measurement of flaw dimensions | | X | X |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Basics of evaluation | Viewing conditions: | | | |
| | | • Room condition | X | X | X |
| | | • Viewing time | X | X | X |
| | | • Lapsed time after dazzling | X | X | X |
| | | • Luminance | | X | X |
| | | • Density measurement | X | X | X |
| | | • Mach effect | | X | X |
| | | Film illuminator: | | | |
| | | • Introduction | X | X | X |
| | | • Minimum luminance | | X | X |
| | | • Homogeneity factor | | X | X |
| | | Measurement tools: | | X | X |
| | | • Linear scales | | X | X |
| | | • Magnifiers | | X | X |
| | | • Measurement of flaw length | | X | X |
| | | • Measurement of areas | | X | X |
| | | • Measurement of depth | | X | X |
| 7.2 | Physical factors | Eyesight | | X | X |
| | | Adaption prior viewing | | X | X |
| 7.3 | Evaluation of radiographs | Verification of the image quality | X | X | X |
| | | Report of imperfections | | X | X |
| 7.4 | Test report | Complies with examination standard | | X | X |
| | | Conformed to test quality | | X | X |
| | | Achieved test class | X | X | X |
| | | Achieved diagnostic coverage of test object | X | X | X |
| **8** | **Assessment** | | **Level 1** | **Level 2** | **Level 3** |
| 8.1 | Classification of imperfections | Type | | X | X |
| | | Size | | X | X |
| | | Localisation | | X | X |
| | | Frequency | | X | X |
| | | Influence of manufacture and material | | X | X |

| 9 | Quality aspects | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 9.1 | Personnel qualification | ISO 9712 | X | X | X |
| | | Other NDT qualification and certification systems | | | X |
| 9.2 | Documentation | Format and scope of working procedures | | | X |
| | | Qualification of NDT procedures | | | X |
| | | Authorisations (NDT instruction, procedures and personnel) | | | X |
| | | Developing written instruction | | X | X |
| | | Working correctly to written instruction | X | | |
| | | Traceability of documents | | X | X |
| | | Reliability of measurements | | X | X |
| 9.3 | Knowledge of applicable NDT application and product standards | Correct technique selection | | X | X |
| | | Use of correct test parameters | | X | X |
| | | NDT method selection | | | X |
| | | Job-specific training | | X | X |
| | | Equipment verification | | X | X |
| **10** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | Special techniques | Stereo radiography | | X | X |
| | | Backscatter radiography | | | X |
| | | Phase contrast X-ray imaging | | | X |
| | | Computed tomography (CT): | | | X |
| | | • Introduction | | | X |
| | | • Applications | | | X |
| | | • Requirements, limitations | | | X |
| | | RT-F *versus* RT-D | | X | X |

**PCN syllabus – Digital radiography (RT-D – Computed and digital)**

| Syllabus reference number | Title | Module subcontent | Digital radiography (RT-D) | | |
|---|---|---|---|---|---|
| **1** | **Terminology and history of RT** | | **Level 1** | **Level 2** | **Level 3** |
| 1.1 | History | History and discovery of radiographic materials, X-rays | X | X | X |
| 1.2 | Purpose of NDT | What is testing? | X | X | X |
| | | What is the purpose of NDT? | X | X | X |
| | | At what stage of life is NDT performed on a product? | X | X | X |
| | | How does it add value? | X | X | X |
| | | Who may carry out NDT? | X | X | X |
| | | Main NDT methods | X | X | X |
| 1.3 | Purpose of RT | Definition | X | X | X |
| | | Applicability and limitations | X | X | X |
| 1.4 | Terminology | Electromagnetic radiation | X | X | X |
| | | Energy | X | X | X |
| | | Dose | X | X | X |
| | | Dose rate | X | X | X |
| | | Wavelength | X | X | X |
| | | Intensity | X | X | X |
| | | Dose rate constant | X | X | X |
| | | Activity | X | X | X |
| 1.5 | Relevant standards | Please refer to PCN24 standards document | | X | X |

