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PCN/AERO Appendix Z1 issue 2 dated 1st January 2016 – NDT Training Syllabi

Contents Page

Introduction

ISO/TC135 and CEN/TC138 are proud to present to the worldwide Non Destructive Community their recommendations for minimum requirements of technical knowledge of NDT personnel; these recommendations provide means for evaluating and documenting the competence of personnel whose duties require the appropriate theoretical and practical knowledge.
As part of the efforts to streamline and harmonize the training and certification of NDT personnel, ISO/TC135 - CEN/TC138 have been actively involved in developing guidelines for training syllabus and guidelines for NDT training organisations. These guides serve to those involved in training and are useful to achieve a uniform level of training material and consequent competence of personnel.
These documents represent 2 years of efforts of ISO/TC135 and CEN/TC138 working groups to promote harmonisation and mutual recognition of minimum requirements of the different existing certification schemes.
The content of this first edition has been based on the experience of the experts as well as comments of the end-user industries and the last publication of the ICNDT recommended guidelines.

1 Scope

This document defines guidelines with the intention to harmonise and maintain the general standard of training of non-destructive testing (NDT) personnel for industrial needs. Associated guidelines for NDT training organisations have been produced for the general part of training courses.
The guidelines also establish the minimum requirements for effective structured training of NDT personnel to ensure eligibility for qualification examinations leading to third party certification according to recognized standards.
This document enclose a clause about NDT in general and a clause specific to each of the following NDT method: acoustic emission testing, eddy current testing, leak testing, magnetic particle testing, penetrant testing, radiographic testing, ultrasonic testing and visual testing,.

2 Introduction, Terminology, Purpose and History of NDT

2.1 The Task of NDT

Non-destructive testing (NDT) gives an important contribution to the safety and the economic and ecological welfare of our society.
NDT is the only choice for the test of an object which must not be destroyed, modified or degraded by the testing process. This is generally required for objects which will be used after testing, for example safety parts, pipelines, power plants and also constructions under in-service inspection, but even for unique parts in archaeology and culture.
NDT is based on physical effects at the surface or the inner structure of the object under test. Often the outcome of the test needs to be interpreted to give a useful result; sometimes different NDT methods must be combined, or verified by other test methods.

2.2 The Task of NDT personnel

NDT personnel have a high responsibility not only with respect to their employers or contractors but also under the rules of good workmanship. The tester shall be independent and free from economic influences with regard to his test results, otherwise the results are compromised. The tester should be aware of the importance of his signature and the consequences of incorrect test results for safety, health and environment. Under legal aspects, the falsification of certificates is an offence and judged according to the national legal regulations. A tester may find himself in a conflicting situation about his findings with his employer, the responsible authorities or legal requirements.
Finally the tester is responsible for all interpretations of test results carrying his signature. NDT personnel should never sign test reports beyond their certification.

2.3 The History of NDT

NDT started with visual checks in prehistoric times. In medieval centuries, test methods like simple leakage tests and hardness checks were introduced. The breakthrough for NDT came with industrialisation in the 19th and 20th century: X-ray and Ultrasonic Testing for inner defects, Penetrant and Magnetic Particle Testing for surface cracks. During the last few decades sophisticated, mostly electronically linked methods like Eddy Current Testing, RADAR, Computer Tomography and Thermography were developed. NDT methods found application in a wide range of industry from civil engineering and industrial plants to space and defence technology.
The history of NDT is linked to many famous researchers and inventors like Röntgen, Becquerel, Curie, Oerstedt, Faraday and even Leonardo da Vinci. They discovered the physical principles and demonstrated early applications. All together, approximately 5000 scientists worldwide made contributions to the present state of NDT.
NDT is a global technology. Since NDT tasks and related technical problems are similar in all developed countries, improved solutions and new equipment are spread around the world within a few months. Many international conferences and standard committees contribute to a steady and consensual development of NDT for the benefit of safety, economy and the environment.

2.4 Terminology of NDT

Correct Terminology is a necessary demand for a worldwide-applied technology. It is needed for communication between contracting parties, testers and certifying bodies. Terms like “Indication”, “Imperfection”, “flaw” and “defect” need a precise and unequivocal definition to avoid any confusion and misinterpretation of results. The European Standards EN 1330–1 and –2 (for different NDT methods) and the synonymous International Standards (partly drafts) give the agreed denominations and short definitions of terms.

2.5 General safety considerations

2.5.1 Non-destructive testing is often applied in conditions where safety of the operator may be in danger due to local conditions, or where the application of the particular NDT method or techniques may in itself compromise the safety of operator and others in the vicinity.
An essential element of any course training for NDT personnel must therefore be safety and the duration of the training for this subject should be adequate and provided addition to the technical training associated with the particular NDT method.

2.5.2 General safety considerations may include but are not necessarily limited to:

- Environmental conditions: heat, cold, humidity;
- Toxicity: of NDT materials, tested products, atmosphere;
- Radiation safety: NDT materials,products, local regulations
- Electrical safety: NDT equipment, lethal voltages, EMC;
- Potential of personnel injury: working at height or in other dangerous environments;
- Personnel protection equipment: closing, radiation dosimeters.

Contents	Level 1	Level 2	Level 3

A. Radiographic testing level 1, level 2 and level 3

1.0 **Introduction,** **Terminology** **History of NDT**	**1.0 History** Purpose	**1.0 History** Purpose	**1.0 History** Purpose
	1.1 Terminology Electromagnetic radiation Energy Dose Dose rate	**1.1 Terminology** Wave-length Dose Dose rate Intensity Dose rate constant	**1.1 Terminology** **EN 1330-3**
2.0 **Physical principles of the method and associated Knowledge**	**2.0 Properties of X- and gamma radiation** Relevant standards: **BS EN ISO 5579: Basic rules** Straight line propagation Effects of radiation Capability of penetration	**2.0 Properties of X- and gamma radiation** Photon Process of ionisation photochemical effects biological effects fluorescent effects Energy	**2.0 Properties of radiation** X-radiography Gamma radiography Neutron radiography Electron radiography Process of ionization photochemical effects biological effects fluorescent effects
2.1	**2.1 Generation of X-radiation** Function of X-ray tubes Tube current I High voltage U effects on dose rate and energy of radiation	**2.1 Generation of X-radiation** Function of X-ray tubes Spectrum intensity max. energy effective energy change of spectrum by tube current and tube voltage	**2.1 Generation of X-radiation** Function of X-ray tubes Spectrum intensity max. energy effective energy change of spectrum by tube current and tube voltage

Contents	Level 1	Level 2	Level 3
		Inherent filtering	Characteristic radiation Inherent filtering Hardening effect
2.2	**2.2 Origin of γ-radiation** Radio isotope Ir 192, Co 60, Se 75 Activity half life characteristics of γ-sources life time energy activity source size	**2.2 Origin of γ-radiation** Radio nuclide Isotope Ir 192, Co 60, Se 75, Yb 169 Activity A Characteristics of γ-sources half life decay curves maximum activity source size Characteristic of Gamma ray Dose rate constant Spectrum and effective energy	**2.2 Origin of γ-radiation** Natural and artificial decay Decay series Radio nuclides for NDT Isotope Ir 192, Co 60, Se 75, Yb 169 Activity A Characteristics of γ-sources half life decay curves maximum activity source size Characteristic of Gamma ray Dose rate constant Spectrum and effective energy

Contents	Level 1	Level 2	Level 3
2.3	**2.3 Interaction of radiation with matter** Attenuation absorption primary radiation scattered radiation Influence of: penetrated thickness Type of material Energy Half value layer Tenth value layer	**2.3 Interaction of radiation with matter** Attenuation photo effect coherent scattering Compton scattering pair production Attenuation coefficient Scatter radiation Specific contrast Radiation contrast Effects of filtering Beam hardening	**2.3 Interaction of radiation with matter** Attenuation vs. energy photo effect coherent scattering Compton scattering pair production Attenuation coefficient Scatter radiation Specific contrast Radiation contrast Effects of filtering Beam hardening Klein-Nishina law

