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IO5. Piloting

Course: Welding Technology- Testing and Quality Assurance in Welding

Erasmus +
Better Effect of Training (BET)

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Course PM of the course: Welding technology - Testing and quality assurance in welding (Svetsteknologi Provning och kvalitetssäkring vid svetsning), targeted and offered to professionals in the manufacturing industry.

Circulation: Available to students registered the course via LMS

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Version: 1.0
Stage: Final

Course title: Welding Technology - Testing and Quality Assurance for Welding

(SPK600, 2,5 HE Credits)

Course Information (Course PM)

This course PM applies to a course instance: VT22, period 2. The purpose of the course PM is to provide such information as you as a student need to be able to plan your studies. The information in the course syllabus always takes precedence over the course PM.
See the current course syllabus for course objectives, content, and entry requirements. For literature, see the course literature. Both documents are available on Canvas under the module Course Information. The current schedule is available at schema.hv.se (Kronox), search for the course code.

Faculty contact information

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Course structure and pedagogical approach

The course provides an overview of testing and quality assurance for welding and knowledge of fundamental theoretical concepts in materials science and welding processes. We analyse how different welding processes, work routines, and choices of materials can affect the quality of welded products. This is combined with discussions on materials characterisation and testing methods. We reflect on how these methods for inspection and quality control of welded products can be applied in practice.

This course is run mainly via distance. We will meet online for four-course meetings, for which we use Zoom. One course meeting will be held physically at the Production Technology Centre (PTC). In the first session on Friday 18. March 13-16, we will introduce you to the course and provide some practical information on, for example, the learning platform Canvas.
At the end of the course, we will meet at the Production Technology Centre (PTC) (**Nohabhgatan 18, Byggnad 73, Trollhättan**). You will present your reflection assignment and visit University West's welding and materials laboratory.
The course relies partly on pre-recorded lecture material made available on Canvas at the start of the respective course week. During our course meetings, we will discuss and apply the theoretical knowledge you get from the lectures through active group discussions. We will also reflect on how the week's learning content relates to welding quality assurance.
It is therefore essential that you prepare yourself in advance of every course meeting with the material provided on Canvas

The course schedule is listed below:

Week 11	Seminar 1: Materials och Processes	22-03-18 13-16	Zoom
Week 12	Seminar 2: Quality control before welding	22-03-25 13-16	Zoom
Week 13	Seminar 3: Welding in practice	22-04-01 13-16	Zoom
Week 14	Seminar 4: Quality control after welding	22-04-08 13-16	Zoom
Week 15	Easter week		
Week 16	Seminar 5: Presentations and lab visit	22-04-22 09-16	PTC

Examination and re-examination

The examination is divided into a written and an oral part.

Written assignment:
You need to write a reflection of max. 1 page A4 where you reason about how the different aspects that are covered in the course affect quality assurance in welding. This can be coupled with examples from your own company. Otherwise, you can base the reflection on establishing a quality assurance system in welding production. The course structure, which is divided into different parts of a complete welding operation, can be used as a guide:

- Materials and welding processes
- Quality control before welding
- Welding in practice
- Quality control after welding

The written assignment needs to be submitted after your presentation.
Oral examination:
At the last course meeting on 22.04., you need to present your written assignment as a PowerPoint presentation. You should present your thoughts and reasoning to your classmates and teachers. All participants are expected to participate in the discussion actively.
Assessment of results:
The course uses the grading scheme Pass (G) or Fail (U)
Re-examination:
If your assignment does not meet the requirements for a passing grade or if you are unable to participate in the ordinary examination for the presentation, you have the possibility to take a re-examination. The time and date are decided together with the Examiner.

Technical prerequisites and equipment

At University West, there are several computer rooms with software that courses require, course-specific software, e.g. Matlab, as well as general as, e.g. MS Office. It is possible to download software (such as MS Office) to a private computer as a student, see hv.se. If you as a student choose another solution, e.g. mobile, Ipad or similar, it is you as a student who is responsible for ensuring that the necessary functionality is ensured. Examples of standard submission formats are DOCX, PPTX, XLSX and PDF.
We use Zoom for our digital course meetings. This requires a stable internet connection, web-cam and headset to work correctly.

