

BET Project

D3.1 Welding Technology – Testing and Quality Assurance- Syllabus with Work-Based Learning

EQF 5-6

Version 1

This syllabus describes and provides an overview of the work-based learning cycles and breaks them down into five work-based instruction phases or domains:

Engage, Explore, Explain, Elaborate and Evaluate (FivE)

These FivE pedagogical model domains are key elements of a complete model for industry engaged delivery of work-based learning within Vocational Education and Training (VET) programs, to be provided to mechanical fabrication industry in Europe.

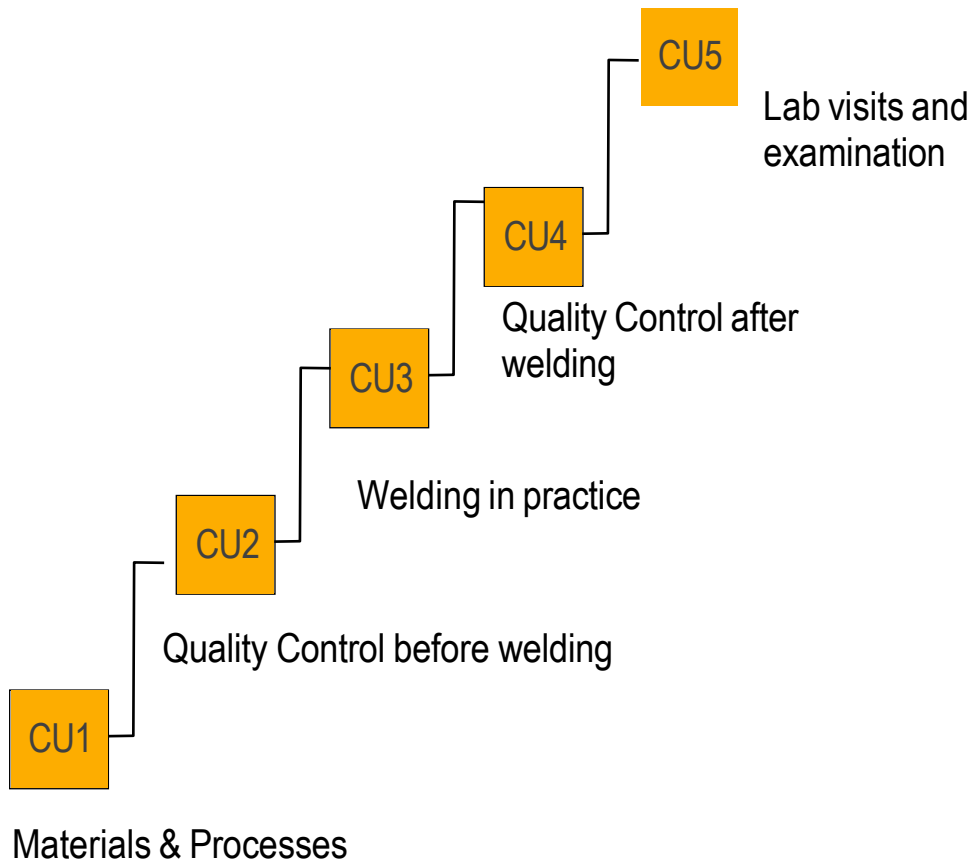
In some lessons, teachers and instructors will naturally apply and switch between several domains in response to industry fabrication companies and their staff's needs, as well as the learning program requirements. In other training activities, they will move through all five domains.

The proposed integration of repeated work-based learning cycles respects this kind of flexibility. They are not designed to become templates for linear or prescriptive lessons plans in a classroom. The new training model with subsequent learning activities, brings flexible training paths into VET by integrating work-based learning activities that are successfully merging theory with practice.

It creates a “High-FivE” line of sight between traditional classroom VET practices, and the new, flexible VET training paths delivered on a “pick and mix” basis.



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The course “Welding Technology: Testing and Quality Assurance for Welding” is structured in 5 Competence Units (CUs). Each CU focuses on the various stages in the Quality Assurance along the fabrication process.

The descriptions of this framework (front page) should be done at *course level* and at the *competence unit levels*. This innovative and flexible training solution methodology demonstrates how VET education applies standards to set up, establish and deliver blended learning solutions that better respond to industry demands. The CUs should be structured and delivered according to industry needs, whereby the CUs follows the fabrication industry requirements for specific methods, processes and materials.

- CU1 – Materials and processes
- CU2 – Quality control before welding
- CU3 – Welding in practice
- CU4 – Quality control after welding
- CU5 – Lab and examination

Welding Technology: Testing and Quality Assurance for Welding



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 after 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.

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

After completing the course, the student will get an advanced *knowledge and competence* of welding and inspection, and how to implement testing and quality assurance at practical levels.

This will enable the skilled worker to carry out:

- 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.



CU 1 – Materials and Processes

General Content

To learn how to use a Learning Management System (LMS), a videoconferencing tool and about the virtual laboratory environment. Integration of these tools into work-based learning. Welding metallurgy of aluminum, stainless steels, nickel-based superalloys and welding processes.

General Learning Outcomes

- Understand different types of welding processes.
- Explain the basic working principle of welding processes.
- Know the various kinds of joint configurations.
- Understand how heat transfers 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, aluminum 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.
- 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 Varestraint test.



CU 2 – Quality control before welding

General Content

In this CU, the students will learn about quality control during manufacturing – necessary standards and qualification procedures such as WPS and operator qualification.

General Learning Outcomes

- 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.
- 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.

Specific Learning Outcomes

- 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.
- Assess 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 – Welding in Practice

General Content

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.

General Learning Outcomes

- Know and explain the requirements related to joint fit-up and tack welding.
- Recognize 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 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.

Specific Learning Outcomes

- 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.
- 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 analyze and develop the welding process based on recorded data.
- Be able to recommend the most suitable method to minimize 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 – Quality Control after Welding

General Content

Through this CU, the students will learn to inspect, assess and analyze the quality of welded components.

General Learning Outcomes

- 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.
- Understand the criteria for the classification of welding defects; their possible cause, and how to avoid them.
- Ability to recognize 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 characterization 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 porosity, and user standards.
- Be able to repair welding defects on working structures.

- Be able to organize 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 characterization.
- Be able to select suitable preparation and etching procedures based on the material and analysis.
- Understand and analyze mechanical testing results such as tensile, bending, fatigue and hardness tests.



CU 5 – Laboratory visit and examination.

General Content

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. The assignments are presented and discussed.

Course evaluation meeting with project administrator.

General Learning Outcomes

- 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.
- Recognize the safety signs for welding.
- To be able to avoid risks related to arc radiation.
- To be able to prevent the dangers due to respirable pollutants.
- Know 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

Specific Learning Outcomes

- 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.