Contents	Level 1	Level 2	Level 3
2.4	**2.4 Properties of film systems and screens** Construction base, emulsion, silver bromide grain size and distribution Processing Properties of films sensitivity granularity contrast optical density film system class Film screens type of film screens intensifying effect filtering effect film to screen contact	**2.4 Properties of film systems and screens** Construction Latent image information origin Photo process Properties of film systems characteristic curve film gradient, film contrast, speed influence of film processing sensitivity granularity detail perceptibility Classification of film systems according to. **BS EN ISO 11699-1** Film screens type of screens film screen contact inherent unsharpness intensifying effect of filtering screens for Co 60 and Linac	**2.4 Properties of film systems, screens and digital detection systems** additional to level 2 New detectors storage phosphor imaging plates flat panels x-ray intensifier line detector Classification of detector systems application
2.5	**2.5 Geometry for radiographic exposures** Geometric unsharpness object to film distance focus size d source to object distance Source film distance	**2.5 Geometry for radiographic exposures** Geometric unsharpness object to film distance focus size d source to object distance Source film distance Determination of the focal spot size of Gamma sources	**2.5 Geometry for radiographic exposures** Additional to level 2 Method of focal spot measurement **according to EN 12543, BS EN 12579** Requirements for optimisation by: Geometric unsharpness, total unsharpness Focus size, current, voltage Source size, activity

Contents	Level 1	Level 2	Level 3
3.0 **Product knowledge and capabilities of the method and its derivate Techniques**	**3.0 Typical weld defects imperfections** Type of discontinuity **according. to EN ISO 6520**	**3.0 Weld imperfections** Type of weld seam and weld seam preparation Welding process origin Type of discontinuity **according to EN ISO 6520**	**3.0 Weld imperfections** Additional to level 2 Introduction to fracture mechanics working load Materials properties Origin of defects Further NDT methods
3.1	**3.1Typical defects in castings** Types of defects	**3.1 Defects in castings** Casting process Types of cast imperfections and their origin Structural indications Beam direction to detectability	**3.1 Defects in castings** Casting process Type of cast imperfections and their origin Structural indications Working load Materials properties Production caused defects
3.2	**3.2 Typical defects in aircraft structures**	**3.2 Typical defects in aircraft structures**	**3.2 Typical defects in aircraft structures**
3.3	**3.3 Influence to detectability** type of defect, size orientation Imaged thickness range Number of exposures	**3.3 Influence to detectability** beam direction geometric distortion increase in wall thickness Imaged thickness range Thickness ranges for x- and γ-rays Number of exposures	**3.3 Influence to detectability** beam direction geometric distortion increase in wall thickness Imaged thickness range Thickness ranges for x- and γ-rays Number of exposures vs. distortion angle

Contents	Level 1	Level 2	Level 3
4.0 Equipment	**4.0 Design and Operation of X-ray Machines** Stationary systems, mobile unit Tubes glass- and metal-ceramic tube Design of tubes standard tube rod anode tube short anode tube Cooling: Gas, water, oil Focal spot High voltage, max. current Exposure time Diaphragm Safety circuit Operation instructions	**4.0 Design and Operation of X-ray Machines** Additional to level 1: inherent filtering pre-filtering Devices for special applications micro focus tubes enlargement technique radioscopy Linac Construction Field of application Typical dates	**4.0 Design and Operation of X-ray Machines** Additional to level 2 beam opening characteristics x-ray flash devices rod anode devices micro focus devices high voltage devices Line focus tubes Rotary anode tubes
4.1	**4.1 Design and Operation of Gamma ray Devices** container, shielding class: P, M type: A, B (transportation) source holder and source capsule Enclosed radioactive material manipulation device connections accessory remote control collimation fittings Operation instructions Reference to national requirements and safety regulations	**4.1 Design and Operation of Gamma ray Devices** Additional to level 1: crawler for pipelines special device for testing of heat exchanger tubes	**4.1 Design and Operation of Gamma ray Devices** Same as level 2

Contents	Level 1	Level 2	Level 3
4.2	**4.2 Accessories for radiographic testing** equipment lead tape measure holding magnets lead screens shielding rubber bands etc. radiation protection equipment		

Contents	Level 1	Level 2	Level 3
5.0 **Information prior the Test**	**5.0 Written procedures are given** Information about the test object Object dimensions Test class of standard Equipment to be used Exposure arrangement Extent of testing (20 % inspection) marking	**5.0 Information about the test object** Identification or designation Material, dimensions, isometrics number of parts field of application kind of manufacture catalogue of defects Test conditions accessibility infrastructure particular test conditions Applicable standards Overview Standards assigned to the test object Preparation of written instructions	**5.0 Information about the test object and national requirements** Additional to level 2: Selection of standards for specific testing applications European standards Application standards overview purpose technical contents and systematic Product specific standards for special industrial sectors for welding for casting for pipes pressurised equipment directive ISO standards American standards: overview ASME-Code overview ASTM-Standards

Contents	Level 1	Level 2	Level 3
6.0 Testing	**6.0 Developing process** Darkroom design developer water bath fixing bath final water bath drying Preparation and regeneration of baths Use of filmstrips **according to BS EN ISO 11699-2** Film processing faults	**6.0 Developing process** Additional to Level 1: Processing equipment, adjustment checking: storage of unexposed films darkroom light test fog test clearing time tally sheet Process-controlling **in accordance with BS EN ISO 11699-2**	**6.0 Developing process** Principles Processing equipment, adjustment checking: storage of unexposed films darkroom light test fog test clearing time tally sheet Use of filmstrips **according to BS EN ISO 11699-2**
6.1	**6.1 Examination of welded joints acc. BS EN ISO 17636 parts 1 & 2 to BS M34** Scope Test classes basic and improved techniques Test arrangements number of exposures **BS EN ISO 17636 parts 1 & 2** Choice of Energy max. x-ray voltage penetrated thickness range for gamma rays special options Film and screen choice film system classes, type and thickness of screens Minimum optical density Minimum source-to-object distance	**6.1 Examination of welded joints acc. BS EN ISO 17636 parts 1 & 2 to BS M34** Scope Test classes basic and improved techniques Test arrangements number of exposures **BS EN ISO 17636 parts 1 & 2** Choice of Energy max. x-ray voltage penetrated thickness range for gamma rays special options Film and screen choice film system classes, type and thickness of screens Minimum optical density Minimum source-to-object distance	**6.1 Explanation and discussion of BS EN ISO 17636 parts 1 & 2 to BS M34** Scope Test classes basic and improved techniques Test arrangements number of exposures **BS EN ISO 17636 parts 1 & 2** Choice of energy max. x-ray voltage penetrated thickness range for gamma rays special options Film and screen choice film system classes, type and thickness of screens Minimum optical density Minimum source-to-object distance

Contents	Level 1	Level 2	Level 3
6.2	**6.2 Examination of castings according to. EN 12681 to BS M34** Scope Test classes basic and improved techniques Test arrangements number of exposures Choice of Energy average wall thickness max. x-ray voltage penetrated thickness range for gamma rays special options Film and screen choice film system classes, type and thickness of screens Minimum optical density Minimum source-to-object distance film	**6.2 Examination of castings according to. EN 12681 to BS M34** Scope for complex shaped objects Classifications basic and improved techniques Test arrangements number of exposures special geometries Choice of Energy average wall thickness max. x-ray voltage penetrated thickness range for gamma rays special options Use of enlargement Double film technique wall thickness compensation use of higher Energy, hardening Film and screen choice film system classes, type and thickness of screens minimum optical density minimum source-to-object distance	**6.2 Explanation and discussion of EN 12681 to BS M34** Scope for complex shaped objects Classifications basic and improved techniques Test arrangements number of exposures special geometries Choice of Energy average wall thickness max. x-ray voltage penetrated thickness range for gamma rays special options Increase of covered thickness range Double film technique wall thickness equalization use of higher Energy, hardening Film and screen choice film system classes, type and thickness of screens minimum optical density minimum source-to-object distance
	6.# Examination of aircraft structures to BS M34	**6.# Examination of aircraft structures to BS M34**	**6.# Examination of aircraft structures to BS M34**
6.3	**6.3 Working with Exposure charts** Definition of exposure value exposure time Correction of exposure time for different Film-focalspot-distance FFD optical density relative film exposure factor	**6.3 Special Technique** Stereo technique Round about technique Testing of corrosion damage Enlargement with micro focus Real-time technique	**6.3 Direct radiography and radioscopy according to. EN 13068** Image detectors: fluoroscope flat panels x-ray intensifier camera and TV-systems

		fluorescent screens radioscopy computed radiography documentation, picture archive	Applications: serial production testing dynamical testing special materials Limits of the method: resolution dynamic signal-to-noise-ratio modulation transfer function Basic image processing monitoring documentation
6.4			**6.4 Special Technique** Stereo technique Round about technique Testing of corrosion damage Enlargement with micro focus Special aspects for radiography of materials with high and low density Low voltage radiography Radiography of art objects light alloys plastics pre filtering High voltage radiography concrete testing Film – screen –systems pre filtering intermediate filtering heavy walled casting special radiation protection, contamination

