



BET Project

D2.2 Framework of Shared Learning Outcomes (LOs)

(SPK600, 2,5 HE Credits)

This guideline describes the learning goals of the course Welding Technology- Testing and Quality Assurance, consisting of

- General Content
- General Learning Outcomes
- Specific Learning Outcomes
- General Competences

at the course level, but also at the Competence Units (CUs) levels.

A CU is the smallest educational unit available. The CU is a specific subject module that is structured and delivered according to the industry needs, whereby they follow the sequential control stages before, during and after welding.

The development of a standard for a common competence framework will ease the recognition of qualification equivalences, assisted by ECVET and shared delivery by VET specialists and industry experts. This is leading to a unitized, modernized delivery system based on CUs to be shared nationally and internationally.

The Welding Technology- Testing and Quality Assurance is structured in 5 Competence Units (CUs). This course provides an overview of testing and quality assurance for welding and knowledge of fundamental theoretical concepts in materials science and welding processes. In the course, it is analyzed how different welding processes, work routines, and choices of materials can affect the quality of welded products. This is combined with

discussions on materials characterization and testing methods. There is a continuous reflection on how these methods for inspection and quality control of welded products can be applied in practice. Four out of the five competence units are designed to be developed over distance via a learning management platform that includes reading material, pre-recorded video material and on-line sessions (Zoom) with the students weekly for scheduled seminars and discussions. The students' digital skills, therefore, are developed and enhanced by applying these tools.

- CU 1: Materials and Processes
- CU 2: Quality control before welding
- CU 3: Welding in practice
- CU 4: Quality control after welding
- CU 5: Laboratory visit and examination

The Welding Technology- Testing and Quality Assurance course

Course content

This course provides an overview of testing and quality assurance for welding and knowledge of fundamental theoretical concepts in materials science and welding processes. In the course, it is analyzed how different welding processes, work routines, and choices of materials can affect the quality of welded products. This is combined with discussions on materials characterization and testing methods. There is a continuous reflection on how these methods for inspection and quality control of welded products can be applied in practice. In a bulleted list,

- Quality assurance of welded products
- Welding processes such as MMA, TIG, MIG/MAG, FSW, laser welding, constructive requirements and regulations
- Mechanical properties and welding microstructure of the following materials: Aluminium, Nickel-based superalloys and different types of steel
- Testing and analysis of mechanical properties and microstructure
- Weldability testing using Varestraint and Gleeble
- Introduction to non-destructive testing

General learning outcomes

After completion of the course, the student should be able to

- Explain and describe the most common welding methods used for metallic materials in production and repair operations.
- Analyse the influence of the welding process on microstructure, material properties and quality of metallic materials.
- Explain and reflect on different methods for inspection, validation and quality assurance for welded products.

Specific learning outcomes

- Identify welding process parameters affecting heat input conditions to the base metal.
- Be able to understand the importance of power beam welding processes recently.
- Be able to compile WPS for welded components and evaluate their compliance with the requirements of relevant national and international standards.
- Assess a welded fabrication case, interprets the specific quality requirements and compiles a quality control procedure.
- Choose the proper type of fixture, jig, or positioner for a particular welded fabrication.
- Be able to identify the risks, accidents, and occupational diseases related to welding,
- Be able to prevent welding-related risks,
- Be able to apply techniques to prevent air pollution in welding,
- Be able to prevent common ergonomic problems in welding,
- Be able to present and discuss their concepts and methods related to welding quality assurance with welding experts.

