

PCN24/SYL/WI

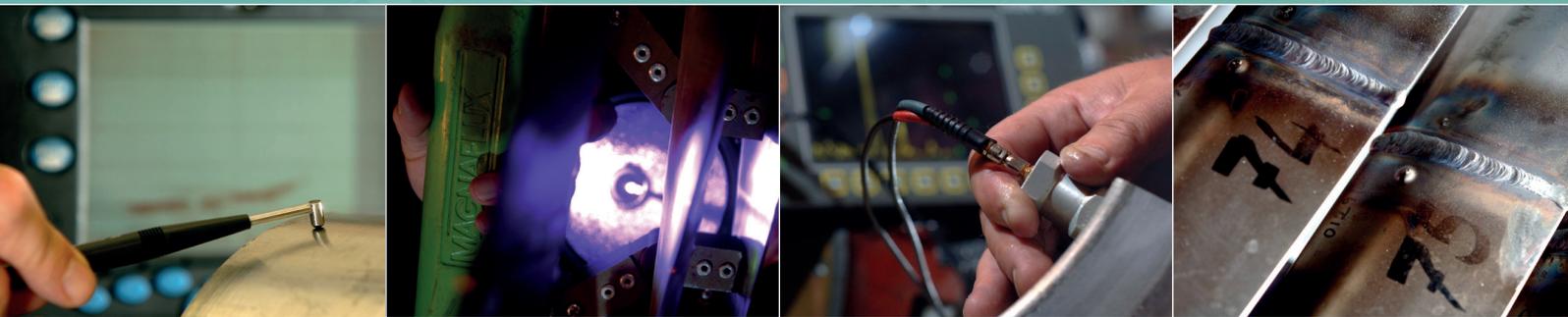
PCN Syllabus – Welding inspection (WI)

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For ease of understanding the following syllabus, weld inspection Levels 1-3 vary in the depth of knowledge the candidate is expected to attain:

- **Level 1 inspectors** shall have a **basic understanding** of the subject, shall be able to perform the basic task required and be able to report results in an approved manner.
- **Level 2 inspectors** shall have **intermediate knowledge** of the subject, shall be able to perform all of the tasks listed and be able to report and interpret results of the test undertaken.
- **Level 3 inspectors** shall have **further knowledge** of the subject, shall be able to coordinate and assume responsibility for the inspection process and report and interpret results, including providing an informed opinion of the results.

Syllabus reference number	Title	Module subcontent	Welding inspection		
			Level 1	Level 2	Level 3
1	Terminology and history of WI				
1.0	History of WI	History of welding inspection	X	X	X
1.1	Purpose of NDT	What is testing?	X	X	X
		What is the purpose of NDT?	X	X	X
		At what stage of life is NDT performed on a product?	X	X	X
		How does it add value?	X	X	X
		Who may carry out NDT?	X	X	X
		Main NDT methods	X	X	X
1.2	Purpose of WI	Definition	X	X	X
		Applicability and limitations	X	X	X
		Extended overview of welding inspection applications	X	X	X
		Use of visual testing as a complement to other NDT methods	X	X	X
1.3	Terminology		X	X	X
2	Physical principles and associated knowledge				
2.1	Introduction to WI	Essential duties of welding inspection	X	X	X
		Duties of a Level 1 welding inspector	X	X	X
		Duties of a Level 2 welding inspector		X	X
		Duties of a Level 3 welding inspector			X
		Supervision		X	X
		Codes, standards and workmanship, both national and international (EN, ISO, AWS, ASME, etc)	X	X	X
		Material types, properties and weldability	X	X	X
		Basic knowledge of quality assurance and quality control	X	X	X
		Knowledge of NDT methods	X	X	X
		Understanding of residual stress and distortion		X	X
		Health and safety related to welding and welding environments	X	X	
2.2	Duties prior to welding	Checking of materials, including size, type and condition	X	X	X
		Separation of materials during welding and minimising cross-contamination (for example carbon steel/stainless steel)	X	X	X
		Checking welding process for conformity	X	X	X
		Checking welding consumables for conformity	X	X	X