Contents	Level 1	Level 2	Level 3
6.5	**6.5 Image quality indicators according. to BS EN ISO 19232 parts 1-5** Definition of Image quality number design of IQI IQI position of different exposures image quality classes image quality number	**6.5 Image quality indicators according to according. to BS EN ISO 19232 parts 1-5** Additional to Level 1: Image quality number for other materials acc. **according. to BS EN ISO 19232 parts 1-5** Detection of unsharpness with duplex-indicator acc. **according. to BS EN ISO 19232 parts 1-5**	**6.5 Image quality indicators according to according. to BS EN ISO 19232 parts 1-5** Same as Level 2: Relevance of image quality indicators International image quality indicators
6.6	**6.6 System of marking** object to film assignment permanent marking of the object, zero point, incremental count direction, marker tape, position of markings on the object	**6.6 Drafting an NDT instruction for the testing of aerospace products welding and castings** Use of BS M38 – Guide to compilation of instructions and reports Organization of simple test procedures Test objects ambient conditions reference documents, specifications, standards choice of radiation source choice of adequate direction of radiation film location plan identification of test piece and radiographs number of exposures performance of the test and reporting of test results viewing of the films classification of defects assessment of the results according to applicable codes and standards list of required accessories	**6.6 Drafting an NDT procedure for the testing of aerospace products welding and castings** Complete organization of test procedures in combination with other NDT-methods Integration of internal priorities Choice of testing method time of testing radiation protection equipment Personal qualification Cost estimation: for personal for equipment for expendable for auxiliary attachment second exposures after repair Selection of specifications for application and evaluation Example of an written practice for weld inspection acc. to ASTM

Contents	Level 1	Level 2	Level 3
	Essential Reading:	**Essential Reading:** BS EN 1330-2 NDT-Terminology — Part 2: Terms common to the non-destructive testing methods. BS EN 1330-3 NDT-Terminology — Part 3: Terms used in industrial radiography testing. BS M34 Method of preparation and use of radiographic techniques BS EN ISO 5579 Industrial radiography – General principles for radiographic examination of metallic materials using X and Gamma ray ASTM E 1742 Standard practice for radiographic examination **Radiography – Aerospace Weld Level 2 (in addition to the above)** BS EN ISO 17636 parts 1 & 2 Non destructive examination of welds. Radiographic examination of welded joints	**Essential Reading:** BS EN ISO 11699-1 Industrial radiographic film – Part 1 Classification of film systems for industrial radiography BS EN ISO 19232-1 NDT image quality of radiographs – Part 1 Image quality indicators (wire type) determination of image quality value BS EN ISO 19232-2 NDT image quality of radiographs – Part 2 Image quality indicators (step/hole type) determination of image quality value BS EN ISO 19232-3 NDT image quality of radiographs – Part 3 Image quality classes for ferrous metals BSEN ISO 19232-5 NDT image quality of radiographs – Part 5 Image quality indicators (duplex wire type) determination of total image unsharpness value ASTM E2104 Standard practice for radiographic examination of advanced aero and turbine materials and components AMS 2175A Castings – Classification and inspection **Radiography – Aerospace Weld Level 3 (in addition to the above)** BS EN 25580 Minimum requirements for radiographic illuminators for non-destructive testing BS EN ISO 17639 Methods of testing fusion welds in aluminium and aluminium alloys

Contents	Level 1	Level 2	Level 3

7. 0 **Evaluation and Reporting**	**7.0 Basics of evaluation** Viewing conditions room condition viewing time lapsed time after dazzling Film illuminator, luminance Density measurement	**7.0 Basics of evaluation** Additional to Level 1: Mach Effect Film illuminator **acc. BS EN 25580** min. luminance homogeneity factor Physiological factors eyesight adaptation prior to viewing	**7.0 Basic of evaluation** Viewing conditions Mach Effect Film illuminator **acc. BS EN 25580** min. luminance homogeneity factor Physiological factors eyesight adaptation prior to viewing
7.1	**7.1 Evaluation of radiographs** Verification the image quality Report of simple welding and casting imperfections	**7.1 Evaluation of radiographs** Verification of image quality Report of imperfections	**7.1 Evaluation of radiographs** Verification of image quality Report of imperfections
7.2	**7.2 Test report** welding according to BS EN ISO 17636 castings according to EN 12681	**7.2 Check of test report** Use of **BS M38** – Guide to compilation of instructions and reports Does it comply with the examination standard? Conformed to the test quality Achieved test class Achieved image quality class Achieved diagnostic coverage of test object	**7.2 Feasibility of test report** Confirmation of the radiographic image quality vs. test report

Contents	Level 1	Level 2	Level 3
8.0 **Assessment**		**8.0 Classification of imperfections** Type, size, localisation, frequency	**8.0 Classification of imperfections** Type, size, localisation, frequency
		8.1 Assessment of imperfections Welding **according to BS EN ISO 5817** **according to BS EN ISO 17635** **according to. BS EN ISO 10675** **according to Standard on inspection of pressure vessels (EN 13445-5)** Casting according to ASTM Aircraft structures Evaluation catalogue to **BS EN ISO 5817** ASTM – catalogue other national training catalogues influence of manufacture and material	**8.1 Assessment of imperfections** Welding **according to ISO 6520** **according to BS EN ISO 5817** **according to BS EN 17635** **according to BS EN ISO 10675** **according to standard on inspection of pressure vessels (EN 13445-5)** Casting according to ASTM Aircraft structures Evaluation catalogue to **BS EN ISO 5817** ASTM – catalogue other national training catalogues influence of manufacture and material
9.0 **Quality aspects**	**9.0 Personnel qualification (according to EN ISO 9712)** Equipment verification	**9.0 Personnel qualification (according to EN ISO 9712)** Equipment verification Written instructions Traceability of documents A review of applicable NDT application and product standards	**9.0 Personnel qualification (according to EN ISO 9712)** Equipment verification Format of working procedures, Traceability of documents Other NDT qualification and certification systems A review of applicable NDT application and product standards
10.0 **Developments**		**10.0 alternative detectors to film** Flat panel detectors	**10.0 Innovative radiological techniques** 3-dimensional radiology inspection stereo technique multi angle technique computed laminography

Contents	Level 1	Level 2	Level 3
			computed tomography Principle Applications digital image processing film digitisation image enhancement

Contents	Level 1	Level 2	Level 3

B. Ultrasonic testing level 1, level 2 and level 3

1.0 Introduction, Terminology History of NDT	**1.0 Task of non-destructive testing - Personnel**	**1.0 Review of level 1 knowledge**	**1.0 Terminology and definitions of UT**
		1.1 Terminology and Definitions of UT	Overview of standards: ISO, CEN and national (general, and products)
	1.1 History of NDT		
	1.2 Terminology of NDT (EN 1330-1 & –2)		
	1.3 History of UT		
	1.4 Terminology of UT (EN 1330-4)		
2.0 Physical principles of the method and associated Knowledge	**2.0 Relevant standards: BS EN ISO 16810 EN 14127**	**2.0 Physical definitions and typical parameters**	**2.0 As level 2 +** Isotropic and anisotropic materials Phenoma of guided propagation Velocity measurement and Dispersion Relation between between velocity and elastic properties of materials
	2.1 Review of mathematical basics Physical definitions and typical parameters Sinusoidal movement, amplitude, period, frequency, wavelength, propagation velocity	**2.1 Same as level 1 +** - acoustic impedance, factors of reflection and transmission (normal beam only) - beam propagation	
	2.2 Various types of wave modes Longitudinal waves Transverse waves Concepts of surface waves or Rayleigh waves and of plate waves or Lamb waves	**2.2 Various types of wave modes** Same as level 1 + - extended knowledge of surface waves or Rayleigh waves and of plate waves or Lamb waves - creeping waves	

Contents	Level 1	Level 2	Level 3
	2.3 Reflection and refraction Normal incidence, transmission and reflection Incidence oblique Snell's law Critical angles, mode conversion	**2.3 Reflection and refraction** Same as level 1 + acoustic pressure	
	2.4 Transmission and reception of ultrasonic waves Piezo-electric effect Ferro-electricity or electrostriction	**2.4 Transmission and reception of ultrasonic waves** Same as level 1	
	2.5 Magnetostriction Ability of a material to change shape or, dimensions during magnetization.	**2.5 Magnetostriction** Same as level 1	
	2.6 Transducer characteristics Material, dimensions, piezo-electric constants	**2.6 Transducer characteristics** Same as level 1 (deeper knowledge)	
	2.7 Characteristics of the beam of a circular transducer Influence of transducer frequency and diameter Near field (Fresnel zone) Far field (Fraunhofer zone) Beam divergence	**2.7 Characteristics of the beam of a circular transducer** Same as level 1 + - characteristics of the beam of a rectangular transducer - beam profiling - beam divergence factor	
3.0 Products knowledge and related capability of the method and derived techniques	**3.0 Various defects related to the manufacturing processes and service induced defects related to the defined sectors** Implementation of the testing techniques according to products and to expected discontinuities Influence of geometry and structure	**3.0 Same as level 1 +** - tandem (zones) - selection of transducers for required resolution and reduction of noise (type, frequency, size) - immersion - TOFD - phased arrays	**3.0 Same as level 2+** Choice of techniques (contact, immersion, transmission, resonance, …) - EMAT - Multiple probe arrays