| 2 | Physical principles and associated knowledge | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 2.1 | General | Structure of the atom | X | X | X |
| | | Electromagnetic spectrum | X | X | X |
| | | Sources of radiation and its properties: | | | |
| | | • X-rays | X | X | X |
| | | • Gamma rays | X | X | X |
| | | • Neutrons | | | X |
| | | X-ray and gamma ray spectrum | X | X | X |
| | | Essential radiographic parameters: | | | |
| | | • Voltage | X | X | X |
| | | • Current | X | X | X |
| | | • Activity | X | X | X |
| | | Radiation filters | | X | X |
| | | Focal spot | X | X | X |
| | | Dose | X | X | X |
| | | Dose rate | X | X | X |
| | | Dose rate constant | | X | X |
| 2.2 | Attenuation of radiation | General mechanism of interaction: | | | |
| | | • Photoelectric effect | X | X | X |
| | | • Compton effect | X | X | X |
| | | • Pair production | | X | X |
| | | HVL, TVL and attenuation law | X | X | X |
| | | Hardening of radiation | X | X | X |
| | | Scattered radiation and build-up factor | X | X | X |
| | | Filtering and collimation | X | X | X |
| | | X-ray fluorescence | X | | X |
| | | Attenuation of neutrons and electrons | | | X |
| 2.3 | Radiation contrast and noise | Contrast, noise, granularity | X | X | X |
| | | Specific contrast | | X | X |
| | | Scatter influence | X | X | X |
| | | Signal-to-noise ratio (SNR) | X | X | X |
| | | Contrast-to-noise ratio | | X | X |
| | | Unsharpness | X | X | X |
| | | Basic spatial resolution | X | X | X |
| | | Pixel size | X | X | X |
| | | Normalised SNR ($SNR_N$) | X | X | X |
| 2.4 | Optimisation of image quality | Compensation principles: | | | |
| | | • Contrast *versus* SNR | | X | X |
| | | • Basic spatial resolution *versus* SNR | | X | X |
| | | • Local unsharpness *versus* SNR | | X | X |
| | | Scatter protection | X | X | X |
| | | Maximum/optimum X-ray voltage | | X | X |
| 2.5 | Geometrical projection conditions | Geometrical and inherent unsharpness | X | X | X |
| | | Geometrical magnification | | X | X |
| | | Effect of magnification | X | X | X |
| | | Optimum magnification | | X | X |
| | | Difference between radiography and radioscopy | | X | X |
| | | Law of the squared distance | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 2.6 | Image quality indicators | Wire type | X | X | X |
| | | Step hole type | X | X | X |
| | | Plate hole type | X | X | X |
| | | Duplex wire type | X | X | X |
| | | Measurement of basic spatial resolution | | X | X |
| | | Measurement of total unsharpness | | X | X |
| | | Converging line pairs | | X | X |
| | | Line pair gauges (MTF) | | | X |
| **3** | **Product knowledge and capabilities** | | **Level 1** | **Level 2** | **Level 3** |
| 3.1 | General defects | Processes overview: | | | |
| | | • Casting | | X | X |
| | | • Forging | | X | X |
| | | • Welding | | X | X |
| | | • Tubes and pipes | | X | X |
| | | • Wrought products | | X | X |
| | | • Corrosion assessment | | X | X |
| | | • Composite materials | | X | X |
| | | Types of discontinuity | X | X | X |
| | | Fracture mechanics | | | X |
| | | Working load | | | X |
| | | Material properties | | X | X |
| | | Origin of defects | | X | X |
| | | Evaluation | | X | X |
| 3.2 | Influence on detectability | Type of defect | X | X | X |
| | | Size | X | X | X |
| | | Orientation | X | X | X |
| | | Number of exposures | | X | X |
| | | Beam direction | X | X | X |
| | | Increase in wall thickness | | X | X |
| | | Thickness ranges for X- and gamma rays | | X | X |
| | | Number of exposures *versus* distortion angle (tubes and pipes) | | X | X |
| **4** | **Equipment** | | **Level 1** | **Level 2** | **Level 3** |
| 4.1 | Radiation sources – X-ray sources | Standard sources: | | | |
| | | • Types of source | X | X | X |
| | | • Stationary *versus* mobile | X | X | X |
| | | • Construction and function of X-ray tubes | X | X | X |
| | | • Unipolar *versus* bipolar | | X | X |
| | | Special sources | | X | X |
| | | Generation of high voltage | | X | X |
| | | Cooling | X | X | X |
| | | Handling | X | X | X |
| | | Parameters: | | | |
| | | • kV | X | X | X |
| | | • mA | X | X | X |
| | | • Spot size | X | X | X |
| | | Measurement of parameters | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 4.2 | Radiation sources – gamma sources | Container: | | | |
| | | • Shielding | X | X | X |
| | | • Classes of containers | | | X |
| | | Transportation | X | X | X |
| | | Source holder and capsule: | | | |
| | | • Handling and projection | X | X | X |
| | | • Special design | | X | X |
| | | • Collimation | X | X | X |
| | | Parameters: | | | |
| | | • Isotope type | X | X | X |
| | | • Spectrum | X | X | X |
| | | • Energy | X | X | X |
| | | • Activity | X | X | X |
| | | • Source size | X | X | X |
| | | • Half life | X | X | X |
| 4.3 | Film | Construction: | | | |
| | | • Latent image information origin | | | X |
| | | • Base, emulsion, silver bromide, grain size, grain form | | | X |
| | | • Photo process | | | X |
| | | Processing: | | | |
| | | • Properties of film systems | | | X |
| | | • Optical density | | | X |
| | | • Characteristic curve | | | X |
| | | • Film gradient, film contrast, speed | | | X |
| 4.4 | Computer radiography (CR), imaging plates | Phosphor imaging plates: | | | |
| | | • Introduction | X | X | X |
| | | • Design | X | X | X |
| | | Imaging plate and CR scanner | X | X | X |
| | | CR system and classification | | X | X |
| | | Quality assurance (phantom) | | X | X |
| | | Exposure conditions | X | X | X |
| | | Working with exposure charts | X | X | X |
| | | Handling | X | X | X |
| | | System selection | | X | X |
| 4.5 | Digital detector arrays (DDAs) | Digital detector arrays (DDAs): | | | |
| | | • Introduction | X | X | X |
| | | • Design | X | X | X |
| | | Indirect converting | | X | X |
| | | Direct converting | | X | X |
| | | CCD, amorphous silicon, CMOS | | X | X |
| | | Detector adjustment | | X | X |
| | | Quality assurance | | X | X |
| | | Exposure conditions | | X | X |
| | | Handling | X | X | X |
| | | System selection | | | X |
| 4.6 | Line detector arrays (LDAs) | Line detector arrays (LDAs): | | | |
| | | • Introduction | X | X | X |
| | | • Design | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 4.6 *(continued)* | | Application areas | | X | X |
| | | Comparison to DDAs | | X | X |
| | | Quality assurance (phantom) | | X | X |
| | | Exposure conditions and diagrams | | X | X |
| | | Handling | | X | X |
| | | System selection | | | X |
| 4.7 | Intensifiers, fluoroscope | Introduction | | | X |
| 4.8 | Film digitisation | Scanner design: | | | |
| | | • Camera based | | | |
| | | • Line scanners | | | |
| | | • Laser scanners | | | X |
| | | Quality assurance (phantom) | | | X |
| | | Handling, archiving | | | X |
| | | System selection | | | X |
| | | Classification | | X | X |
| 4.9 | Accessories | Equipment: | | | |
| | | • Lead letters and tape | X | X | X |
| | | • Holding magnets | X | X | X |
| | | • Lead shielding, collimation, masking | X | X | X |
| | | • Rubber bands | X | X | X |
| | | • Radiation protection equipment | X | X | X |
| 4.10 | Data acquisition, detector adjustment | A/D interface | X | X | X |
| | | Computer structure: | | | |
| | | • Processor, memory, bus, disk | X | X | X |
| | | • Load and save of digital images | X | X | X |
| | | • Image formats | X | X | X |
| | | Image integration: | | | |
| | | • On-chip integration/frame time | X | X | X |
| | | • In-memory integration/frame number | X | X | X |
| | | • Optimum gain and latitude settings | | X | X |
| | | • Accumulation *versus* integration | | X | X |
| **5** | **Information prior to testing** | | **Level 1** | **Level 2** | **Level 3** |
| 5.1 | Information about the test object | Identification or designation material: | X | X | X |
| | | • Object to be tested | X | X | X |
| | | • Kind of manufacture | X | X | X |
| | | • Catalogue of defects | | X | X |
| | | • Extent of test coverage | X | X | X |
| 5.2 | Test conditions and application of standard | Accessibility | | X | X |
| | | Infrastructure | | X | X |
| | | Particular test conditions | | X | X |
| | | Application standard | | X | X |
| | | Stage of manufacture or service life when testing is to be carried out | | X | X |
| | | Standards assigned to the test object | | X | X |
| | | Requirements of test personnel | | X | X |
| | | Acceptance criteria | | X | X |
| 5.3 | Technique and sequence of performing test | Surface condition | | X | X |
| | | Surface preparation | | X | X |
| | | Post-test documentation | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 5.4 | Instructions | Preparation of written procedure | | | X |
| | | Preparation of written instruction | | X | X |
| | | Performing inspection in accordance with written instruction | X | | |
| | | Presentation of the standards, codes and procedures | | | X |
| **6** | **Testing** | | **Level 1** | **Level 2** | **Level 3** |
| 6.1 | Standard practice and evaluation standards | Selection of technique: | | | |
| | | • Different exposure geometries | | X | X |
| | | • Interpretation of images | | X | X |
| | | • Evaluation of flaws | | X | X |
| | | • Use of catalogues | | X | X |
| | | Measurement of flaw dimensions | | X | X |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Basics of evaluation | Viewing conditions: | | | |
| | | • Room condition | X | X | X |
| | | • Viewing time | X | X | X |
| | | • Luminance | | X | X |
| | | • Mach effect | | X | X |
| | | Review monitor: | X | X | X |
| | | • Introduction | | X | X |
| | | • Pixel density | | X | X |
| | | • Bit depth | | X | X |
| | | • Brightness/luminance cd/m$^2$ | | X | X |
| | | • Contrast and min/max driving level (DDL) | | | X |
| | | • Gamma and GSDF | | | X |
| | | • Luminance ratio | | | X |
| | | • Just noticeable differences | | | X |
| | | • Resolution | | | X |
| | | • Colour/greyscale | | | X |
| | | • Positive/negative | | | X |
| | | • Monitor test patterns | | | X |
| | | • Viewing angle | | | X |
| | | • Monitor calibration | | | X |
| | | • Monitor/viewing environment | | | X |
| 7.2 | Physical factors | Eyesight | | X | X |
| 7.3 | Evaluation of radiographs | Verification of the image quality | X | X | X |
| | | Report of imperfections | | X | X |
| 7.4 | Test report | Complies with examination standard | | X | X |
| | | Conformed to test quality | | X | X |
| | | Achieved test class | X | X | X |
| | | Achieved diagnostic coverage of test object | X | X | X |
| 7.5 | Digital image processing | Image structure, quantisation (bits and bytes) | X | X | X |
| | | Basic operation: | | | |
| | | • Picture element (pixel) | X | X | X |
| | | • Grey value | X | X | X |
| | | Point operations: | | | |
| | | • Contrast | X | X | X |
| | | • Brightness | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 7.5 *(continued)* | | • Gamma correction | X | X | X |
| | | • Histogram | | X | X |
| | | • Lookup table (LUT) | | X | X |
| | | Matrix operations, filters: | | | |
| | | • Smoothing, improvement of SNR | | X | X |
| | | • High pass, gradient | | X | X |
| | | • Edge enhancement, line extraction | | X | X |
| | | • Median | | X | X |
| | | Measurement tools: | | | |
| | | • Adjustment | | X | X |
| | | • Line profile | | X | X |
| | | • Measurement of flaw length | | X | X |
| | | • Measurement of areas | | X | X |
| | | • Measurement of depth | | X | X |
| | | Correction of raw data: | | | |
| | | • Introduction | | X | X |
| | | • Linearisation, LUT | | | X |
| | | • Bad pixel interpolation | | | X |
| 7.6 | Automated image interpretation | Principles | | X | X |
| | | Binarisation | | | X |
| | | Measurement of dimensions | | X | X |
| | | Artificial Intelligence | | X | X |
| **8** | **Assessment** | | **Level 1** | **Level 2** | **Level 3** |
| 8.1 | Classification of imperfections | Type | | X | X |
| | | Size | | X | X |
| | | Localisation | | X | X |
| | | Frequency | | X | X |
| | | Influence of manufacture and material | | X | X |
| **9** | **Quality aspects** | | **Level 1** | **Level 2** | **Level 3** |
| 9.1 | Personnel qualification | ISO 9712 | X | X | X |
| | | Other NDT qualification and certification systems | | | X |
| 9.2 | Documentation | Format and scope of working procedures | | | X |
| | | Qualification of NDT procedures | | | X |
| | | Authorisations (NDT instruction, procedures and personnel) | | | X |
| | | Developing written instruction | | X | X |
| | | Working correctly to written instruction | X | | |
| | | Traceability of documents | | X | X |
| | | Reliability of measurements | | X | X |
| 9.3 | Knowledge of applicable NDT application and product standards | Correct technique selection | | X | X |
| | | Use of correct test parameters | | X | X |
| | | NDT method selection | | | X |
| | | Job-specific training | | X | X |
| | | Equipment verification | | X | X |
| **10** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | Special techniques | Stereo radiography | | X | X |
| | | Backscatter radiography | | | X |
| | | Phase contrast X-ray imaging | | | X |

