Certification Services Division
Midsummer House, Riverside Way
Bedford Road, Northampton, NN1 5NX
United Kingdom

Tel: +44(0)1604-438-300.
Fax: +44(0)1604-438-301.
E-mail: pcn@bindt.org

PCN ISI/ Appendix Z1 Issue 1 – dated 1st June 2015 Implementation 01/07/2015

Syllabus document for qualification and PCN certification of NDT personnel for In- Service Inspection

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.

Note "direct access to level 2 examination requires the total hours shown for level 1 and level 2".

Contents	Level 1	Level 2	Level 3 The following should be covered in addition to that in Level 1 & 2
1.0 Introduction, Terminology, purpose & history of NDT	**Module 1** Introduction to NDT Methods - (Overview only) Magnetic Particle Penetrant Testing Radiography - Film, digital, Computed, Real time, Small controlled area systems. Ultrasonic testing - MUT, corrosion mapping, phased array, ToFD, long range Eddy Current Tube testing - MFL, ET, IRIS Hardness testing Leak testing Thermography PEC - Incotest ACFM Intelligent pigs Holiday testing Pressure testing Mechanical testing Why it is done Tensile Bend	**Module 1** Introduction to NDT Methods - (Overview only) Magnetic Particle Penetrant Testing Radiography - Film, digital, Computed, Real time, Small controlled area systems. Ultrasonic testing - MUT, corrosion mapping, phased array, ToFD, long range Eddy Current Tube testing - MFL, ET, IRIS Hardness testing Leak testing Thermography PEC - Incotest ACFM Intelligent pigs Holiday testing Pressure testing Mechanical testing Why it is done Tensile Bend	**Theory Part E** Requirements for NDT supervisory personnel

	Charpy Hardness Macro	Charpy Hardness Macro	
2.0 **Physical principles of the method and associated Knowledge**	**Module 1** Surface Coating Paints Thermal sprayed aluminium Galvanising Epoxy Wraps - GRP, cold tar, epoxy	**Module 1** Surface Coating Paints Thermal sprayed aluminium Galvanising Epoxy Wraps - GRP, cold tar, epoxy **Module 2 Specific Theory** Review of typical Oil & Gas systems and components including Offshore Installations & Mobile Offshore Drilling Units (MODUs). Relevant Standards – Pressure Systems - PSSR, PUWER etc – Overview	**Theory Part E** Introduction to manufacturing technology. Personnel. Nomenclature. Materials. Processes. Economics. Order.
3.0 **Product knowledge and capabilities of the method and its derivate Techniques**	**Module 1** Product Technology Manufacturing methods, common use in industry, why they are used and some advantages and disadvantages off each. Steel manufacture Casting - (not just steel) Forging - (not just steel) Aluminium Corrosion resistant materials, Stainless, Inconel, monel, etc.	**Module 1** Product Technology Manufacturing methods, common use in industry, why they are used and some advantages and disadvantages off each. Steel manufacture Casting - (not just steel) Forging - (not just steel) Aluminium Corrosion resistant materials, Stainless, Inconel, monel, etc.	**Theory Part E** Properties of materials. Classes of properties and significance of properties on design. Loading systems and available destructive tests and how to use the given data. Material properties and solid state changes. Energy effects on atoms. Metallic structure, solidification and grain size.

	Cladding, explosion bonded, welded. What is it why is it used CMV Cunifer Composites Plastics Grain structure GRP Grain structure All: use, probable failure types and limitation for NDT testing for each material type Construction and fabrication Welding Mma Tig/Tag Mig/Mag Sub arc Others A small bit on welding procedures and welder qualifications Heat Treatment: Annealing Normalizing Stress relieving Tempering Problems associated with incorrect HT e.g. sigma phase in stainless	Cladding, explosion bonded, welded. What is it why is it used CMV Cunifer Composites Plastics Grain structure GRP Grain structure All: use, probable failure types and limitation for NDT testing for each material type Construction and fabrication Welding Mma Tig/Tag Mig/Mag Sub arc Others A small bit on welding procedures and welder qualifications Heat Treatment**:** Annealing Normalizing Stress relieving Tempering Problems associated with incorrect HT e.g. sigma phase in stainless **<u>Module 2 Specific Theory</u>**	Solid state changes in metals including work hardening, plastic deformation and cold working. Recrystallization, recovery and grain growth. Age hardening. Allotropic changes. Heat treatment of steel, approximate equilibrium Heat-treatment processes. Austenitisation, annealing, normalising, spheroidising, hardening, tempering. Corrosion, direct chemical action, electrolytic /electrochemical reaction, rate of corrosion and associated factors, types of corrosion and degradation, corrosion protection. Ferrous metals. Choice of metal and alloys. Knowledge of raw materials and steel making processes. Nonferrous metals including the alloys of aluminium, copper, brass, bronze, nickel magnesium, zinc and other specialised alloys. Heat- and corrosion-resistant alloys. Non-metallic including plastics, the material types and characteristics. Modern manufacturing methodology coving the casting, forging and wrought processes. Associated defects and flaws.