2.2 (continued)		Checking welding consumables for correct storage and handling	X	X	X
		Consumable designation and classification			X
		Checking correct welding procedure specification (WPS) is applicable		X	X
		Checking of edge preparation, including type, method and joint set-up	X	X	X
		Checking of joint alignment and ensuring correct process and method is used for tacking, etc, if required	X	X	X
		Application and control of pre-heat, measurement and method used	X	X	X
		Control of interpass temperature	X	X	X
		Qualification of welders		X	X
		Validation and verification of equipment and tools used (volt/amp meter, temperature gauge, etc)		X	X
2.3	Duties during welding	Checking correct process in use per weld run as per WPS (for example TIG/gas tungsten arc welding (GTAW) – root and subsequent passes, MMA/shielded metal arc welding (SMAW) – fill and capping passes)	X	X	X
		Checking heat input during welding (volts × amps/travel speed × k factor)		X	X
		Checking that the correct technique is in use during welding (weave or stringer bead)	X	X	X
		Checking correct direction of welding and position (for example leftward, rightward and vertical up/down)	X	X	X
		Checking correct weld run sequence is used during welding	X	X	X
		Checking of interpass temperature	X	X	X
		Checking of method and interpass cleaning	X	X	X
2.4	Duties after welding	Ensure that the weld face is completed to specification	X	X	X
		Ensure any remedial work is carried out while the weld is still adequate in temperature as per the WPS, if applicable		X	X
		Check the weld is adequately post-cleaned	X	X	X
		Visual assessment of completed weld	X	X	X
		Ensure the weld is covered, if required by the appropriate WPS, with heat-insulated blankets to retard cooling rate	X	X	X
		Check post-weld heat treatment is carried out as per WPS or procedure, where specified	X	X	X
2.5	Visual testing of finished weld	Factors affecting the visual inspection, lighting levels, etc	X	X	X
		Material under inspection and its properties	X	X	X
		Preparation of area for test	X	X	X
		Dimensional check of weld	X	X	X
		Visual check of weld face and root against acceptance criteria	X	X	X
		Influence of geometry on weld imperfection detectability	X	X	X
		Surface conditions	X	X	X
2.6	Reporting of weld	Reporting on and completion of report for completed welds	X	X	X
		Minimum information required for recording as stated in EN ISO 17637 Section 5 'Test records'		X	X
		Releasing weld for NDT		X	X
		Acceptance/rejection of weld		X	X

2.7	Monitoring of any weld repairs required	Correct WPS is used		X	X
		Correct consumables are used as per WPS		X	X
		Correct process used as per WPS		X	X
		Correct pre-heat used as per WPS		X	X
		Correct depth of repair excavation and length are made as per NDT results		X	X
		Correct NDT applied to repair area as per WPS – work instructions/ quality plan		X	X
		Qualification of welder for repair welding		X	X
3	Product knowledge and capabilities				
3.1	Welding imperfections	Imperfection acceptance levels:			
		● Classification of imperfections	X	X	X
		● Acceptance to codes and standards		X	X
		Planar imperfections:			
		● Lack of sidewall fusion	X	X	X
		● Lack of inter-run fusion	X	X	X
		● Lack of root penetration	X	X	X
		● Lack of root fusion	X	X	X
		● Cracks	X	X	X
		● Tears	X	X	X
		Gas inclusions:			
		● Gas pore	X	X	X
		● Elongated gas cavities (worm holes)	X	X	X
		● Porosity	X	X	X
		Solid inclusions:			
		● Copper	X	X	X
		● Tungsten	X	X	X
		● Slag	X	X	X
		● Silica	X	X	X
		Workmanship imperfections:			
		● Incomplete filled groove	X	X	X
		● Arc strikes/stray arcs	X	X	X
		● Root concavity (suck back)	X	X	X
		● Burn through	X	X	X
		● Overlap	X	X	X
		● Spatter	X	X	X
		● Poor profile	X	X	X
		● Undercut	X	X	X
		In-service imperfections:			
		● Fatigue		X	X
		● Stress corrosion cracking		X	X
● Brittle fracture		X	X		
Cracks:					
● Solidification cracks	X	X	X		
● Cracking mechanisms		X	X		
● Heat-affected zone (HAZ) cracks (hydrogen induced)		X	X		
● Chevron cracks		X	X		

3.2	Weld joint design	Weld joint terminology:			
		● Bevel angle	X	X	X
		● Included angle	X	X	X
		● Root face	X	X	X
		● Root gap	X	X	X
		Type of joint:			
		● Butt weld	X	X	X
		● Fillet weld	X	X	X
		● Cruciform	X	X	X
		● Edge, lap and corner joints	X	X	X
		● Spot, seam, projection and slot welds	X	X	X
		● Compounded welded joints	X	X	X
		Weld zone terminology:			
		● Heat-affected zone (HAZ)	X	X	X
		● Weld root	X	X	X
		● Weld face (cap)	X	X	X
		● Fusion boundary, fusion faces and sidewall	X	X	X
		● Leg length (z)	X	X	X
		● Throat thickness (a and s details)	X	X	X
		Welding position:			
		● Slope	X	X	X
		● Rotation	X	X	X
		● Position (PA, PB, PC, PDetc)	X	X	X
Weld symbols:					
● Weld symbols on drawings	X	X	X		
● EN ISO 2553, AWS		X	X		
3.3	Materials, properties and weldability	Typical steel composition. Elements and properties:			
		● Carbon		X	X
		● Manganese		X	X
		● Silicon		X	X
		● Aluminium		X	X
		● Molybdenum		X	X
		● Chromium		X	X
		● Vanadium		X	X
		● Nickel		X	X
		● Copper		X	X
		● Sulphur		X	X
		● Phosphorus		X	X
		Grain structures:			
		● Austenite		X	X
		● Ferrite		X	X
		● Pearlite		X	X
		● Bainite		X	X
		● Martensite		X	X
		Heat-affected zone:			
		● Heat input formula (EN 1011) versus arc energy		X	X