| | | | | | |
|---|---|---|---|---|---|
| 10.1 *(continued)* | | Computed tomography (CT): | | | |
| | | • Introduction | | X | X |
| | | • Inspection geometry | | X | X |
| | | • 2D *versus* 3D | | | X |
| | | • Reconstruction principles | | | X |
| | | • Filtered back projections | | | X |
| | | • Artefacts | | X | X |
| | | • Applications | | X | X |
| | | • Requirements, limitations | | | X |
| | | RT-F *versus* RT-D | | X | X |

**PCN syllabus – Ultrasonic testing (UT)**

| Syllabus reference number | Title | Module subcontent | Ultrasonic testing (UT) | | |
|---|---|---|---|---|---|
| 1 | **Terminology and history of UT** | | Level 1 | Level 2 | Level 3 |
| 1.1 | History of UT | History of ultrasonic testing | X | X | X |
| 1.2 | Purpose of NDT | What is testing? | X | X | X |
| | | What is the purpose of NDT? | X | X | X |
| | | At what stage of life is NDT performed on a product? | X | X | X |
| | | How does it add value? | X | X | X |
| | | Who may carry out NDT? | X | X | X |
| | | Main NDT methods | X | X | X |
| 1.3 | Terminology of NDT | Please refer to PCN24 standards document | X | X | X |
| 1.4 | Terminology of UT | Please refer to PCN24 standards document | X | X | X |
| 2 | **Physical principles and associated knowledge** | | Level 1 | Level 2 | Level 3 |
| 2.0 | Relevant standards | Please refer to PCN24 standards document | X | X | X |
| 2.1 | Review of mathematical basics | Algebra | X | X | |
| | | Trigonometry | X | X | |
| | | Logarithms | X | X | |
| 2.2 | Physical definitions and typical parameters | Sinusoidal movement | X | X | |
| | | Amplitude | X | X | |
| | | Period | X | X | |
| | | Frequency | X | X | |
| | | Velocity | X | X | |
| | | Acoustic impedance | X | X | |
| | | Acoustic pressure | X | X | |
| | | Factors of reflection and transmission (normal beam only) | X | X | |
| | | Isotropic materials | X | | X |
| | | Anisotropic materials | | X | X |
| 2.3 | Waves | Sinusoidal movement | X | | |
| | | Amplitude | X | | |
| | | Frequency | X | | |
| | | Wavelength | X | | |
| | | Propagation velocity | X | | |
| | | Longitudinal | X | X | |

| | | | | | |
|---|---|---|---|---|---|
| 2.3 *(continued)* | | Transverse | X | X | |
| | | Rayleigh waves (surface waves) | X | X | X |
| | | Creeping waves | | | X |
| | | Guided waves | | | X |
| 2.4 | Transmission and reflection | Effects at interfaces at normal incidence: | X | X | |
| | | • Transmission | X | X | |
| | | • Reflection | X | X | |
| | | • Interference | | X | |
| | | • Dispersion | X | X | X |
| | | Snell's Law | X | X | |
| | | Relation between velocity and elastic properties | | | X |
| | | Effects at interfaces at oblique incidence: | X | X | |
| | | • Transmission | X | X | |
| | | • Reflection | X | X | |
| | | • Refraction | X | X | |
| | | Corner reflectors: | X | X | |
| | | • Reflection | X | X | |
| | | • Mode conversion | X | X | |
| | | Electrostriction | | | X |
| | | Magnetostriction | | | X |
| | | Electrodynamic generation | | | X |
| | | Generation by laser | | | X |
| | | Piezoelectric effect | X | X | |
| | | Reverse piezoelectric effect | X | X | |
| 2.5 | Transducer characteristics | Material | X | X | |
| | | Dimensions | X | X | |
| | | Frequency | X | X | |
| | | Piezoelectric constants | X | X | |
| 2.6 | Sound fields of disc-shaped transducers | Near field (Fresnel zone) | X | X | |
| | | Far field (Fraunhofer zone) | X | X | |
| | | Beam divergence | X | X | |
| | | Influence of transducer frequency and diameter | X | X | |
| **3** | **Product knowledge and capabilities** | | **Level 1** | **Level 2** | **Level 3** |
| 3.1 | General defects | Casting | X | X | |
| | | Welding | X | X | |
| | | Wrought products (including forgings, tubes and pipes) | X | X | |
| | | Composite material | X | X | |
| 3.2 | Implementation of the testing techniques | According to products | X | X | |
| | | According to expected discontinuities | X | X | |
| | | Standards, specifications and codes | | X | |
| 3.3 | Overall properties of the specimen | Influence of surface conditions | X | X | |
| | | Geometry (additional echoes due to grazing incidence and radial straight beam incidence) | X | X | |
| | | Structure (sound attenuation) | X | X | |
| | | Selection of probe: | | X | |
| | | • Inspection-oriented design of specimen | | | X |

