Ultrasonic testing (UT)

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

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

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

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

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

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