		Steel production methods, manufacturing processes relative to steel wrought products. Casting and forging of steel components. Impact of Corrosion, Why metals Corrode Types of corrosion including, General/Uniform, Pitting and Microbial pitting, Erosion, Fatigue, Galvanic, Crevice, Inter-granular, Selective leaching, Environmentally assisted cracking, Cavitation and Turbulence. Corrosion mechanisms including: CO_2 (Sweet Corrosion), H_2S (Sour Corrosion), Oxygen Corrosion, Electrochemical Corrosion. Where Corrosion Occurs, Corrosion Control System (Overview). Material Selection; Metallic materials/Metallurgical principles Influence of Service Conditions on Materials, Interaction of Operating Conditions; Stress and specific corrosion environments, Combination of Temperature and Corrosion, (Common	Welding processes including welding metallurgy encompassing composition , grain size, structure effect of heat including stress and distortion. Weld design. Weld defects. Plastic flow including the effects of deformation. Work hardening and recrystallization. Flow rate effects. Influence of flow direction. Temperature and loading systems effects. Grain size. Relative effects of hot and cold working relating to mechanical properties, finish, accuracy and process requirements. Forging operations including hot and cold working, tube and pipe making. Powder metallurgy, pressing. Sintering and more common manufacturing processes. Miscellaneous processes for plastic processing. Compression moulding, closed die moulding, casting, extrusion, reinforced plastic moulding, post forming. Adhesive bonding of composites, laminates. Metal removal processes, electrical discharge machining, electrochemical machining and common processes. Surface finishing of steels including carburising, flame hardening. Cleaning processes wire brushing, blasting.

		Corrosion Mechanisms, include SCC, CUI etc.). Corrosion Resistant Alloys (CRA) – Overview	Coatings, types, preparation for coating, effect on subsequent NDT activities.
4.0 **Equipment**		**Module 2 Specific Theory** Safe Working Practices – Permit to Work – Assessing Risk etc. **Module 4 Specific Practical** Appropriate instrument and sensitivity settings.	**Theory Part E** Relevant equipment systems for the task.
5.0 **Information prior to the Test**		**Module 2 Specific Theory** Design Considerations Visual inspection and characterisation of c Drawing formats – P & IDs, Isometric drawings – Overview and working understanding. Common anomalies and defects Drawing formats – P & IDs, Isometric drawings – Overview and working understanding. Relevant Inspection/NDT Standards – Overview (API 570, 572, 574 etc.) **Module 3 General Practical** Instrument settings: General initial settings. Differing methods including those for digital thickness instruments and A-scan instruments. Instrument checks for settings.	

		Factors influencing accuracy including: Operational conditions, surface conditions, surface temperature, metallic and non-metallic coatings, geometry. Equipment resolution and range Evaluation of accuracy: General and specific influencing factors. Method of calculation. Influence of materials: General factors, inhomogeneity, anisotropy, attenuation, surface conditions including contact and reflecting surfaces, corrosion and erosion.	
6.0 **Testing**		**<u>Module 3 General Practical</u>** Parent material and weld heat affected zone examination: Information required prior to examination. Parent material examination, attenuation measurements, methods of flaw sizing 20dB, 6dB, DGS, maximum amplitude, use of flaw location slide, reporting methods. Brief knowledge of component surface finish and its measurement. Calibration of compression wave and 45 degree probes. Appropriate sensitivity settings. Surface conditions and surface preparation Practical techniques including:	

		General application, measurements during manufacturing of product and in-service measurement of residual wall thickness. Probe selection: Limiting parameters Material differing from the reference Specific measuring conditions including measurements at elevated temperatures and temperatures below 00C, hazardous atmospheres. **Module 4 Specific Practical** Probe selection and limiting parameters	
7.0 **Evaluation and Reporting**	**Module 1** Measurement and Drawings Use of ruler, protractor, vernier calipers. Use of datum Isometric drawing Isometric line drawings (piping) Orthographic drawings Drawing symbols (basic) CAD Maths and calculations Addition, subtraction multiplication, division Simple formula - selection of element required. Use of calculator Basic trigonometry (soc-cah-toa) Reporting requirement Accurate and concise	**Module 1** Measurement and Drawings Use of ruler, protractor, vernier calipers. Use of datum Isometric drawing Isometric line drawings (piping) Orthographic drawings Drawing symbols (basic) CAD Maths and calculations Addition, subtraction multiplication, division Simple formula - selection of element required. Use of calculator Basic trigonometry (soc-cah-toa) Reporting requirement Accurate and concise	

	Drawing Photography Recording and reporting Acceptance and rejection	Drawing Photography Recording and reporting Acceptance and rejection **<u>Module 2 Specific Theory</u>** Reporting formats including Material, Corrosion and Defect Registers. Reference data. **<u>Module 3 General Practical</u>** Test reports. General information and inspection data. **<u>Module 4 Specific Practical</u>** Measurement of general corrosion, corrosion with pitting.	
8.0 Assessment	**<u>Module 1</u>** Visual Testing Overview Physics of light Environmental conditions Light sources Optical aids Measuring equipment Surface condition Standards Specifications Standards Procedures Instructions	**<u>Module 1</u>** Visual Testing Overview Physics of light Environmental conditions Light sources Optical aids Measuring equipment Surface condition Standards Specifications Standards Procedures Instructions	

9.0 **Quality aspects**		**Module 3 General Practical** Evaluation of accuracy: General and specific influencing factors. Method of calculation.	
10.0 **Development**		**Module 2 Specific Theory** NDT Corrosion Monitoring Methods	

Notes:

(1) It is considered necessary to allocate a period of not less than 80 hours tuition for the above. All practical has to be conducted with both compression and 45 degree probe.

(2) It is extremely unlikely that the level of practical described above will be conducted as part of a standard 3.1/3.2 weld inspection course.

(3) It is therefore unlikely that a Technician holding a 3.1/3.2 will have the necessary skills required to conduct the corrosion monitoring techniques relative to Oil and Gas Industry.

(4) Supplemental training and assessment will be necessary for holders of 3.1/3.2. This shall consist of the Industry Specific theory and the Practical Examination