General competence for the course

- Appropriate selection of welding processes per standards
- Visual Inspection of the welds
- Qualification of Welders and Welding Procedures
- Inspection of structures before and after welding

Course Competence Units--- CU's

Start	RPL mapping of students' work experience				Short Mapping for Prior Learning before starting the course	
CU-1	Title: Materials and Processes					
CU-1	Content/Subject	Type	Learning Materials distributed through LMS	Work-Based training for the student	Deliverables from students	Hours
	<p>General. In this CU, the students will get an introduction to the course, containing the following topics: * Presentation of the participants (by each participant). * A presentation of the course schedule, including the course content. * A presentation of the education structure and methodology with emphasis on work-based training and how this will be implemented in the course The CU further contains: *A lecture on welding metallurgy of Aluminium, Stainless Steels and Nickel-based superalloys *A lecture on Welding Processes *A lecture on Weldability testing in Research *A practical exercise using a virtual laboratory environment where the students work with welding processes and microscopy.</p> <p>General Learning outcomes:</p> <ul style="list-style-type: none"> Understand different types of welding processes. 	Zoom with teacher+e-learning	Course introduction, course description Guides for Zoom and Canvas (LMS) Lecture slides and pre-recorded video lectures	*Learning to know each other and the background. * Learning the course schedule *Visit the virtual material characterisation and welding laboratory.		3 hours zoom seminar + 1.5 hours of pre-recorded lectures

- Explain the basic working principle of welding processes.
- Know the various kind of joint configurations.
- Understand how heat transfer from the heat source to the base metal.
- Distinguish fusion and solid-state welding processes.
- Understand and explain different types of metallurgy-related weld cracking mechanisms
- Know and understand the difference between representative and simulative weldability testing
- Show knowledge of weldability testing methods such as the hot ductility test and vareststraint testing and related weldability criteria
- Understand and describe the classification of stainless steels, aluminium alloys, and nickel-based superalloys
- Know typical applications for different advanced materials and alloys
- Show knowledge of the physical and welding metallurgy of different metallic materials
- Understand and explain metallurgy-related weld cracking mechanisms
- Be able to identify welding problems related to the microstructure of the material

Specific Learning Outcomes.

- Be able to identify materials based on their classification
- Be able to explain the formation of crack formation in welds
- Be able to select materials based on their welding performance
- Be able to avoid material-related welding defects
- Know the significance of ARC characteristics, metal transfer and electrode polarities.
- Identify welding process parameters affecting heat input conditions to the base metal.

	<ul style="list-style-type: none"> • Be able to understand the importance of power beam welding processes recently. • Be able to know advancements in solid-state welding processes. • Be able to apply weldability testing methodology • Be able to identify critical parameters for avoiding crack formation during and after welding • Be able to identify weldability testing methods suitable for a given material and type of weld crack • Be able to interpret results from simulative weldability testing such as hot ductility test and vareststraint test 					
CU-2	Title: Quality Control before Welding					
CU-2	Content/Subject	Type	Learning Materials distributed through LMS	Work-Based on training for the student	Deliverables from students	Hours
	<p>General. In this CU, the students will learn about quality control during manufacturing – necessary standards and qualification procedures such as WPS and operator qualification.</p> <p>General Learning Outcomes:</p> <ul style="list-style-type: none"> • Explain the essential elements of WPS/WPQR/pWPS BPS/pBPS/BPQR and the main advantages to the quality of welded fabrication requirements. • Explain the purpose of welder qualification and the main advantages to the quality of welded fabrication • Clarify the purpose of a welding operator qualification and its outcomes with the welded fabrication quality requirements. • Clarify the welding control tasks of the welding coordinator responsible for welded fabrication/ manufacture. • Explain the impact of the specific tasks on weld quality. • Classify the welding control tasks of welding inspectors. • Analyse the principles of quality assurance, quality control and inspection systems concerning welded fabrication to realise its specific quality requirements • Define the essential elements of quality control procedures and quality plans concerning welded fabrication quality requirements. • Define an audit plan's purpose and consider its influence on welded fabrication quality requirements. 	Zoom with teacher+e-learning	Lecture slides and pre-recorded video lectures	Discuss and report on the following topics: -Parameters that affect weld quality -Welding standards -Operator and procedure qualification		Estimate: 3 hours zoom seminar + 1 hour of pre- recorded lectures