Contents	Level 1	Level 2	Level 3
	(spurious echoes, sound attenuation)	Influence of the main parameters	A comprehensive understanding and knowledge of the manufacturing processes and associated metallurgy & flaw types etc… A comprehensive understanding and knowledge of the cause and formation of in-service defects including associated metallurgy & flaw types etc…
4.0 **Equipment**	**4.0 Various probes (normal, angle, dual)** Instruments (analogical and digital) Pulse generation Reception and amplification (percentage and dB) Range setting A- scan presentation B- and C-scan presentation Additional functions: Couplant	**4.0 Same as level 1 +** - detailed knowledge of the different functions of UT test equipment - automatic and semi automatic systems - B- and C-scan presentation (deeper knowledge) - couplant (deeper knowledge) Calibration reference and transfer blocks	**4.0 Same as level 2 +** Systems (manual/semi-automatic, automatic,): speed, incrementation, repeatability … Analog flaw detectors (different circuits) Digital flaw detectors (Comparison with analog flaw detectors, Sampling-rate) Special equipment including thickness measurement Probes - Dynamic range - Probes for immersion: focused, spherical, cylindrical, Fermat surface; - Measurement of pulse length practical measurement of the near field Shoe (delay, curvature, …); Connecting cables (sealing, insulation and flexibility; Blocks: representativity
5.0 **Information prior to test**	**5.0 Written instruction (prepared by a level 2 or 3)** Objectives Requirements	**5.0 Same as level 1 (deeper knowledge)+** - contents and requirements of instructions, procedures and standards - - Preparation of written instructions	**5.0 As level 2 +** Selection of technical parameters: - Products: geometry, surface quality, accessibility, environment… - UT indication/ discontinuity/ defect: type, origin, shape, dimension, orientation, tilt/skew … - properties of the equipment: Preparation of written specifications

Contents	Level 1	Level 2	Level 3
6.0 **Testing**	**6.0 Verification of combined equipment according to EN 12668-3**	**6.0 Same as level 1 (deeper knowledge)** **+** - reference reflectors (laws of distance and size) - DGS-method - DAC-curves - distance/amplitude-correction - transfer correction (surface and attenuation) - sizing techniques, principles and limitations - scanning	**6.0 Same as level 2 +** Control and assessment of procedures and instructions for their efficiency
	6.1 Standardized calibration blocks ref : BS EN ISO 2400 & BS EN ISO 7963		
	6.2 Contact technique (straight and angle beam) Reflection Transmission		
	6.3 Immersion techniques (straight and angle beam) Reflection Transmission		
	6.4 Setting of range and sensitivity Reference reflectors Transfer correction		
	6.5 Ultrasonic thickness measurement Equipment Techniques		
	Essential Reading:	**Essential Reading:** BS EN 1330-4 NDT-Terminology — Part 4: Terms used in ultrasonic testing BS EN ISO 16810 Non destructive testing, Ultrasonic examination – Part 1 General principles ASTM E 114 Standard practice for Pulse echo straight beam contact testing ASTM E 587 Standard practice for Ultrasonic angle beam testing	**Essential Reading:** BS EN 12668-3 Non destructive testing – Characterisation and verification of equipment, Part 3 combined equipment BS EN ISO 16823 Non destructive testing, Ultrasonic examination – Part 3 Transmission technique BS EN ISO 16827 Non destructive testing, Ultrasonic examination – Part 5 Characterisation and sizing of discontinuities

Contents	Level 1	Level 2	Level 3
			BS EN ISO 2400 Calibration block No 1 ultrasonic examination AMS 2175A Castings – Classification and inspection
7.0 **Evaluation and reporting**	**7.0 Detecting, locating (trigonometrical rules) and sizing techniques** Recording and evaluation level Acceptance levels Test reports System of coordinate Measurement (probe, reflector) Calculated values	**7.0 Same as level 1 (deeper knowledge)+** - characterization (planar / non planar according to **BS EN ISO 23279** for welds) - Interpretation and evaluation of indications	**7.0 Use of complementary NDT methods;** Interpretation of relevant standards and codes Evaluation (conventional approach, validated method) ; Distinction defect/artefact; Acceptance criteria; Level of significant variation; Storage and recording process
8.0 **Assessment**	**(not applicable)**	**8.0 Evaluation and confirmation of test reports** Application of the acceptance criteria according to standards, codes and procedures	Detailed knowledge of how to classify & assess observations, analyse the results and compare them to codes, standards and design specifications etc…. How to develop codes, standards and design specifications etc…. into clear acceptance criteria to be written into procedures and instructions Also how to find information /assistance to investigate observations not covered by codes and standards & develop acceptance criteria. The training of levels 1 & 2 for these acceptance criteria.
9.0 **Quality aspects**	**9.0 Personnel qualification** (according to EN ISO 9712) Equipment verification	**9.0 Personnel qualification** (according to EN ISO 9712) Equipment verification Written instructions Traceability of documents	**9.0 Personnel qualification and responsibility** (according to EN ISO 9712) Equipment verification Format of working procedures, Traceability of documents Other NDT qualification and certification

Contents	Level 1	Level 2	Level 3
			systems A review of applicable NDT application and product standards
10.0 Developments	**(not applicable)**	**10.0 General information**	Newest developments for industrial and scientific applications of UT: e.g. tomography holography, acoustic microscopy …

Contents	Level 1	Level 2	Level 3

C. Eddy current testing level 1, level 2 and level 3

1.0 Introduction, Terminology, History of NDT	**1.0 Generalities on NDT**: What is testing? What is the purpose of NDT? At what stage of the life of a "product" is NDT performed? How does it add value? Who may carry out NDT? Main NDT methods.	**1.0 Generalities on NDT**: What is testing? What is the purpose of NDT? At what stage of the life of a "product" is NDT performed? How does it add value? Who may carry out NDT? Main NDT methods.	**1.0 Generalities on NDT**: What is testing? What is the purpose of NDT? At what stage of the life of a "product" is NDT performed? How does it add value? Who may carry out NDT? Main NDT methods.
	1.1 Eddy current testing: Definition: electromagnetic interaction between a sensor and a test object conducting electricity, providing information on physical characteristics of the test object. History of the method	**1.1 Eddy current testing**: Definition: electromagnetic interaction between a sensor and a test object conducting electricity, providing information on physical characteristics of the test object. History of the method	**1.1 Eddy current testing**: Definition: electromagnetic interaction between a sensor and a test object conducting electricity, providing information on physical characteristics of the test object. History of the method
	1.2 Terminology EN 1330 –1and –2 EN 1330- 5	**1.2 Terminology** EN 1330 –1and –2 EN 1330- 5	**1.2 Terminology** EN 1330 –1and –2 EN 1330- 5
2.0 Physical principles and associated knowledge[1]	**2.0 Fundamentals ***	**2.0 Fundamentals ***	**2.0 Fundamentals ***
	2.1 Electricity : elements Direct current : current, voltage, resistance, conductance, Ohm's law, resistivity, conductivity. Units, conductivity values for some metals. Alternating current : sinusoidal current and voltage, amplitude, frequency, period, phase.	**2.1 Electricity :** Direct current : current, voltage, resistance, conductance, Ohm's law, resistivity, conductivity. Units, conductivity values for some metals. Alternating current : sinusoidal current and voltage, amplitude, frequency, period, phase. Vector representation.	**2.1 Electricity :** Direct current : current, voltage, resistance, conductance, Ohm's law, resistivity, conductivity. Units, conductivity values for some metals. Alternating current : sinusoidal current and voltage, amplitude, frequency, period, phase. Vector representation. Other periodic currents.

[1] Section 2 lists the notions necessary to understand eddy current testing. The knowledge associated to the physical principles (physics, mathematics) may as well be the object of a preliminary course of training.