3.3 (continued)		Hydrogen:			
		● Effects of hydrogen in steel	X	X	X
		● Hydrogen scales		X	X
		Carbon equivalent:			
		● International Institute of Welding (IIW) formula		X	X
		● Need for pre-heat	X	X	X
		Heat treatments:			
		● Post-weld stress relieving	X	X	X
		● Post-weld heating techniques	X	X	X
		● Annealing		X	X
		● Normalising		X	X
		● Hardening/quenching		X	X
		● Tempering		X	X
		● Thermos-mechanical treatments		X	X
		● Hydrogen release		X	X
		Various metals, steel types (and guide to weldability):			
		● Low-carbon steels		X	X
		● Fine-grained steels		X	X
		● Medium-carbon steels		X	X
		● High-carbon steels		X	X
		● Low-temperature steel (cryogenic)		X	X
		● High-temperature steel (creep resistant)		X	X
		● Micro-alloyed steel		X	X
		● Austenitic stainless steel		X	X
		● Ferritic stainless steel		X	X
		● Martensitic stainless steel		X	X
		● Duplex and super duplex stainless steels		X	X
		● Nickel – nickel alloys		X	X
		● Copper		X	X
		● Light metal alloys including aluminium and associated alloys		X	X
		Residual stress and distortion:			
		● Stress and distortion caused by welding		X	X
		● Effects of residual stress and distortion, including distortion control		X	X
4	Welding equipment				
4.1	Construction and mode of operation of welding equipment	● MMA/SMAW (111)	X	X	X
		● TIG/GTAW (141)	X	X	X
		● MIG/gas metal arc welding (GMAW) (131)	X	X	X
		● Metal active gas (MAG)/GMAW (135)	X	X	X
		● Flux-cored arc welding (FCAW) (136)	X	X	X
		● Submerged arc welding (SAW) (12)	X	X	X
		● Plasma arc welding (PAW) (15)	X	X	X
4.2	Block diagram of welding processes	Control and function of equipment, including inverter systems		X	X
		Manual/semi-automatic/mechanised/automated processes		X	X
		Significance of drooping characteristic (constant current)		X	X
		Significance of flat characteristic (constant voltage)		X	X

4.3	Welding current and type of polarity	AC sine and square wave types	X	X	X
		DC electrode positive (DCEP)	X	X	X
		DC electrode negative (DCEN)	X	X	X
		Pulsed-arc processes		X	X
4.4	Calibration and validation of equipment	Use of measuring equipment for weld inspection	X	X	X
		Welding gauges, rules, go/no-go gauges, fillet gauges, borescopes, magnifiers, etc	X	X	X
		Equipment calibration	X	X	X
		Volt/amp meter calibration	X	X	X
		Digital thermometers/pyrometers, etc	X	X	X
		Heat-indicating temperature crayons, etc	X	X	X
		Illumination	X	X	X
4.5	Health and safety of equipment	Hazards of working with welding equipment	X	X	X
		Hazards of different welding processes	X	X	X
4.6	Welding consumables	Applicable codes and standards (national AWS/DIN, etc, international (EN/ISO))		X	X
		Consumable by process (SMAW):			
		● Type of flux covering	X	X	X
		● Basic	X	X	X
		● Rutile	X	X	X
		● Cellulosic	X	X	X
		● Key constituents		X	X
		Classification of consumables:			
		● EN ISO 2560, for example E 46 3 1Ni B 5 4 H5	X	X	X
		● AWS D5.1, for example E7018	X	X	X
4.7	Thermal cutting	Flame-cutting processes and their effects:			
		● Flame cutting (manual and mechanised)	X	X	X
		● Gas types used	X	X	X
		● Special applications		X	X
		Electric arc cutting processes:			
		● Plasma arc cutting	X	X	X
		● Oxy arc gouging	X	X	X
		● Arc-air	X	X	X
		Non-thermal cutting methods and effects:			
		● Shearing	X	X	X
● Machining	X	X	X		
● Shaping	X	X	X		
● Water jet	X	X	X		
5	Information prior to testing				
5.1	Information about the test object	Identification or designation material:			
		● Object to be tested	X	X	X
		● Kind of manufacture	X	X	X
		● Catalogue of defects		X	X
		● Extent of test coverage	X	X	X