| | | | | | |
|---|---|---|---|---|---|
| *3.3 (continued)* | | Testing technique based on task: | | X | |
| | | • Simulations | | | X |
| **4** | **Equipment** | | **Level 1** | **Level 2** | **Level 3** |
| 4.1 | Ultrasonic instruments | Digital instruments: | X | X | |
| | | • Design | X | X | |
| | | • Function | X | X | |
| | | • Pulse generation | X | X | |
| | | • Reception | X | X | |
| | | • Amplification | X | X | |
| | | • A-scan presentation | X | X | |
| | | • RF-signal | X | X | |
| | | • Rectification | X | X | |
| | | • Peak and flank measurement | X | X | |
| | | Analogue *versus* digital | | X | X |
| | | Ultrasonic thickness gauge | X | X | |
| | | Automated and semi-automated systems | | X | X |
| | | Manual | | | X |
| | | Speed | | | X |
| | | Incrementation | | | X |
| | | Repeatability | | | X |
| | | Sampling rate | | | X |
| 4.2 | Probes | Straight beam: | X | X | |
| | | • Design | X | X | |
| | | • Application | X | X | |
| | | Angle beam: | X | X | |
| | | • Design | X | X | |
| | | • Effects at interface wedge/specimen | X | X | |
| | | • Critical angles | X | X | |
| | | • Typical angles for testing of steel | X | X | |
| | | • Sound fields | X | X | |
| | | • Probe index | X | X | |
| | | • Beam angles | X | X | |
| | | • Change of probe index and beam angle due to abrasion or probe shoes | X | X | |
| | | • Half and full skip | X | X | |
| | | • Application | X | X | |
| | | Dual element: | X | X | |
| | | • Design | X | X | |
| | | • Deviation error | X | X | |
| | | • Sound field | X | X | |
| | | • Adjustment | X | X | |
| | | • Application | X | X | |
| | | Dynamic range | | | X |
| | | Immersion probes (focused, spherical, cylindrical, Fermat surface) | | X | X |
| | | Measurement of pulse length | | X | X |
| | | Practical measurements of directional characteristics | | X | X |
| | | Shoe (delay, curvature) | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 4.3 | Couplant | | X | X | |
| 4.4 | Connecting cables | Length | | | X |
| | | Impedance | | | X |
| 4.5 | Adjustment reference and transfer blocks | Adjustment block No 1 | X | X | X |
| | | Adjustment block No 2 | X | X | X |
| | | Reference blocks | X | X | X |
| | | Resolution: | X | X | X |
| | | • Near | X | X | X |
| | | • Far | X | X | X |
| **5** | **Information prior to testing** | | **Level 1** | **Level 2** | **Level 3** |
| 5.1 | Information about the test object | Identification or designation material: | X | X | X |
| | | • Object to be tested | X | X | X |
| | | • Kind of manufacture | X | X | X |
| | | • Catalogue of defects | | X | X |
| | | • Extent of test coverage | X | X | X |
| 5.2 | Test conditions and application of standard | Accessibility | | X | X |
| | | Infrastructure | | | X |
| | | Particular test conditions | | X | X |
| | | Application standard | | X | X |
| | | Stage of manufacture or service life when testing is to be carried out | | | X |
| | | Standards assigned to the test object | | X | X |
| | | Requirements of test personnel | | X | X |
| | | Acceptance criteria | | X | X |
| 5.3 | Technique and sequence of performing test | Surface condition | X | X | |
| | | Surface preparation | X | X | |
| | | Post-test documentation | | X | |
| 5.4 | Instructions | Preparation of written procedure | | | X |
| | | Preparation of written instruction | | X | |
| | | Performing inspection in accordance with written instruction | X | | |
| **6** | **Testing** | | **Level 1** | **Level 2** | **Level 3** |
| 6.1 | Techniques | Pulse echo and transmission | X | X | |
| | | Contact | X | X | |
| | | Tandem technique | | X | |
| | | Immersion technique | | X | |
| | | TOFD technique | | X | |
| | | Phased array technique | | X | |
| | | TFM technique | | X | |
| | | Techniques for ultrasonic thickness measurement: | X | X | |
| | | • Reference reflectors (laws of distance and size) | | X | |
| | | Verification of combined equipment: | X | X | |
| | | • DGS techniques | | X | |
| | | • Multiple-probe arrays | | | X |
| | | Electromagnetic acoustic transducer (EMAT) | | X | |
| | | Range setting: | X | X | |
| | | • Single-point adjustment | X | X | |
| | | • Two-point adjustment | X | X | |

| | | | | | |
|---|---|---|---|---|---|
| 6.1 *(continued)* | | Sensitivity setting: | X | X | |
| | | • Reference reflectors (BW, SDH, DSR) | X | X | |
| | | • Single-reflector technique (reference height) | X | X | |
| | | • Air-coupled ultrasonic testing | | | X |
| | | • Guided waves | | X | X |
| | | • Testing at higher temperatures | | X | X |
| | | Different sizing techniques: | | X | |
| | | • Principles | | X | |
| | | • Limitations | | X | |
| | | • Requirements for reference blocks | X | X | |
| | | • DAC technique | X | X | |
| | | • Transfer correction | X | X | |
| | | • Recording gain (testing level) | X | X | |
| | | • Errors at echo height evaluation | X | X | |
| | | Laser UT | | | X |
| | | Verification of procedures and instructions for their efficiency | | | X |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Interpretation | Relevant standards | | | X |
| | | Relevant specifications | | | X |
| | | Relevant codes | | | X |
| | | Evaluation (conventional or computer-aided methods, for example echo tomography, synthetic aperture focusing technique (SAFT)) | | | X |
| | | Data storage process (for example ALOK) | | | X |
| 7.2 | Detecting, locating and sizing techniques | Detecting | X | X | |
| | | Distinction between defect and geometry echo | X | X | |
| | | Locating (calculation, trigonometrical rules) | X | X | |
| | | Interpretation | | X | |
| | | Evaluation | | X | |
| | | A-scan presentation | X | X | X |
| | | B-scan presentation | | X | X |
| | | C-scan presentation | | X | X |
| | | D-scan presentation | | | X |
| | | E-scan presentation | | | X |
| | | F-scan presentation | | | X |
| | | P-scan presentation | | | X |
| | | S-scan presentation | | | X |
| | | Recording results | X | X | |
| | | Classifying results | X | X | |
| | | Acceptance levels | X | X | |
| | | Echo height evaluation with distance gain size (DGS) method | | X | |
| | | Sizing and half-amplitude technique | X | | |
| | | Sizing using the fixed-amplitude-level technique | | X | |
| | | Echo height evaluation with single-reflector technique and DAC method | X | X | |
| | | Reporting | X | X | |
| | | Checking content and matching of test reports, instructions and procedures | | | X |

| 8 | Assessment | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 8.1 | Evaluation and confirmation of test reports | Application of the acceptance criteria according to standards, codes and procedures | | X | |
| **9** | **Quality aspects** | | **Level 1** | **Level 2** | **Level 3** |
| 9.1 | Personnel qualification | ISO 9712 | X | X | X |
| | | Other NDT qualification and certification systems | | X | X |
| 9.2 | Documentation | Traceability of documents | | X | X |
| | | Equipment verification | | X | X |
| | | Reliability of measurements | | X | X |
| | | Format of working procedures | | | X |
| **10** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | Newest developments for industrial and scientific applications of UT | Phased array | X | X | X |
| | | Time-of-flight diffraction | X | X | X |
| | | Long range | X | X | X |
| | | Computer modelling | | | X |
| | | TFM technique | | X | X |