Course evaluation

The formal process that the university uses to ensure that students' views, linked to course evaluations, are taken advantage of and contribute to course development assumes that students answer the course evaluation. Student representatives are part of the program council, department committee and research and education committee. Student engagement is essential. Contact the student union if you want to be a student representative.
It is important as a student to do a course evaluation. The students' course evaluation answers are compiled and commented on by the examiner and course coordinator in a course evaluation response that is published on the course's Canvas page. The course evaluation response is also communicated and discussed in the program council. The Program Council compiles an annual program report based on all course evaluation responses. This program report is presented and discussed in the department committee. The department committee compiles all program reports in a department-wide quality report that is discussed in the research and education committee and is communicated to the department management and reported back to the program councils. The Research and Education Board compiles the quality reports of all departments in a university-wide quality report which is communicated to the university's top management and is reported back to all department boards.

Information on misleading examination (cheating)

Misleading examination, so-called cheating, can lead to a written warning or suspension from studies with the support of the Higher Education Ordinance (1993: 100). Therefore, you must be aware of what is not allowed.

Cheating is about trying to make an examination performance appear more prominent, better or in some other way of higher quality than would otherwise have been the case. This can, for example, be about plagiarism, using unauthorised aids, illicit cooperation, etc. See more information at https://www.hv.se/en/student/studies/examination/plagiarism-is-cheating/
You must clearly state the source if you use text that someone else has written (from literature, other student work, the internet, etc.). The same goes for direct translations. Quotes must be marked with quotation marks. The Examiner must be able to see what is your text and what is written by others. If a source reference or quotation mark is missing, it may be counted as plagiarism, which may lead to you being suspended from your studies.

If you reuse a text that you have previously been examined for, it may be considered self-plagiarism. Therefore, clearly state whether you have already used your text in another examination.

To detect plagiarism, Högskolan Väst uses "Ouriginal", a software for plagiarism control. Ouriginal's source material is extensive and consists of published and unpublished texts, such as previous student work.

Teachers who suspect misleading examination must report this to the Vice-Chancellor, who decides if it should be referred to the Disciplinary Board at University West. https://www.hv.se/en/meet-university-west/organisation/boards-councils-and-committees/disciplinary-board/

Support for students with disabilities

Contact the coordinators for pedagogical support at HV before the start of the course if you, as a student, require any support. https://www.hv.se/en/student/support-and-service/students-with-disabilities/
To receive support, you must have a certificate stating that your disability is permanent or long-term, and you as a student need to apply to receive support.

Specific conditions

The course requires that the student access a workshop where products are manufactured. The products in the workshop will be used during the practical training sessions in this course.

Student's background

Students enrolling on this course ought to have the following background:

- 2 years' work experience in the manufacturing industry where welding is an important joining process or from inspection.
- Technical background with preferably a diploma or certificate from EWF, Level EWT/EWP or higher

Expected workload for the students

The expected total workload for the course is 65 hours, where 18 hours are allocated for seminars, six hours for pre-recorded lecture material and and estimated own student workload for self-study and course assignments as approximately 41 hours in addition.

Welding Technology - Testing and Quality Assurance for Welding

From the course plan:

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.

Course content

- 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 Outcome for the course

This course is designed to provide students with an understanding of

- Materials and processes of welding technologies.
- Concepts for quality control before, during and after welding.
- Welding practices.
  - Laboratory visits and examinations.

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.
- Asses 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 Weld
- 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**
	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. **General Learning outcomes:** • Understand different types of welding processes. • 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	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

	• Show knowledge of weldability testing methods such as the hot ductility test and varestraint 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. • 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	**Title: Quality Control before Welding**					
CU-2	**Content/Subject**	**Type**	**Learning Materials**	**Work-Based on training**	**Deliverables from**	**Hours**

			distributed through LMS	**for the student**	**students**	
	General. 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.	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

	• 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**
	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. **General Learning outcomes:** • Know and explain the requirements related to joint fit-up and tack welding. • 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	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: -Measurement and control techniques in welding; which parameters to control -How to minimize deformation and economic aspects of fixtures		3 hours zoom seminar + 1.5 hours of pre-recorded lectures

	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 **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 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**
	General. Through this CU, the students will learn to inspect, assess and analyse 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 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.	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 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 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**
	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 **General Learning outcomes: Knowledge** • 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 • 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 **Specific Learning Outcomes.** • Be able to identify the risks, accidents and occupational diseases related to welding	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

	• 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 length:**	**65 hours**

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