5.2	Test conditions and application of standard	Accessibility		X	X
		Infrastructure			X
		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
5.3	Technique and sequence of performing test	Surface condition		X	X
		Surface preparation		X	X
		Post-test documentation		X	X
5.4	Instructions	Preparation of written procedure			X
		Preparation of written instruction		X	X
		Documents			X
		Presentation of the standards, codes and procedures			X
6	Mechanical testing				
6.1	Definitions	● Brittle	X	X	X
		● Ductile	X	X	X
		● Elasticity	X	X	X
		● Toughness	X	X	X
		● Hardness	X	X	X
6.2	Typical test carried out on welds (usually as part of weld procedure and qualification)	● Tensile		X	X
		● Bend		X	X
		● Fracture		X	X
		● Impact (Charpy, Izod)		X	X
		● Hardness (Vickers, Brinell)		X	X
		● Macro/microscopic		X	X
		● Crack tip opening displacement (CTOD)		X	X
		● Fatigue		X	X
6.3	Stress-strain	Stress-strain relationship diagram		X	X
6.4	Ultimate tensile strength	Calculation		X	X
6.5	Elongation	Calculation		X	X
7	Evaluation and reporting				
7.1	Welding procedure qualification	Witness of welding procedure qualification test:			
		● Witness of all material/consumable certification		X	X
		● Monitor and record all parameters (WPQR)		X	X
		● Ensure all required NDT is carried out as per specification/code/standard applicable		X	X
		● Witness all mechanical testing carried out on WPQR and report all findings as applicable		X	X
● Signing off WPQR as a true record			X		
7.2	Reporting results	Reference to test standards	X	X	X
		Adjustment status	X	X	X
		Reference points for location of indications	X	X	X
		Classification of indications:			
		● Instructed acceptance criteria		X	X
		● Reports and documentation		X	X
		● Reporting verification results		X	X

7.3	Control and monitoring of test results	Interpretation		X	X
		Evaluation:			
		● Objective		X	X
		● Subjective		X	X
		Reporting of results to specifications and standards		X	X
		Completion of adjustment forms		X	X
7.4	Developing report forms	Organisation of final forms			X
		Storage of final forms			X
		Distribution of final forms			X
		Investigation of suitable codes and product standards for each application			X
		Acting as a reference point for Level 2 advice for interpretation and evaluation			X
8	Assessment				
8.1	Evaluation and confirmation of test reports	Application of the acceptance criteria according to standards, codes and procedures		X	X
9	Quality aspects				
9.1	Personnel qualification	Personnel certification	X	X	X
9.2	Quality assurance	Definition and aims of quality assurance	X	X	X
		Benefits of adopting a quality assurance system	X	X	X
		Inspection <i>versus</i> quality control		X	X
		Inspection <i>versus</i> quality assurance		X	X
		Quality assurance <i>versus</i> quality control		X	X
		Quality standards		X	X
9.3	Documentation	Format and scope of working procedures			X
		Qualification of NDT procedures			X
		Authorisations (NDT instruction, procedures and personnel)			X
		Code of practice	X	X	X
		Developing written instruction		X	
		Working correctly to written instructions	X		
		Traceability of documents		X	X
		Reliability of measurements		X	X
10	Health and safety aspects				
10.1	Safety and hazards	As well as having a general understanding of safety in the workplace, inspectors are required to have specific knowledge related to the risks and hazards associated with welding and welding plant	X	X	X
10.2	Protection against heat and light	● Protection from burns	X	X	X
		● Laser welding and cutting		X	X
		● Arc radiation	X	X	X
10.3	Protection against electrical shock	● Electrical risks and magnetic fields	X	X	X
		● Effects of volts and amperage		X	X
10.4	Protection against fumes and gases	● Metal fume fever	X	X	X
		● Cadmium exposure	X	X	X
		● Oxy-fuel safety	X	X	X
		● Confined space	X	X	X
		● Ventilation	X	X	X
10.5	Ergonomics in the welding environment		X	X	
10.6	Tungsten electrodes		X	X	X

11	Developments				
11.1	Developments in welding inspection	Importance of investigating current and developing technology and method of application			X
		Summary of latest developments			X

Change control record

PCN24/SYL/WI – Document issue and review status		
Document issue for review	Changes/amendments	Current document status
Issue 1	Document updated to PCN24 format	January 2025

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