Contents	Level 1	Level 2	Level 3
	2.2 Magnetism Magnetism : magnetic field, lines of force, magnetic field strength. Permeability, flux density (induction). Flux. Hysteresis loop. Units.	**2.2 Magnetism** Magnetism : magnetic field, lines of force, magnetic field strength. Permeability, flux density (induction). Flux. Hysteresis loop. Reluctance. Magneto-motive force. Units. Diamagnetism, paramagnetism, ferromagnetism.	**2.2 Magnetism** Magnetism : magnetic field, lines of force, magnetic field strength. Permeability, flux density (induction). Flux. Hysteresis loop. Reluctance. Magneto-motive force. Units. Diamagnetism, paramagnetism, ferromagnetism.
	2.3 Electromagnetism Magnetic field created by a current, (wire, coil). Electromagnetic induction phenomenon, inductance, Electromagnetic coupling. Induced currents and secondary field**.** Lenz's law Eddy current distribution in conducting materials - depth of penetration, amplitude, phase -characteristic frequency Impedance.	**2.3 Electromagnetism** Magnetic field created by a current, (wire, coil). Electromagnetic induction phenomenon, inductance, mutual induction. Electromagnetic coupling. Induced currents and secondary field**.** Lenz's law Eddy current distribution in conducting materials - planar wave: standard depth of penetration, amplitude, phase - cylindrical conductors: characteristic frequency Impedance. Complex plane representation. Impedance plane diagrams	**2.3 Electromagnetism** Magnetic field created by a current, (wire, coil). Electromagnetic induction phenomenon, inductance, mutual induction. Electromagnetic coupling. Induced currents and secondary field**.** Lenz's law Eddy current distribution in conducting materials - planar wave: standard depth of penetration, amplitude, phase - cylindrical conductors: characteristic frequency Impedance. Complex plane representation. Impedance plane diagrams

Contents	Level 1	Level 2	Level 3
3.0 **Product knowledge and related capability of the method and derived techniques**	Applications of eddy current testing: Metal sorting Measurement of a physical parameter: conductivity, ferrite content , thickness of coatings, etc... Detection of local discontinuities (flaws). Capabilities : depth of penetration, conductive materials Non contact, high speed, high temperature, may be mechanised. Techniques: single frequency, multifrequency, multiparameter.	Manufacturing related discontinuities (typical flaws) Service induced discontinuities (flaws). Material properties influencing eddy current testing: conductivity, permeability, Product characteristics influencing eddy current testing: condition (surface condition, heat treatment, cold working, temperature, etc...), shape, wall thickness, accessibility Products being tested : Semi-finished products, pipes, heat exchanger tubes, mechanical parts (e.g. car, railway and aircraft industry), welds (e.g. offshore) Applications of eddy current testing : Metal sorting Measurement of a physical parameter : conductivity, ferrite content , thickness of coatings, etc... Detection of local discontinuities (flaws) Capabilities: - depth of penetration, conductive materials Non contact, high speed, high temperature, may be mechanised. Techniques : single frequency, multifrequency, multiparameter. Remote field. Codes and standards	Manufacturing related discontinuities (typical flaws) Service induced discontinuities (flaws). Material properties influencing eddy current testing : conductivity, permeability, Product characteristics influencing eddy current testing : condition (surface condition, heat treatment, cold working, temperature, etc...), shape, wall thickness, accessibility Applications of eddy current testing : Metal sorting Measurement of a physical parameter : conductivity, , thickness of coatings, etc... Detection of local discontinuities (flaws) Capabilities : - depth of penetration, conductive materials Non contact, high speed, high temperature, may be mechanised. Techniques : single frequency, multifrequency, multiparameter. Remote field. Codes and standards
4.0 **Equipment**	**4.0 Eddy current testing system:** instrument, probe, reference blocks.	**4.0 Eddy current testing system:** instrument, probe, reference blocks.	**4.0 Eddy current testing system:** instrument, probe, reference blocks.

Contents	Level 1	Level 2	Level 3
	4.1 Relevant standards: **BS EN ISO 15548 parts 1 & 2** Measurements: absolute, differential, others Output and signal display	**4.1 Relevant standards:** **BS EN ISO 15548 parts 1 & 2** General purpose application instrument : essential functions Specific application instruments Probe functions: combined or separate transmit- receive Probe family : surface, coaxial Probe designs Measurements : absolute, differential, others Output and signal display Reference blocks : material, design, production, storage. Mechanised equipment standards	**4.1 Relevant standards:** **BS EN ISO 15548 parts 1 & 2** General purpose application instrument: essential functions Specific application instruments Probe functions: combined or separate transmit- receive Probe family : surface, coaxial Probe designs Measurements : absolute, differential, others Output and signal display Reference blocks : material, design, production, storage. Mechanised equipment Codes and standards
5.0 **Information prior to testing**	Information on the product : grade, metallurgical condition, shape. Type of discontinuities anticipated and location, duty of the product. Extent of examination. Information on test conditions : temperature, humidity, access, availability, unwanted interfering signals, electric and/or magnetic disturbances.	Information on the product : grade, metallurgical condition, shape. Type of discontinuities anticipated and location, duty of the product. Extent of examination. Information on test conditions : temperature, humidity, access, availability, unwanted interfering signals, electric and/or magnetic disturbances. - Preparation of written instructions	Information on the product : grade, metallurgical condition, shape. Type of discontinuities anticipated and location, duty of the product. Extent of examination. Information on test conditions : temperature, humidity, access, availability, unwanted interfering signals, electric and/or magnetic disturbances. Use of other NDT methods Codes, standards, specifications.
6.0 **Testing**	Reference blocks : design, production, storage. Operating conditions : Excitation frequency and if necessary auxiliary frequencies Probe speed, probe clearance, probe vibration and centring Calibration curves Settings : data acquisition procedure/instructions	Reference blocks : design, production, storage. Probe : selection, as a result of the information in 5.0, Operating conditions as a result of the information in 5.0 : Excitation frequency and if necessary auxiliary frequencies Probe speed, probe clearance, probe vibration and centring Calibration curves Settings : data acquisition procedure	Reference blocks : design, production, storage. Probe : selection or design, as a result of the information in 5.0, Operating conditions as a result of the information in 5.0 : Excitation frequency and if necessary auxiliary frequencies Probe speed, probe clearance, probe vibration and centring Calibration curves Settings : data acquisition procedure

Contents	Level 1	Level 2	Level 3
	Essential Reading:	**Essential Reading:** BS EN ISO 12718 NDT Terminology – Eddy Current Testing BS EN ISO 15549:2010 NDT. Eddy Current Testing. General Principles. ASTM E 1004. Standard method for determining electrical conductivity using the Eddy Current method. SAE ARP 4002. Eddy Current inspection of open fastener holes in Aluminium structure. ASTM E376-11. Standard practice for measuring coating thickness by magnetic field or Eddy Current methods AMS 2658C Hardness and Conductivity of Wrought Aluminium Alloys	**Essential Reading:** BS EN ISO 15548-1-2013 NDT. Equipment for Eddy Current examination Part 1. Instrument characteristics verification. BS EN ISO 15548-2:2008 NDT. Equipment for Eddy Current examination Part 2. Probe characteristics and verification BS EN ISO 15548-3:2008 NDT. Equipment for Eddy Current examination Part 3. System characteristics and verification
7.0 **Evaluation And Reporting**	**7.0 Evaluation** **NOT APPLICABLE**	**7.0 Evaluation.** Characterisation of the indications : single frequency analysis, multifrequency analysis, data analysis procedure	**7.0 Evaluation.** Characterisation of the indications : single frequency analysis, multifrequency analysis, data analysis procedure
	7.1 Reporting Examination report	**7.1 Reporting** Reporting level Examination report	**7.1 Reporting** Reporting level Examination report
8.0 **Assessment**	**NOT APPLICABLE**	Acceptance criteria Codes, standards	Acceptance criteria Significance of discontinuities Codes, standards
9.0 **Quality aspects**	**9.0 Personnel qualification** (according to EN ISO 9712) Equipment verification	**9.0 Personnel qualification** (according to EN ISO 9712) Equipment verification Written instructions Traceability of documents	**9.0 Personnel qualification** (according to EN ISO 9712) Equipment verification Format of working procedures, Traceability of documents Other NDT qualification and certification systems A review of applicable NDT application and product standards

Contents	Level 1	Level 2	Level 3
10.0 **Developments**	**NOT APPLICABLE**	General information	Array probes Pulsed eddy currents Non inductive techniques : Magneto-Optical Imaging, SQUID, Giant magneto-resistance,... Imaging Modelling

Contents	Level 1	Level 2	Level 3

D. Penetrant testing level 1, level 2 and level 3

* E = educational training time P = Practical training time
Note "direct access to level 2 examination requires the total hours shown for level 1 and level 2".