	<ul style="list-style-type: none"> Define audit principles, illustrate how each can affect the reliability of results, and compare their impacts on welded fabrication quality requirements. Compare the personnel and equipment factors that have a significant effect on welded fabrication quality Define the welding coordinator's quality assurance tasks responsible for welding fabrication/ manufacture concerning the impact of the specific tasks on weld quality. <p>Specific Learning Outcomes.</p> <ul style="list-style-type: none"> Be able to compile WPS for welded components and evaluate their compliance with relevant national and international standards requirements. Determine the main variables for a particular WPS qualification and its range of qualifications. Be able to discuss the requirements of relevant standards for welder qualification and elaborate on the essential content of materials procedures and certificates Asses a welded fabrication case interprets the specific quality requirements and compiles a quality control procedure. Be able to use quality control procedures and instructions in welding fabrication. Be able to use standards (e.g. ISO 9000 and ISO 3834) to guarantee the quality of the welded fabrication. 					
CU-3	Title: Welding in Practice					
CU-3	Content/Subject	Type	Learning Materials distributed through LMS	Work-Based on training for the student	Deliverables from students	Hours
	<p>General. Through this CU, the students will learn about quality aspects of welding related to jigs and fixtures and residual stresses. Further, the CU includes measurement and control techniques.</p> <p>General Learning outcomes:</p> <ul style="list-style-type: none"> Know and explain the requirements related to joint fit-up and tack welding. 	e-learning	<p>Course introduction, course description Guides for Zoom and Canvas (LMS) Lecture slides and pre-recorded video lectures</p>	<p>Discuss and report on the following topics: -Measurement and control techniques in welding; which parameters to control -How to minimize deformation and economic aspects of fixtures</p>		<p>3 hours zoom seminar + 1.5 hours of pre-recorded lectures</p>

<ul style="list-style-type: none"> • Recognise the principles for improved productivity, economic benefits, safety and comfort of using jigs and fixtures • Identify the advantages of using fixtures, jigs and positioners. • Identify the unique requirements for joint fit-up and tack welding • List the most common type of fixture, jig and positioner used in a specific welded construction. • Identify the type of auxiliary equipment and cables, heat treatment, and temperature control equipment to be used in a welded fabrication. • To be able to identify the need for measurements of various process parameters during welding • Know types of devices to measure the welding parameters • To be able to record and interpret the welding parameters • Know the techniques to measure real-time temperature during welding • Understand how to control the welding process by a suitable measurement and recording system • Understand the formation of residual stresses and distortion after welding • Be able to explain different types of distortion and residual stresses in welds. • Understand and describe different methods to prevent and minimise distortion and residual stresses in welds. • Know the factors that cause welding distortion and residual stress <p>Specific Learning Outcomes.</p> <ul style="list-style-type: none"> • Choose the proper type of fixture, jig or positioner for a particular welded fabrication. • Appraise a given welded fabrication case study with limited autonomy by selecting the fixtures, jig or positioner, auxiliary equipment and cables, heat treatment and temperature control according to productivity, safety and comfort. • Be able to measure current and voltage in arc welding 								
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	<ul style="list-style-type: none"> • Be able to know external sensors equipped with welding equipment • To be able to control heat input with the help of measurements and recording • To be able to apply different techniques to monitor the welding temperature during the process • Be able to analyse and develop the welding process based on recorded data • Be able to recommend the most suitable method to minimise distortion/residual stress • Be able to explain the reasons for residual stress/distortion formation. • Be able to understand the most critical factors that lead to the formation of distortion/residual stress • Be able to explain the most used determination methods for measuring distortion/residual stress 					
CU-4	Title: Quality Control after Welding					
CU-4	Content/Subject	Type	Learning Materials distributed through LMS	Work-Based on training for the student	Deliverables from students	Hours
	<p>General. Through this CU, the students will learn to inspect, assess and analyse the quality of welded components.</p> <p>General Learning outcomes:</p> <ul style="list-style-type: none"> • Be able to explain the standards applicable to welding tests and their specifications in the manufacture of welds. • Be able to explain the standards applicable to welding personnel. • Understand and describe the significant differences between quality assurance, quality control, and welding systems. • Know the factors that cause welding defects 	Zoom with teacher + e-learning	Course introduction, course description Guides for Zoom and Canvas (LMS) Lecture slides and pre-recorded video lectures	Discuss and report on the following topics: -Identifying welding defects and how to avoid their formation -What to consider for repair welding operations -Selecting suitable characterization methods and how to analyse the results		3 hours zoom meeting + 2 hours pre-recorded lectures