**PCN syllabus – Phased array ultrasonic testing (PAUT)**

| Syllabus reference number | Title | Module subcontent | Phased array ultrasonic testing (PAUT) | | |
|---|---|---|---|---|---|
| **1** | **Terminology and history of PAUT** | | **Level 1** | **Level 2** | **Level 3** |
| 1.0 | History of PAUT | History of phased array ultrasonic testing | X | X | X |
| 1.1 | Introduction to PAUT | Overview | X | X | X |
| | | Applicability and limitations | X | X | X |
| | | Difference between conventional and ultrasonic phased array techniques | X | X | X |
| **2** | **Physical principles and associated knowledge** | | **Level 1** | **Level 2** | **Level 3** |
| 2.1 | Mathematical and physical basics | Basics of sound beam | X | X | X |
| | | Waves: | X | X | X |
| | | • Sinusoidal movement | X | X | X |
| | | • Amplitude | X | X | X |
| | | • Frequency | X | X | X |
| | | • Wavelength | X | X | X |
| | | • Propagation velocity | X | X | X |
| | | • Longitudinal waves | X | X | X |
| | | • Transverse waves | X | X | X |
| | | • Consideration of near field, beam spread, element width | X | X | X |
| | | Terms relating to sound: | | X | X |
| | | • Side lobes | | X | X |
| | | • Grating lobes | | X | X |
| | | • Artefacts | | X | X |
| | | Terms relating to arrays: | X | X | X |
| | | • Active aperture | X | X | X |
| | | • Elementary aperture | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 2.1 *(continued)* | | • Primary axis of an array | X | X | X |
| | | • Secondary axis of an array | X | X | X |
| | | Influence of band width | | X | X |
| | | Electronical beam steering and focusing of sound beams | | X | X |
| **3** | **Product knowledge and capabilities** | | **Level 1** | **Level 2** | **Level 3** |
| 3.1 | Defects relating to the manufacturing processes | Welding | X | X | X |
| | | Forgings | X | X | X |
| | | Castings | X | X | X |
| 3.2 | Implementation of PAUT techniques according to products and to expected discontinuities | Likely flaw types and flaw orientations per product, including probe type, beam type and encoder to optimise the scanning | X | X | X |
| 3.3 | Overall properties of specimen | Influence of surface conditions | X | X | X |
| | | Geometry | X | X | X |
| | | Attenuation | X | X | X |
| | | Reference reflectors: | X | X | X |
| | | • Backwall | X | X | X |
| | | • Side-drilled holes | X | X | X |
| | | • Flat-bottom holes | X | X | X |
| | | • Notches | X | X | X |
| **4** | **Equipment** | | **Level 1** | **Level 2** | **Level 3** |
| 4.1 | Test instrument and combined equipment | Phased array instrument | X | X | X |
| | | Multi-channel instrument (number of pulses and receivers that can be addressed) | | X | X |
| | | Transmitting delay | | X | X |
| | | Receiving delay | | X | X |
| | | Delay laws | | X | X |
| | | Amplitude balancing | | X | X |
| | | Multi-group capability | | X | X |
| | | Number of focal laws | | X | X |
| | | Digitisation concepts and associated instrument settings (replication of analogue signal) | | X | X |
| | | Axial, lateral and encoder resolution (effects of instrument settings) | | X | X |
| 4.2 | Phased array probes | Linear array | X | X | X |
| | | Annular array | X | X | X |
| | | Annular sectorial array | X | X | X |
| | | Acoustic properties of wedge materials that affect phased arrays | | X | X |
| | | Encircling array | X | X | X |
| | | 1,5D array | X | X | X |
| | | Linear array with separate transmitters and receivers | X | X | X |
| 4.3 | Multi-group capabilities | Number of focal laws that may be addressed | | X | X |
| 4.4 | Encoders | Different types of scanner and encoding system | | X | X |
| 4.5 | Couplant and coupling techniques | Couplant types, built-in irrigation systems or manually applied | | X | X |
| 4.6 | Adjustment blocks | Block No 1 according to ISO 2400 | | X | X |
| | | Block No 2 according to ISO 7963 | | X | X |
| | | Reference block according to ISO 13588 | | X | X |
| | | Different reference blocks | | X | X |

| 5 | **Information prior to testing** | | **Level 1** | **Level 2** | **Level 3** |
|---|---|---|---|---|---|
| 5.1 | Applied standards for UT and PAUT | Content | | X | X |
| | | Requirements for procedures | | | X |
| | | Developing of test procedures | | | X |
| **6** | **Testing** | | **Level 1** | **Level 2** | **Level 3** |
| 6.1 | Techniques | Linear scanning with zero-degree (forgings and castings) | X | X | X |
| | | Linear scanning with constant angle (welding) | X | X | X |
| | | Sectorial scanning (welding, forging) | X | X | X |
| | | Multi-group scanning | | X | X |
| | | Compound scans | | | X |
| | | Focusing techniques, including overview of dynamic depth focusing (DDF), total focusing method (TFM) and full matrix capture (FMC) | | | X |
| | | Range setting: | | X | X |
| | | • Single-point adjustment | | X | X |
| | | • Two-point adjustment | | X | X |
| | | Sensitivity setting: | | X | X |
| | | • Angle correct gain (ACG) | | X | X |
| | | • Reference reflectors (BW, SDH, FBH) | | X | X |
| | | • Single-reflector technique (reference height) | | X | X |
| | | • Requirements for reference blocks | | X | X |
| | | • DAC method | | X | X |
| | | • TCG method | | X | X |
| | | • DGS method | | X | X |
| | | Typical applications of phased array techniques | X | X | X |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Evaluation of indications | DGS method | | X | X |
| | | DAC method | | X | X |
| | | TCG method | | X | X |
| | | Distinction between defect and geometry echo | | X | X |
| | | Location of defects | | X | X |
| | | Interpretation and evaluation of indications | | X | X |
| | | Sizing of defects | | X | X |
| | | A-, E-, S-, B- and C-scan interpretation | | X | X |
| 7.2 | Reporting | Recording | | X | X |
| | | Classifying of results according to written procedure | | X | X |
| | | Storage of data files | | X | X |
| | | Generation of reports | | X | X |
| **8** | **Assessment** | | **Level 1** | **Level 2** | **Level 3** |
| 8.1 | | Evaluation and confirmation of test reports | | X | X |
| | | Application of the acceptance criteria according to standards, codes and procedures | | X | X |
| **9** | **Quality aspects** | | **Level 1** | **Level 2** | **Level 3** |
| 9.1 | Personnel qualification | ISO 9712 | | X | X |
| | | Other NDT qualification and certification systems | | X | X |
| **10** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | | Not applicable | | | |

**PCN syllabus – Ultrasonic testing – Time-of-flight diffraction (TOFD)**

| Syllabus reference number | Title | Module subcontent | UT – Time-of-flight diffraction (TOFD) | | |
|---|---|---|---|---|---|
| **1** | **Terminology and history of TOFD** | | **Level 1** | **Level 2** | **Level 3** |
| 1.0 | History of TOFD | History of TOFD | X | X | X |
| 1.1 | Introduction to ultrasonic TOFD technique | Overview | X | X | X |
| | | Applicability and limitations | X | X | X |
| **2** | **Physical principles and associated knowledge** | | **Level 1** | **Level 2** | **Level 3** |
| 2.1 | Mathematical and physical basics | Basics of sound beam | X | X | X |
| | | Waves: | X | X | X |
| | | • Sinusoidal movement | X | X | X |
| | | • Amplitude | X | X | X |
| | | • Frequency | X | X | X |
| | | • Wavelength | X | X | X |
| | | • Propagation velocity | X | X | X |
| | | • Longitudinal waves | X | X | X |
| | | • Transverse waves | X | X | X |
| | | Principle of wave diffraction | X | X | X |
| | | Sound field of UT-TOFD probes | | X | X |
| | | Visualisation of UT-TOFD images | | X | X |
| | | Probe centre separation (PCS) | | X | X |
| | | Dead-zone assessments and consideration | | X | X |
| **3** | **Product knowledge and capabilities** | | **Level 1** | **Level 2** | **Level 3** |
| 3.1 | Various defects related to the manufacturing processes and service-induced defects related to the defined sectors | Defects related to the manufacturing processes (welding) | X | X | X |
| | | Implementation of UT TOFD technique according to products and to expected discontinuities (weld defects) | | X | X |
| 3.2 | Overall properties of specimen | Influence of surface conditions | | X | X |
| | | Geometry | | X | X |
| | | Attenuation | | X | X |
| | | Reference reflectors (SDH, notch) | | X | X |
| **4** | **Equipment** | | **Level 1** | **Level 2** | **Level 3** |
| 4.1 | Test instrument and combined equipment | UT TOFD instrument | X | X | X |
| | | UT TOFD probes | X | X | X |
| | | Adaption of probes to curved scanning surfaces | | X | X |
| | | Encoders and scanning mechanisms (parallel and non-parallel scan set-ups) | | X | X |
| | | Different types of scanners | | X | X |
| | | Reference blocks | | X | X |
| | | Different reference blocks | | X | X |
| | | Digitisation concepts (replication of analogue signal) | | X | X |
| **5** | **Information prior to testing** | | **Level 1** | **Level 2** | **Level 3** |
| 5.1 | Items to be defined by specification | Purpose | X | X | X |
| | | Extent of UT TOFD testing | X | X | X |
| | | Information required by the operator | X | X | X |
| | | Written test instruction or procedure | | X | X |