1.0 **Introduction, Terminology** **History of NDT**	**1.0 History** Purpose	**1.0 History** Purpose	**1.0 History** Purpose
	1.1 Terminology Product family **EN ISO 12706** Penetrant Developer Remover Reference block e.g.	**1.1 Terminology** Product family **EN ISO 12706** Sensitivity level Post emulsifiable Dual purpose penetrant Background	**1.1 Terminology** Product family **EN ISO 12706** Sensitivity level Post emulsifiable Dual purpose penetrant Background
2.0 **Physical principles of the method and associated Knowledge**	**2.0 Relevant standards:** **BS EN ISO 3452-1: General principles** Viscosity Bleed out Flash point Emulsification of penetrant Development Coloured and fluorescent penetrant	**2.0 Relevant standards:** **BS EN ISO 3452-1: General principles** Viscosity Bleed out Capillarity Flash point Emulsification of penetrant	**2.0 Relevant standards:** **BS EN ISO 3452-1: General principles** Physical basics of the method Superficial tension Viscosity Contact angle Vapour pressure
3.0 **Product knowledge and capabilities of the method and its derivate techniques**	**3.0 Typical defects according to the production process (forgings, castings, rolling, welding, …)**	**3.0 Typical defects according to the production process (forgings, castings, rolling, welding, …)**	**3.0 Typical defects according to the production process (forgings, castings, rolling, welding, …)** Welding process, casting process, process of rolled bars
4.0 **Equipment**	**4.0 Design and operation of penetrant installations and units** Aerosol spray cans Dip installations, brushing, light sources, measuring units and reference blocks	**4.0 Design and operation of penetrant installations and units** Electrostatic systems, fluidised bed Aerosol spray cans Dip installations, brushing, light sources, measuring units and reference blocks **(EN 3452-3 and EN 3452)** Viewing condition **(EN ISO 3059)**	**4.0 Design and operation of penetrant installations and units** Semiautomatic and automatic systems Electrostatic systems, fluidised bed Aerosol spray cans Dip installations, brushing, light sources, measure units and reference blocks **(EN 3452-3 and EN 3452-4)** (According to various standards e.g. **EN**

Contents	Level 1	Level 2	Level 3
			ISO 3452-4) Viewing condition **(EN ISO 3059)**
5.0 **Information prior the test**	**5.0 Verification that the test object is in suitable conditions for testing** Written instructions are given	**5.0 Information about the test object, prepare written instruction** Identification or designation Material, dimensions, field of application Kind of product family, catalogue of defects Test conditions, Applicable standards and codes, assigned to the test object	**5.0 Prepare written procedure** Identification or designation Material, dimensions, field of application Kind of product family, catalogue of defects Test conditions Applicable standards and codes assigned to the test object
6.0 **Testing**	**6.0 Performance of the test** According to written instruction	**6.0 Preparation and performance of the test** Preparation of written instructions according to **BS EN 1371-1, BS EN 10228-2, EN 1289**	**6.0 Preparation of the test** According to **BS EN ISO 3452-1**
	Essential Reading:	**Essential Reading:** BS EN ISO 3452-1 Penetrant Testing, Part 1. General principles for the examination BS M39 Method for Penetrant Inspection of Aerospace materials and components ASTM E 1417 Standard practice for Liquid Penetrant examination BS EN 1330-2 NDT-Terminology — Part 2: Terms common to the non-destructive testing methods.	**Essential Reading:** BS EN ISO 3059 Non Destructive Testing. Penetrant testing and Magnetic Particle testing – viewing conditions BS 667 Luminance meter, requirements and test methods BS EN ISO 3452-2 Non Destructive Testing, Penetrant testing. Testing of penetrant materials BS EN 3452-3 Non Destructive Testing, Penetrant testing. Reference test blocks BS EN 3452-4 Non Destructive Testing, Penetrant Testing. Equipment QPL-AMS2644 Qualified products list SAE-AMS2644 Inspection materials, Penetrants

Contents	Level 1	Level 2	Level 3
7.0 **Evaluation and Reporting**	**7.0 Test report** Welding according to **BS EN 23277** Casting according to **EN 1371-1** Forging according to **EN 10228-2** Rolled products	**7.0 Check test report** Welding according to **BS EN 23277** Casting according to **EN 1371-1** Forging according to **EN 10228-2**	**7.0 Written procedure with check of test reports:** Welding according to **BS EN ISO 3452-1** Casting according to **EN 1371** Forging according to **EN 10228-2**
	7.1 Basics of evaluation Viewing conditions according to **BS EN ISO 3059** Use of TAM panels Reference block No 2 (according to **BS EN ISO 3452-3**) Verification the indication quality Report of simple welding, forging, rolled products and casting imperfections	**7.1 Basics of evaluation** Viewing conditions according to **BS EN ISO 3059** Reference block Nos. 1 and 2 (according to **BS EN ISO 3452-3**) Other used reference blocks Calibration of test units Batch test report	**7.1 Basics of evaluation** Viewing conditions according to **BS EN ISO 3059** Reference block Nos. 1 and 2 (according to **BS EN ISO 3452-3**) Other used reference blocks Calibration of test units
		7.2 Evaluation Verification the indication quality Report of discontinuities according to **BS EN ISO 23277, EN 1371-1, EN 10228-2**	**7.2 Evaluation** Verification the indication quality
8.0 **Assessment**	**8.0 Assessment of discontinuities** Depth, width, shape, position, orientation	**8.0 Assessment of discontinuities** Influence of manufacture and material	**8.0 Assessment of discontinuities** Depth, width, shape, position, orientation
9.0 **Quality aspects**	Personnel qualification (according to EN ISO 9712) Equipment verification	Personnel qualification (according to EN ISO 9712) Equipment verification Written instructions Traceability of documents A review of applicable NDT application and product standards	Personnel qualification (according to EN ISO 9712) Equipment verification Format of working procedures Traceability of documents Other NDT qualification and certification systems A review of applicable NDT application and product standards
10.0 **Environmental and safety conditions**	**10.0 Disposing of chemicals** Penetrants Developer Emulsifier Material of process excess removal Safety data sheet	**10.0 Disposing of chemicals** Penetrants Developer Emulsifier Material of process excess removal Safety data sheet Active carbon method, ultrafiltration method UV radiation, electrical hazard	**10.0 Disposing of chemicals** Penetrants Soluble remover, developer Safety data sheets UV-radiation, electrical hazard A review of applicable NDT application and product standards

Contents	Level 1	Level 2	Level 3
		Disposal is regulated by national regulations	
11.0 Developments	(Not applicable)	Special installations Automotive installations (examples)	Creative and innovative special installations Automotive installations (examples) Tube installations

Contents	Level 1	Level 2	Level 3

E. Magnetic particle testing level 1, level 2 and level 3

* E = educational training time P = Practical training time
Note "direct access to level 2 examination requires the total hours shown for level 1 and level 2".

1.0 **Introduction, terminology, purpose and history of NDT**	**1.0 Introduction** Presentation of the magnetic particle testing Applicability and limits History Terminology	**1.0 Introduction** Presentation of magnetic particle testing Applicability and limits History Terminology	**1.0 Introduction** Presentation of the magnetic particle testing Applicability and limits History Terminology
2.0 **Physical principles and associated knowledge**	**2.0 Basic physical phenomena in terms of general description** Electric circuits, typical values, units Magnetic circuits, typical values, units Magnetic field created by electric circuits Passage of the flux from a magnetic medium to a non magnetic media Magnetic flux of a magnetic discontinuity Influence of depth and orientation of a magnetic discontinuity on its detection Magnetic properties of materials Nonmagnetic materials Magnetic materials. Curie point	**2.0 Basic physical phenomena** Electric circuits, typical value, units Magnetic circuits, typical value, units Magnetic field created by electric circuits Indefinite rectilinear conductor Long magnetic coil Short or flat magnetizing coil magnetic flow in a non magnetic media Continuity of HT Continuity of BN Magnetic flux of a magnetic discontinuity Influence of the geometry (depth, thickness) and of the orientation of a magnetic discontinuity on its detection Magnetic properties Designation of alloys Non magnetic materials Magnetic materials Field of application Curie Point Curve of the first magnetization Hysteresis cycle and remarkable points Magnetic properties of steels	**2.0 Basics** Diamagnetism – Paramagnetism Ferromagnetism – Ferrimagnetism Magnetic fields characterization and measurements Magnetic field H - magnetic Induction B Hysteresis cycle and remarkable points Influence of the temperature on the magnetic properties Principle of magnetic particle testing Influence of the interface between a magnetic medium and a nonmagnetic medium Continuity of HT Continuity of BN Influence of the orientation of the discontinuity on magnetic flux Behaviour of a magnetic particle in the vicinity of a magnetic flux Influence of geometry (depth, thickness and orientation) on detectability Magnetic properties of principal ferromagnetic alloys Magnetic field H, magnetic induction B, relative magnetic permeability μ_R, coercitive force Hc, electrical resistance ρ. Influence of composition, heat treatments and work hardening of the steel.