- Understand the criteria for the classification of welding defects; their possible cause, and how to avoid them
- Ability to recognise imperfect weld shapes and dimensions
- Understand the limitation requirements for B-welds
- Be able to identify problems in factory welding and propose solutions to avoid them.
- Be able to suggest techniques to repair welding defects.
- Know the standard of repair welding workflow.
- Understand how to interpret and use repair standard documents.
- Identify the damage due to corrosion during welding, its causes, effects, mechanism, and how to prevent it.
- Describe the basics of essential non-destructive testing techniques and their capacity/limitations in different applications.
- Describe the most common destructive material characterisation and testing techniques.
- Give reasons for choosing the method of analysis and testing and link it to its possibilities and limitations.

Specific Learning Outcomes.

- Be able to use the norms and standards applicable to welding tests
- Be able to explain the reasons for pore formation in welds.
- Understand the factors that lead to incomplete root penetration in the weld.
- Be able to avoid solidification cracks
- Be able to differentiate between underfill and backfill
- Be able to avoid hydrogen-induced cold cracking
- Understand the phenomenon of porosity in welds, types of porosity, allowable limits of

	<ul style="list-style-type: none"> porosity, and user standards. • Be able to repair welding defects on working structures • Be able to organise the workflow according to the existing standards and norms • Be able to interpret and exploit the documents of the weld repair standards • Be able to know the damage due to corrosion during welding, its causes, its effects, its mechanism, and how to prevent it • Be able to plan and carry out sample preparation for microstructure characterisation • Be able to select suitable preparation and etching procedures based on the material and analysis • Understand and analyse mechanical testing results such as tensile, bending, fatigue and hardness tests. 					
CU- 5	Title: Laboratory visit and examination					
CU- 5	Content/Subject	Type	Learning Materials distributed through LMS	Work-Based on training for the student	Deliverables from students	Hours
	<p>General. During this CU, the students will learn about health and safety precautions related to welding operations The students will visit the welding and material laboratory and discuss processes and applications with the teacher and a research engineer. The students will use a virtual welder (Soldamatic) The assignments are presented and discussed Course evaluation meeting with project administrator</p> <p>General Learning outcomes: Knowledge</p> <ul style="list-style-type: none"> • To be able to identify the potential risks related to welding safety, to prevent accidents and occupational diseases and their consequences • Know the dangers of different welding processes • Recognise the safety signs for welding • To be able to avoid risks related to arc radiation 	Physical meeting	Course introduction, course description Guides for Zoom and Canvas (LMS) Lecture slides and pre-recorded video lectures	Visit the welding and material laboratory – discussion of methods Carrying out welding trials on a virtual welding machine Presentation and discussion of assignments	Submission of written assignment. Presentation and discussion of assignment during course meeting	6 hours of physical meeting + 0.5 hours of pre-recorded lecture

	<ul style="list-style-type: none"> To be able to prevent the dangers due to respirable pollutants Know the techniques to prevent air pollution in welding To know the PPE Know the different types of welding methods Show knowledge of the application range of different welding methods <p>Specific Learning Outcomes.</p> <ul style="list-style-type: none"> Be able to identify the risks, accidents and occupational diseases related to welding Be able to interpret the safety signs for welding To be able to prevent risks associated with welding To be able to prevent hazards due to welding gas pollutants To be able to apply techniques to prevent air pollution in welding To be able to prevent the risks related to PPE Be able to prevent common ergonomic problems in welding Be able to identify and discuss different welding processes in practice Identify welding processes based on weld appearance Be able to reflect on quality in welding-related to the application in the students' work environment, alternatives generally based on the course modules Be able to present and discuss your concepts and methods related to quality assurance in welding with experts welding specialists 					
Hours	Zoom meetings	12 hours	Pre-recorded lectures/ e-learning	6 hours		
	Face to face	6 hours	Self-study length:	41 hours	Total estimated	65 hours