| 6 | Testing | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 6.1 | Testing | Setting of test range and sensitivity | X | X | X |
| | | Set-up of probes: | | X | X |
| | | • Scan increment setting | | X | X |
| | | • Geometry considerations | | X | X |
| | | • Preparation of scanning surfaces | | X | X |
| | | • Couplant and coupling techniques | | X | X |
| | | Range and sensitivity settings: | | X | X |
| | | • Time window | | X | X |
| | | • Time-to-depth conversion | | X | X |
| | | • Sensitivity settings | | X | X |
| | | • Checking of settings | | X | X |
| | | • Averaging, signal filtering | | X | X |
| | | Reference blocks: | | X | X |
| | | • Material | | X | X |
| | | • Dimensions | | X | X |
| | | • Shape | | X | X |
| | | • Reference reflectors, SDH and notch | | X | X |
| | | Interpretation and analysis of UT TOFD images: | | X | X |
| | | • Assessing the quality of the UT TOFD image | | X | X |
| | | • Identification and classification of relevant UT TOFD indications | | X | X |
| | | • Determination of location and size | | X | X |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Evaluation and reporting | Evaluation according to acceptance criteria | | X | X |
| | | Test report: | | X | X |
| | | • Information relating to the test object | | X | X |
| | | • Equipment | | X | X |
| | | • Test technique | | X | X |
| | | • Test results | | X | X |
| | | Storage of data files | X | X | X |
| | | Generation of reports | | X | X |
| | | Near-surface and opposite-surface resolution | | X | X |
| | | Defect location and length measurement | | X | X |
| **8** | **Assessment** | | **Level 1** | **Level 2** | **Level 3** |
| 8.1 | Assessment | Evaluation and confirmation of test reports | | X | X |
| | | Application of the acceptance criteria according to standards, codes and procedures | | X | X |
| | | Offline evaluation using PC software | | X | X |
| **9** | **Quality aspects** | | **Level 1** | **Level 2** | **Level 3** |
| 9.1 | Personnel qualification | ISO 9712 | | X | X |
| | | Other NDT qualification and certification systems | | X | X |
| **10** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | | Not applicable | | | |

## PCN syllabus – Visual testing (VT)

| Syllabus reference number | Title | Module subcontent | Visual testing (VT) | | |
|---|---|---|---|---|---|
| **1** | **Terminology and history of VT** | | **Level 1** | **Level 2** | **Level 3** |
| 1.0 | History of VT | History of visual testing | X | X | X |
| 1.1 | Purpose of NDT | What is testing? | X | X | X |
| | | What is the purpose of NDT? | X | X | X |
| | | At what stage of life is NDT performed on a product? | X | X | X |
| | | How does it add value? | X | X | X |
| | | Who may carry out NDT? | X | X | X |
| | | Main NDT methods | X | X | X |
| 1.2 | Purpose of VT | Definition | X | X | X |
| | | Applicability and limitations | X | X | X |
| | | Extended overview of visual testing applications | X | X | |
| | | Use of visual testing as a complement to other NDT methods | X | X | |
| 1.3 | Terminology | Please refer to PCN24 standards document | X | X | X |
| **2** | **Physical principles and associated knowledge** | | **Level 1** | **Level 2** | **Level 3** |
| 2.1 | Fundamentals | Goals and principles of visual testing | X | X | |
| | | Comprehensive knowledge and understanding of the physical principles and physics of light | X | X | X |
| | | Optical performance: | X | X | |
| | | • Polarisation of light | X | X | |
| | | • Stroboscopic principles | X | X | |
| | | • Dispersion | X | X | |
| | | • Refraction and refractive index | X | X | |
| | | • Reflection | X | X | |
| | | • Fluorescence | X | X | |
| | | • Advantages and disadvantages of different wavelengths of optical radiation (UV, infrared (IR)), including colour temperature | X | X | X |
| 2.2 | Vision | The eye: | X | X | |
| | | • Operation | X | X | |
| | | • Construction | X | X | |
| | | • Vision limitations | X | X | |
| | | • Adaption and accommodation | X | X | |
| | | • Disorders | X | X | |
| | | • Vision ranges | X | X | X |
| | | • Effects of disorders | X | X | X |
| 2.3 | Lighting | Transmission | X | X | |
| | | Reflection | X | X | |
| | | Absorption | X | X | |
| | | Physics of light | X | X | |
| | | Electromagnetic radiation | X | X | |
| | | Visible wavelengths | X | X | |
| | | Types of light source: | X | X | X |
| | | • Natural | X | X | X |
| | | • Artificial – including laser | X | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 2.3 *(continued)* | | LED light sources (advantages and disadvantages): | X | X | X |
| | | • Different wavelengths of optical radiation (UV, IR) | | | X |
| | | • Colour temperature | | X | X |
| | | • LED light sources | X | X | X |
| | | Photometry | X | X | |
| | | Light levels | X | X | |
| | | Light measurement | X | X | |
| | | Luminance: | X | X | |
| | | • Lighting levels | X | X | |
| | | • Lighting techniques | X | X | |
| | | • Contrast | X | X | |
| 2.4 | Optical principles | Operation of lenses | | X | |
| | | Operation of magnifiers | | X | |
| | | Image construction | | X | |
| | | Virtual images | | X | |
| | | Chromatic aberration | | X | |
| | | Geometric distortion | | X | |
| | | Magnification principles | | X | |
| 2.5 | Camera and photo sensor operation and principles | Optical filters | | | X |
| | | Construction of digital images and problems | | | X |
| | | Image processing | | | X |
| | | Image analysis | | | X |
| | | Image compression and transmission | | | X |
| | | Image storage | | | X |
| | | Resolution | | | X |
| | | Video monitors | | | X |
| | | Other monitors | | | X |
| | | Light meters and photometers | | | X |
| 2.6 | Principles of operation of fibre bundles and lenses | Coherent | | | X |
| | | Incoherent | | | X |
| 2.7 | Photogrammetry | | | | X |
| 2.8 | Visual perception | What the eye sees | | X | |
| | | What the mind sees | | X | |
| | | What others perceive | | X | |
| | | What the designer, engineer, etc, sees | | X | |
| 2.9 | Material attributes affecting the test | Colour | X | X | |
| | | Surface condition | X | X | |
| | | Surface preparation | X | X | |
| | | Cleanliness | X | X | |
| | | Shape | X | X | |
| | | Size | X | X | |
| | | Temperature | X | X | |
| | | Texture | X | X | |
| | | Type | X | X | |
| | | Surface finish | X | X | |