Contents	Level 1	Level 2	Level 3
			Influence of work hardening. Influence of heat treatment Particular alloys: e.g. Permalloys, Invar, Inconel
3.0 **Product knowledge and capabilities of method and its derivate techniques**	**3.0 Typical discontinuities** according to the production process (welds, forgings, castings and rolled products	**3.0 Typical discontinuities** in welds, forgings, castings and roller products and there indications	**3.0 Typical discontinuities** in welds, forgings, castings and roller products and there indications
	3.1 Testing parameters: Magnetization, detection media and test of detection media indication.	**3.1 Testing parameters**: Magnetization, detection media and test of detection media indication.	**3.1 Testing parameters**: Magnetization, detection media and test of detection media indication
4.0 **Equipment**	**4.0 Equipment** Magnetizing equipment Viewing condition Measurement and calibration Demagnetization	**4.0 Equipment** Various types Portable electromagnet Mobile Magnetic benches Automatic and robotized with automatic detection (magnetic leakage field) Sources of light and conditions of illumination Accessories Flux indicators and products indicators Field strength measuring devices Photometers and radiometers Considerations on the choice of the equipment Elements to be taken into account materials and components to be controlled zones to be controlled, goal of the test place and environment Choice of the technique type of current Magnetic flow technique (open and closed circuit) Current flow technique – Induced current flow combined system Multidirectional magnetization and rotating field	**4.0 Equipment** Mobile or fixed equipment using magnetic flow technique or current flow technique Automatic and robotized with automatic detection (magnetic leakage field)

Contents	Level 1	Level 2	Level 3
	4.1 Relevant standards: **BS EN ISO 9934 parts 2 & 3**		**4.1 Relevant standards:** **EN ISO 9934-2 and EN ISO 9934-3**
5.0 **Information prior the test**	**5.0 Application of a written instruction**	**5.0 Identification or designation material.** -Kind of manufacture. -Catalogue of defects -Test condition and application of standard: -Accessibility -Infrastructure -Particular test condition -Application standard. Overview -Standard and codes assigned to the test objects -Acceptance criteria Preparation of written instructions Documents Presentation of the standards, codes and procedures	**5.0 Identification or designation materials.** -Kind of manufacture. -Catalogue of defects -Test condition and application of standard: -Accessibility -Infrastructure -Particular test condition -Application standard. Overview -Standard and codes assigned to the test objects -Acceptance criteria Preparation of written instructions Documents Presentation of the standards, codes and procedures
6.0 **Testing**	**6.0 Testing according to the written instructions** Surface preparation Cleaning, machining Use of contrast paint Magnetization, types and time of application Application of the detection media Recording of discontinuities Continuous technique Remanence technique Grid and covering Control of conditions of magnetization	**6.0 Testing** Surface preparation Cleaning, machining Use of contrast paint Magnetization, types and time of application Application of the detection media Continuous technique Remanence technique Grid and covering Control of conditions of magnetization	**6.0 Testing** Preparation of the parts and influence of the surface quality Means of magnetization. Values of the parameters. Continuous or simultaneous method. Remanence method . Flux indicators Choice of the detection media. products indicators

Contents	Level 1	Level 2	Level 3
	6.1 Treatment of the components after test Residual field Basic principle of demagnetization Demagnetization. Industrial methods of demagnetization Cleaning of the components	**6.1 Treatment of the components after test** Residual field. Conditions requiring demagnetization. Level of residual field Basic principle of demagnetization Demagnetization. Industrial methods of demagnetization and influence of terrestrial magnetic field Cleaning of the components	**6.1 Treatment of the components after test** Demagnetization Principle, minimal value of the magnetic field of demagnetization, frequency, effect of skin and calculation of magnetizing coil Level of residual field according to the later use of material Influence of terrestrial magnetic field Cleaning of the components
	Essential Reading:	**Essential Reading:** BS EN 9934-1 Non destructive testing, Magnetic particle testing. General principles ASTM E 1444 Standard practice for magnetic particle testing BS EN ISO 9934-1-2001 *Method for Magnetic Particle Flaw Detection* BS EN 1330-2 NDT-Terminology — Part 2: Terms common to the non-destructive testing methods.	**Essential Reading:** BS EN 3059 Non Destructive Testing. Penetrant testing and Magnetic Particle testing – viewing conditions BS 667 Luminance meter, requirements and test methods BS EN 9934-2 Non destructive testing, Magnetic particle testing. Detection Media BS EN 9934-3 Non destructive testing, Magnetic particle testing. Equipment LATEST SAE AMS 2641C MPI Vehicle
7.0 **Evaluation and reporting**	**7.0 Classification of the indications** Welding according to **BS EN ISO 17638** Casting according to **EN 1369** Forging according to **EN 10228-1** Steel forgings Viewing conditions according to reference block Verification the indication quality (**BS EN ISO 3059**) Report of simple welding, forging, rolled products and casting imperfections	**7.0 Test report** Check test report Basic of evaluation Viewing conditions (**BS EN ISO 3059**) according to reference block, other used reference blocks, calibration of test units, batch test report Evaluation and verification the indication quality Report of imperfections according to **BS EN ISO 17638, EN 1369, EN 10228-1**	**7.0 Test report** Written procedure with check of test reports: Welding according to **BS EN ISO 17688** Casting according to **EN 1371** Forging according to **10228-2** Basics of evaluation, viewing conditions (**BS EN 3059**) according to reference block, other used reference blocks calibration of test units Evaluation verification the indication quality

Contents	Level 1	Level 2	Level 3
8.0 **Assessment**	Not applicable	Assessment of discontinuities Influence of manufacture and material	Assessment of discontinuities Influence of manufacture and material
9.0 **Quality aspects**	**9.0 Personnel qualification** (according to EN ISO 9712) Equipment verification	**9.0 Personnel qualification** (according to EN ISO 9712) Equipment verification Written instructions Traceability of documents A review of applicable NDT application and product standards	**9.0 Personnel qualification** (according to EN ISO 9712) Equipment verification Format of working procedures Traceability of documents A review of applicable NDT application and product standards
10.0 **Environmental and Safety conditions**	**10.0 Health and Safety** Electric risks hazards Risks related to the products (magnetic inks) Risks related to the ultraviolet radiation Disposal of the effluents and environmental conditions (concepts) Safety data sheet	**10.0 Health and Safety** Electric risks hazards Risks related to the products (magnetic inks) Risks related to the ultraviolet radiation Disposal of the effluents and environmental conditions (concepts) Safety data sheet	**10.0 Health and Safety** Electric risks hazards Risks related to the products (magnetic inks) Risks related to the ultraviolet radiation Disposal of the effluents and environmental conditions (concepts) Harmfulness and toxicity of the products Treatment and rejection of the effluents, environmental conditions Fire hazards Risks related to the ultraviolet radiations
11.0 **Developments**	(Not applicable)	Special installation and equipment	New techniques Creative and innovative special installations

Contents	Level 1	Level 2	Level 3

F. Syllabus visual testing level 1, level 2 and level 3

* E = educational training time P = Practical training time
Note "direct access to level 2 examination requires the total hours shown for level 1 and level 2".