| | | | | | |
|---|---|---|---|---|---|
| 2.10 | Environmental and physiological factors | Atmosphere | | X | |
| | | Comfort | | X | |
| | | Perspective | | X | |
| | | Distance | | X | |
| | | Accessing | | X | |
| | | Fatigue | | X | |
| | | Health | | X | |
| | | Humidity | | X | |
| | | Mental attitude | | X | |
| | | Position | | X | |
| | | Safety | | X | |
| | | Temperature | | X | |
| | | Cleanliness | | X | |
| 2.11 | Direct and remote methods | | X | X | |
| 2.12 | Vision | Requirements | X | X | |
| | | Employer's responsibility | | X | |
| **3** | **Product knowledge and capabilities** | | **Level 1** | **Level 2** | **Level 3** |
| 3.1 | Product knowledge | Outline of basic flaws detected with visual testing as necessary to work in a specific sector | X | | |
| | | Evaluation of surfaces | | | X |
| | | Test objects and flaws | | X | X |
| | | Basic production and degradation process | | X | X |
| | | Terms, origin, nature and appearance of flaws | | X | X |
| | | Product technology sectors | | X | X |
| | | Basic metallurgy of the process/component | | X | X |
| | | Welding/joining methods | | X | X |
| | | Cladding and buffering: | | X | X |
| | | • Wrought product production methods | | X | X |
| | | • Cold working processes | | X | X |
| | | • Heat treatment processes | | X | X |
| | | Roughness and waviness | | | X |
| | | Definition of shape and geometry of flaws | | | X |
| | | Material composition: | | X | X |
| | | • Surface-finishing methods | | X | X |
| | | • Basic foundry technology | | X | X |
| | | • Machining and material removal processes | | X | X |
| | | • Polymers/composites | | X | X |
| | | In-service aspects: | | X | X |
| | | • Service-induced flaws | | X | X |
| | | • Mechanically | | X | X |
| | | • Thermally | | X | X |
| | | • Tribology | | X | X |
| | | • Wear | | X | X |
| | | • Chemical | | X | X |
| | | • Electrochemical | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| 3.2 | Capability and limitations of visual testing | Overview/awareness | X | | |
| | | Detectability: | X | X | |
| | | • Flaw size | X | X | |
| | | • Shape | X | X | |
| | | • Orientation/position | X | X | |
| | | • Flaw types | X | X | |
| | | • Surface condition effects | X | X | |
| | | • Equipment limitations | X | X | |
| | | • Lighting effects | X | X | |
| 3.3 | Associated techniques | Gauging | | X | |
| | | Comparators | | X | |
| | | Measurement | | X | |
| | | Thermographic imaging | | X | |
| | | Replication | | X | |
| **4** | **Equipment** | | **Level 1** | **Level 2** | **Level 3** |
| 4.1 | Introduction and applications | Mirrors | X | X | X |
| | | Magnifiers | X | X | X |
| | | Borescopes | X | X | X |
| | | Fibrescopes | X | X | X |
| 4.2 | Photographic and video | Imaging cameras | X | X | |
| | | Video monitors | X | X | |
| | | Light sources and special lighting | X | X | |
| | | Gauges | X | X | |
| | | Templates | X | X | |
| | | Scales | X | X | |
| | | Special tools | | | X |
| | | Automated systems | | X | X |
| | | Computer-enhanced systems | | X | X |
| | | Demonstration test-piece | X | X | |
| | | Resolution targets | X | X | X |
| | | Graticules | | X | X |
| | | Effect on test arrangement | | | X |
| | | Evaluation of equipment to fulfil a particular task | | | X |
| | | Development of verification for equipment performance: | | | X |
| | | • Choice/design | | | X |
| | | • Application of demonstration test-pieces | | | X |
| 4.3 | Image recording, transfer and storage equipment | Equipment selection | | X | |
| | | Equipment limitations | | X | |
| | | Verification of equipment | X | X | |
| | | Procedure for control, maintenance and adjustment of equipment | | | X |
| 4.4 | Sizing of indications | Imaging systems | | X | |
| | | Special optical systems | | X | |
| | | Special equipment requirements (*ie* underwater, radiation resistant) | X | X | |

| 5 | Information prior to testing | | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 5.1 | Information about the test object | Identification or designation of material: | | X | X |
| | | • Object to be tested | | X | X |
| | | • Kind of manufacture | | X | X |
| | | • Catalogue of defects | | X | X |
| | | • Extent of test coverage | | X | X |
| 5.2 | Test conditions and application of standard | Accessibility | | X | X |
| | | Infrastructure | | X | X |
| | | Particular test conditions | | X | X |
| | | Application of standard | | X | X |
| | | Stage of manufacture or service life when testing is to be carried out | | X | X |
| | | Standard and codes assigned to the test object | | X | X |
| | | Requirements of test personnel | | X | X |
| | | Acceptance criteria | | X | X |
| 5.3 | Technique and sequence of performing test | Surface condition | | X | |
| | | Surface preparation | | X | |
| | | The illumination (type, level and direction) | | X | |
| | | Post-test documentation | | X | |
| | | Visual testing equipment to be used | | X | |
| | | Demonstration test-piece and inspection checkpoints | | X | |
| | | Requirement for recorded images | | X | |
| 5.4 | Instructions | Preparation of written procedure | | | X |
| | | Preparation of written instruction | | X | |
| | | Performing inspection in accordance with written instruction | X | | |
| | | Documents | | X | X |
| | | Presentation of the standards, codes and procedures | | | X |
| **6** | **Testing** | | **Level 1** | **Level 2** | **Level 3** |
| 6.1 | Test set-up | Demonstration test-pieces | X | X | |
| | | Resolution targets | X | X | |
| | | Adjustment | | X | |
| | | Written instruction | | X | X |
| | | Written procedure | | X | X |
| **7** | **Evaluation and reporting** | | **Level 1** | **Level 2** | **Level 3** |
| 7.1 | Reporting results | Reference to test standards | X | X | |
| | | Adjustment status | X | X | |
| | | Reference points for location of indications | X | X | |
| | | Classification of indications: | X | X | |
| | | • Instructed acceptance criteria | X | X | |
| | | • Reports and documentation | X | X | |
| | | • Reporting verification results | X | X | |
| 7.2 | Control and monitoring of test results | Interpretation | | X | X |
| | | Evaluation: | | X | X |
| | | • Objective | | X | X |
| | | • Subjective | | X | X |
| | | Reporting of results to specifications and standards | | X | X |
| | | Completion of adjustment forms | | X | X |
| 7.3 | Developing report forms | Organisation of final forms | | | X |

| | | | | | |
|---|---|---|---|---|---|
| 7.3 *(continued)* | | Storage of final forms | | | X |
| | | Distribution of final forms | | | X |
| | | Investigation of suitable codes and product standards for each application | | | X |
| | | Acting as a reference point for Level 2 advice for interpretation and evaluation | | | X |
| **8** | **Assessment** | | **Level 1** | **Level 2** | **Level 3** |
| 8.1 | Classification and assessment of observations | Acceptance criteria: | | X | X |
| | | • Codes | | X | X |
| | | • Standards | | X | X |
| | | • Written instructions | | X | X |
| | | • Level 3 reference where no codes or standards exist | | X | X |
| | | • Design specifications | | | X |
| | | By comparison | | X | X |
| | | By measurement | | X | |
| | | Automated evaluation (for example pattern recognition) | | X | |
| | | Recording | | X | |
| | | Reporting | | X | |
| | | Analysing results | | | X |
| | | Translation of codes, standards and design specifications, etc, into clear acceptance criteria to be written into procedures and instructions | | | X |
| | | Finding information of assistance to investigate observations not covered by codes and standards, and develop acceptance criteria | | | X |
| | | Training of Level 1 and 2 for acceptance criteria | | | X |
| **9** | **Quality aspects** | | **Level 1** | **Level 2** | **Level 3** |
| 9.1 | Personnel qualification | ISO 9712 | X | X | X |
| | | Other NDT qualification and certification systems | | | X |
| 9.2 | Documentation | Format and scope of working procedures | | | X |
| | | Qualification of NDT procedures | | | X |
| | | Authorisations (NDT instruction, procedures and personnel) | | | X |
| | | Developing written instruction | | X | |
| | | Working correctly to written instructions | X | | |
| | | Traceability of documents | | X | X |
| | | Reliability of measurements | | X | X |
| 9.3 | Knowledge of applicable NDT application and product standards | Correct technique selection | | X | X |
| | | Use of correct test parameters | | X | X |
| | | NDT method selection | | | X |
| | | Job-specific training | | | X |
| | | Equipment verification | X | X | X |
| **10** | **Developments** | | **Level 1** | **Level 2** | **Level 3** |
| 10.1 | Importance of investigating current and developing technology and methods of application | | | | X |
| 10.2 | Summary of latest developments | | | | X |

**PCN syllabus – Limited certification ultrasonic testing (UT) of manufactured wrought plate (ISO 9712)**

| Syllabus reference number | Title | Module subcontent | Level 2 |
|---|---|---|---|
| 1 | **Terminology and history of UT** | | |
| 1.1 | Task of NDT personnel | What is testing? | X |
| | | What is the purpose of NDT? | X |
| | | At what stage of life is NDT performed on a product? | X |
| | | How does it add value? | X |
| | | Who may carry out NDT? | X |
| | | Main NDT methods | X |
| 1.2 | Overview of general and product standards | Please refer to PCN24 standards document | X |
| 1.3 | Terminology | Please refer to PCN24 standards document | X |
| 2 | **Physical principles and associated knowledge** | | |
| 2.2 | Physical definitions and typical parameters | Amplitude | X |
| | | Period | X |
| | | Frequency | X |
| | | Velocity | X |
| | | Acoustic impedance | X |
| | | Factors of reflection and transmission (normal beam only) | X |
| 2.3 | Properties of sound waves | Amplitude | X |
| | | Frequency | X |
| | | Wavelength | X |
| | | Propagation velocity | X |
| | | Longitudinal/compression waves | X |
| 2.4 | Transmission and reflection | Effects at interfaces at normal incidence (transmission, reflection, interference and dispersion) | X |
| | | Piezoelectric effect | X |
| | | Reverse piezoelectric effect | X |
| 2.5 | Transducer characteristics | Transducer materials and construction | X |
| | | Dimensions | X |
| | | Frequency (crystal thickness relationship) | X |
| | | Transducer types (single crystal, single crystal with standoff, twin crystal) | X |
| | | Sensitivity resolution and damping | X |
| | | Mechanical vibration into test material | X |
| 2.6 | Sound fields of disc-shaped transducers | Near field (Fresnel zone) | X |
| | | Far field (Fraunhofer zone) | X |
| | | Beam divergence | X |
| | | Influence of transducer frequency and diameter | X |
| 3 | **Product knowledge and capabilities** | | |
| 3.1 | General defects | Wrought products (continuous casting, plate, rolling process, types and origins of discontinuities, response of discontinuities to ultrasound, discontinuity detection, sensitivity to reflections, size type and locations of discontinuities) | X |

| | | | |
|---|---|---|---|
| 3.2 | Implementation of the testing technique | According to products | X |
| | | According to expected discontinuities | X |
| | | Standards, specifications and codes | X |
| | | Selection of probe (inspection-oriented design of specimen) | X |
| | | Testing technique based on task | X |
| 3.3 | Overall properties of the specimen | Influence of surface conditions | X |
| | | Geometry (additional echoes due to grazing incidence and radial straight beam incidence) | X |
| | | Structure (sound attenuation) | X |
| **4** | **Equipment** | | |
| 4.1 | Ultrasonic instruments | Digital instruments (design, function, pulse generation TX, pulse reception RX, probe delay, dead zone, amplification, A-scan presentation, RF signal, rectification, peak and flank measurement) | X |
| | | Analogue *versus* digital | X |
| | | Signal gating and alarms | X |
| | | Ultrasonic thickness gauge | X |
| | | Automated and semi-automated systems | X |
| | | Manual | X |
| | | Scanning speed | X |
| | | Incrementation | X |
| | | Repeatability | X |
| | | Sampling rate/pulse repetition frequency (PRF) | X |
| | | Knowledge and understanding of timebase and timebase linearity | X |
| | | Knowledge of timebase functionality, amplifier, pulsar, receiver, monitor displays | X |
| 4.2 | Transducers | Straight beam (design, application) | X |
| | | Effects of ultrasonic frequency | X |
| | | Damping effects | X |
| | | Dual element (design, deviation error, sound field, adjustment, application) | X |
| | | Dynamic range | X |
| | | Practical measurements of directional characteristics | X |
| | | Shoe (delay) | X |
| 4.3 | Couplants | Purpose and principles, materials and efficiency | X |
| | | Length | X |
| | | Impedance | X |
| 4.4 | Calibration | Basic instrument calibration | X |
| | | Calibration blocks | X |
| | | Reference blocks | X |
| | | Resolution (near, far) | X |
| **5** | **Information prior to testing** | | |
| 5.1 | Information about the test object | Identification or designation material (object to be tested, kind of manufacture, catalogue of defects, extent of test coverage) | X |
| 5.2 | Test conditions and application of standard | Accessibility | X |
| | | Particular test conditions | X |
| | | Application standard | X |
| | | Stage of manufacture of service life when testing is to be carried out | X |

| | | | |
|---|---|---|---|
| 5.2 *(continued)* | | Standards assigned to the test object | X |
| | | Requirements of test personnel | X |
| | | Acceptance criteria | X |
| 5.3 | Technique and sequence of performing test | Transmission factors of materials | X |
| | | Surface condition | X |
| | | Surface preparation | X |
| | | Post-test documentation | X |
| 5.4 | Instructions | Preparation of written instruction | X |
| | | Performing inspection in accordance with written instruction | X |
| **6** | **Testing** | | |
| 6.1 | Techniques | Pulse echo and transmission | X |
| | | Contact | X |
| | | Techniques for ultrasonic thickness measurement (reference reflectors, laws of distance and size) | X |
| | | Range setting (single-point adjustment, two-point adjustment) | X |
| | | Sensitivity setting (reference reflectors: BW, SDH, DSR; single-reflector technique reference height, testing at higher temperatures) | X |
| | | Different sizing techniques (principles, limitations, requirements for reference blocks, DAC technique, DGS, transfer correction, recording gain, errors at echo height evaluation) | X |
| **7** | **Evaluation and reporting** | | |
| 7.1 | Interpretation | Relevant standards | X |
| | | Relevant specifications | X |
| | | Relevant codes | X |
| | | Evaluation (conventional) | X |
| 7.2 | Detecting, locating and sizing techniques | Detection probability of type of discontinuity | X |
| | | Distinction between defect and geometry echo | X |
| | | Locating | X |
| | | Interpretation | X |
| | | Evaluation | X |
| | | A-scan presentation | X |
| | | C-scan presentation | X |
| | | Recording results | X |
| | | Classifying results | X |
| | | Acceptance levels | X |
| | | Echo height evaluation with DGS method | X |
| | | Sizing and half-amplitude technique | X |
| | | Sizing using the fixed amplitude level technique | X |
| | | Echo height evaluation with single-reflector technique and DAC method | X |
| | | Reporting | X |
| | | Check content and matching of test reports and instructions | X |
| **8** | **Assessment** | | |
| 8.1 | Evaluation | Transducer movement *versus* display | X |
| | | Signal patterns (abnormal values, no readout, loss of signals) | X |
| | | Location of discontinuity | X |

| | | | |
|---|---|---|---|
| 8.1 *(continued)* | | Amplitude and linear time | X |
| | | Search technique | X |
| | | Mapping (spot, grid) | X |
| | | Evaluation and use of correction factors/charts | X |
| | | Comparison procedures | X |
| | | Standards and references | X |
| | | Amplitude, area and distance | X |
| | | Object appraisal | X |
| | | Type of discontinuity and location | X |
| 8.2 | Confirmation of test reports | Application of the acceptance criteria according to standards, codes and procedures | X |
| **9** | **Quality aspects** | | |
| 9.1 | Personnel qualification | ISO 9712 | X |
| 9.2 | Documentation | Traceability of documents | X |
| | | Equipment verification | X |
| | | Reliability of measurements | X |
| | | Format of working procedures | X |
| 9.3 | Employer and certificate holder responsibilities | ISO 9712 Section 5 | X |
| **10** | **Developments** | | |
| 10.1 | Newest developments for industrial and scientific applications of UT | Awareness of UT method, technique and equipment developments | X |

## Change control record

| PCN24/GEN/Appendix Z1 – Document issue and review status | | |
|---|---|---|
| **Document issue for review** | **Changes/amendments** | **Current document status** |
| Issue 01 | New document to meet PCN24/GEN, BS EN ISO 9712:2022 and ISO/TS 25107:2019 requirements.<br>Supersedes PCN/GEN Appendix Z1, which is now withdrawn. | PCN24/GEN/Appendix Z1.<br>Issue 01: February 2024.<br>Implementation: July 2024. |

**Issued by Certification Services Department, The British Institute of Non-Destructive Testing**
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