1.0 **Introduction, Terminology, purpose & history of NDT**	**1.0 History of NDT** History of Visual Testing (VT) Purpose of NDT Definition of visual testing	**1.0 History of NDT** History of Visual Testing Purpose of NDT Definition of visual testing	**1.0 As level 2** Use of VT as a complement to other NDT methods.
	1.1 Terminology Terminology applicable to VT **EN1330-2 & EN 1330-10** Overview of VT applications	**1.1 Terminology** Terminology applicable to VT **EN1330-2 & EN 1330-10** Extended overview of VT applications	
2.0 **Physical principles of the method and associated Knowledge**	**2.0 Relevant standards** **EN 13018** VT General principles **BS EN 13927** VT Equipment Fundamentals Vision Lighting Transmission Reflection Absorption Photometry Light levels Light measurement Optical principles	**2.0 Relevant standards** **EN 13018** VT General principles **BS EN13927** VT Equipment Fundamentals Vision — The eye, inc operation & construction — Vision limitations — Adaptation & accommodation — Disorders Lighting — Physics of light Electromagnetic radiation Visible wavelengths — Fundamentals of light Transmission Reflection Absorption — Lighting measurements Luminance — Lighting levels — Lighting techniques — Contrast Optical principles — Operation of lenses — Operation of magnifiers — Image construction	**2.0 As level 2, plus** Goals and principles of VT A comprehensive knowledge and understanding of the physical principles and physics of light including Optical performance Polarization of light Stroboscopic principles Dispersion Refraction and refractive index Reflection Fluorescence Advantages and disadvantages of different wavelengths of optical radiation (UV, IR), including Colour temperature Types of light sources, natural, artificial including laser Details of the eye including Vision ranges Effects of disorders Camera & photo sensor operation & principles Optical filters

Contents	Level 1	Level 2	Level 3
	Visual perception Material attributes — Colour — Surface condition — Surface preparation Environmental factors Direct and remote methods Vision requirements References: **EN 13028** **BS EN 13927**	— Virtual images — Chromatic aberration — Geometric distortion — Magnification principles Visual perception — What your eyes see — What your mind sees — What others perceive — What the designer, engineer etc. want you to see Material attributes affecting the test — Cleanliness — Colour — Condition — Shape — Size — Temperature — Texture — Type — Surface Finish — Surface preparation Environmental & physiological factors — Atmosphere — Comfort — Perspective — Distance — Accessing — Fatigue — Health — Humidity — Mental attitude — Position — Safety — Temperature — Cleanliness Direct and remote methods vision requirements & the employers responsibility	Construction of digital images and problems Image processing Image analysis Image compression & Transmission Image storage Resolution Video monitors Other monitors Light meters & photometers Principles of operation of fibre bundles and lenses Coherent Incoherent Photogrammetry
3.0 **Product knowledge and capabilities of the**	The depth of knowledge required for this section is given below: Outline of basic flaws detectable by VT as	The depth of knowledge required for this section is given below: Test objects and flaws	**Level 2, plus** Evaluation of surfaces

Contents	Level 1	Level 2	Level 3
method and its derivate Techniques	necessary to work in a specific sector References **BS EN ISO 17637, BS EN 1370, BS EN ISO 5817** Awareness of capability and limitations	Basic production and degradation process; Terms, origin and nature and appearance of flaws Product technology sectors Basic metallurgy of the process/ component Welding / joining methods Including Cladding & Buttering: Wrought product production methods Cold working processes Heat treatment processes Material composition: Surface finishing methods Basic foundry technology Machining & material removal processes Polymers/composites In-service aspects: Service induced flaws Mechanically Thermally Tribology Wear Chemical Electrochemical References **BS EN ISO 17637, BS EN 1370**, **EN 10163 parts 1 to 3 inclusive, EN 5817 etc…** Capability and limitations of VT Detectability Flaw size Shape Orientation/ position Flaw types Surface condition effects Equipment limitations Lighting effects	Roughness & waviness Definition of shape & geometry of flaws A comprehensive understanding and knowledge of the manufacturing processes and associated metallurgy & flaw types etc… A comprehensive understanding and knowledge of the cause and formation of in-service defects including associated metallurgy & flaw types etc…

Contents	Level 1	Level 2	Level 3
		Associated techniques Gauging Comparators Measurement Thermographic imaging Replication References: ISO3057	
4.0 **Equipment**	**4.0 Introduction to equipment** Mirrors Magnifiers (**ref ISO 3058**) Borescopes Fibrescopes Photographic & video: Imaging cameras Light sources and special lighting Gauges, templates, scales, special tools, etc. Automated systems Computer-enhanced systems Demonstration test piece Resolution targets Or other special equipment as necessary for the test. Why equipment must be verified References: **EN 13927** **ISO 3058**	**4.0 Introduction to, and applications of equipment** Mirrors Magnifiers (**ref ISO 3058**) Borescopes Fibrescopes Photographic & video: Imaging cameras Video monitors Light sources and special lighting Gauges, templates, scales, special tools, etc. Automated systems Computer-enhanced systems Demonstration test piece Resolution targets Graticules Image recording, transfer & storage equipment: Equipment selection & limitations Verification of equipment Sizing of indications: Imaging systems Special optical systems Or other special equipment as necessary for the test, such as underwater, radiation resistant, etc.	**As level 2, plus the inclusion of equipment for assessment of surface conditions** A good understanding of equipment performance limitations & the selection of new equipment for its suitability. Additionally, the effect this will have on the test arrangement The evaluation of equipment to fulfil a particular task Development of verification for equipment performance, including the choice/design and application of demonstration test pieces Understanding of the procedure for control, maintenance and calibration of equipment
5.0 **Information prior to the Test**	**5.0 Pre-test documentation** (**ref EN13018**) Test instruction Written procedure (when required) These should specify the following aspects:	**5.0 Pre-test documentation** (**ref EN13018**) Test instruction Written procedure or standard (when required)	**5.0 As level 2, plus the writing of procedures and the design of the test arrangement.** The development & application of verification techniques including the demonstration of procedures and

Contents	Level 1	Level 2	Level 3
	Object to be tested Extent of test coverage Technique & sequence of performing test Surface condition Surface preparation The stage of manufacture or service life when testing is to be carried out The requirements of test personnel The acceptance criteria The illumination (type, level and direction) The visual testing equipment to be used The post test documentation A demonstration test piece & inspection checkpoints Requirement for recorded images **References:** **EN 13018**	These should specify the following aspects: Object to be tested Extent of test coverage Technique & sequence of performing Test Surface condition Surface preparation The stage of manufacture or service life when testing is to be carried out The requirements of test personnel The acceptance criteria The illumination (type, level and direction) The visual testing equipment to be used The post test documentation A demonstration test piece & inspection checkpoints Requirement for recorded images Development and writing of NDT instructions for level I for a given test specimen, from standards or codes.	instructions for effectiveness. A thorough knowledge of complementary NDT methods that may be referenced in written procedures.
6.0 **Testing**	**6.0 How to set up a test** Working with demonstration test pieces and resolution targets Practical training on test equipment and performing tests on training test pieces with known flaws to provided instructions/ procedures including equipment and test parameters.	**6.0 How to set up and calibrate a test** Specifying & Working with demonstration test pieces and resolution targets Prepare written test instructions from standards or codes for given test pieces. Practical training on test equipment and performing tests on training test pieces with known flaws to instructions as above including equipment and test parameters.	**6.0 As level 2, plus the control of procedures and instructions for their effectiveness**
7.0 **Evaluation and Reporting**	**7.0 Reporting the results of tests** Reference to test standards Calibration status Reference points for location of indications Classification of indications per: instructed acceptance criteria reports and documentation	**7.0 Level 1 detail, plus How to control and monitor a Level 1 test done with your guidance.** Interpretation, evaluation & reporting of results to specifications and standards Objective/Subjective evaluation Completion of calibration forms	**7.0 As level 2 plus how to develop report formats for ease of use and clarity.** Organization and storage/distribution of final reports Investigation of suitable codes & product standards for each application Acting as a reference point for level 2 advice for interpretation and evaluation **References:**

Contents	Level 1	Level 2	Level 3
	reporting verification results		**EN 13445-5** **EN 12732** **EN 12952 etc.**
8.0 **Assessment**	Not Applicable	Classification & assessment of observations per acceptance criteria from the codes, standards or written instructions etc. or by specific reference to a level 3 where no codes or standards exist. By comparison By measurement Automated evaluation e.g. pattern recognition Recording Reporting	Detailed knowledge of how to classify & assess observations, analyse the results and compare them to codes, standards and design specifications etc. How to develop codes, standards and design specifications etc. into clear acceptance criteria to be written into procedures and instructions Also how to find information /assistance to investigate observations not covered by codes and standards & develop acceptance criteria. The training of levels 1 & 2 for these acceptance criteria.
9.0 **Quality aspects**	**9.0 Personnel qualification** (according to **EN ISO 9712**) Equipment verification	**9.0 Personnel qualification** (according to **EN ISO 9712**) Equipment verification Written instructions Traceability of documents A review of applicable NDT application and product standards	**9.0 Personnel qualification** (according to **EN ISO 9712**) Equipment verification Format of working procedures Traceability of documents Other NDT qualification and certification systems A review of applicable NDT application and product standards
10.0 **Development**	Not applicable	General information	The importance of investigating current and developing technology and methods of application. Summary of latest developments