Transition to a green welding industry

Curriculum

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1. Version History

Revision	Date	Author/Organisation	Description
1st	30/06/2024	MSZC	Draft version
2nd	27/09/2024	ISIM	Based on the outcome of Genova international campus
3rd	11/11/2024	MSZC	with observations
4th	15/01/2025	MSZC	Final version

Content

2. List of Tables

3. List of Abbreviations

CU: Competence Unit

EACEA: European Education and Culture Executive Agency

EWF: European Federation for Welding, Joining and Cutting

FSW: Friction Stir Welding

GMAW: Gas Metal Arc Welding

GTAW: Gas Tungsten Arc Welding

LBW: Laser Beam Welding

LMS: Learning Management System

NDT: non-destructive testing

PPE: Personal Protection Equipment

RSW: Resistance Spot Welding

USW: Ultrasonic Welding

VET: Vocational Education and Training

4. Executive Summary

The curriculum and the guidelines focus on technical skill and key competence required for transition to green welding sector. The topics of the course are as follows:

(i) Introduction to green welding technologies;

(ii) Green developments in preparation of the materials to be welded;

(iii) Green developments in thermal treatments related to welding;

(iv) Advancements in post weld treating of welded joints;

(v) Green developments in welding processes;

(vi) Green developments in Welding Power Sources;

(vii) Welding safety measures contribution towards green industry.

The curriculum is structured around a modular approach, with the use of e-learning tools to ensure efficiency. The course topics are divided into 8 subjects, each covering a specific topic and having a specific learning objective. The applied teaching methods are as follows: (i) A video lecture that presents the main concepts and theories related to the topic; (ii) Readings that offer additional information and examples on the topic; (iii) A quiz to test learners' understanding and retention of the topic; (iv) A discussion to encourage learners' interaction and reflection on the topic.

There will be a written exam at the end of the training. Participants in the training program are eligible to take the examination if they can demonstrate attendance of at least 80% of the lessons. Participants that have more than 60% correct answers will be granted the „COVE-WENDT Green Welding Industry Diploma". If the result is between 50% and 60% percent the participant need to pass an oral examination.

5. Minimum Requirement for the Education, Training, Examination, and Qualification Personnel

5.1 Course Description

This course aims to provide learners with the knowledge and skills to understand an apply green welding technologies including the preparation operations before welding and post weld treating, green welding processes and safety measures. The course covers the following topics:

- Introduction to green welding technologies
- Green developments in preparation of the materials to be welded
- Green developments in thermal treatments related to welding
- Advancements in post weld treating of welded joints
- Green developments in welding processes
- Green developments in Welding Power Sources
- Welding safety measures contribution towards green industry

Trainees who successfully pass the examinations are expected to be able to apply the achieved learning outcomes at a level in line with the level of the qualification diploma.

The contents of the modular course are presented in Table 1 according to the following structure (overview).

Table 1. Overview of competence units

COMPETENCE UNITS	Inputs	
	Contact Hours*	Workload Hours**
CU1: Introduction to green welding technologies	2	4
CU2: Preparations and post weld treating operations	6	12
CU3: Welding processes and power sources	10	20
CU4: Welding safety measures contribution towards green industry	2	4
TOTAL	20	40

* Contact Hours are the minimum recommended teaching hours for the Standard Routes.

A contact hour shall contain at least 50 minutes of direct teaching time.

** Workload is calculated in hours, corresponds to an estimation of the time trainees typically need to complete all learning activities required to achieve the defined learning outcomes in formal learning environments plus the necessary time for individual study.

Within EWF´s qualifications, there are two types of Competence Units:

Cross-cutting Competence Unit - A competence unit whose learning outcomes are not directly linked with one job function since the knowledge and skills achieved will be mobilized in several job functions and activities.

Functional Competence Unit - A competence unit whose learning outcomes are directly linked with at least one job function and in which the knowledge and skills achieved will be mobilized in specific job functions and related activities.

The expected learning outcomes are described in two ways: generic outcome descriptors organized in knowledge, skills, autonomy and responsibility; and in detail for each competence unit, organized in job functions and related activities, knowledge and skills corresponding to a specific proficiency level within EWF´s Systems Framework levels (see Appendix I).

On each Competence Unit, objectives and scope are defined for a specific depth of knowledge and skills.

Recommended contact hours are distributed between theoretical (A), assigned projects/exercises (B), practical workshop training(C), as showed in the following example (Table 2).

Table 2. Qualification: Example 1

Qualification: **Example 1**	
CONTACT HOURS	**X= (SUM A:C)**
Subject Contents	A + B + C

5.2 Competency-based learning

The modular approach is a growing trend in educational philosophy that shifts from traditional instruction to an outcome-based learning model. This approach divides the curriculum into small, distinct, and independent units or modules that are typically brief and non-sequential. By adopting a modular approach, learners gain more control over their learning process and take on greater responsibility. This method emphasizes the importance of learner autonomy, making it particularly suitable for more mature trainees. In a modular system, all necessary competencies for performance are closely connected, and tasks are organized into cohesive sets.

Moreover, the core principle of modularization is placing learners at the centre of the teaching-learning process. This approach requires a classroom environment where trainees actively participate in constructing knowledge. It also transforms the teacher's role from a transmitter of knowledge to a facilitator of learning. Additionally, modularization demands continuous monitoring and assessment of trainees' progress throughout each module. Effective continuous assessment enables instructors to adjust their teaching methods based on assessment results. This process also provides trainees with feedback on their learning and guidance on how to improve further.

The modular approach must emphasize:

- Designing assessment tasks as integral parts of the learning process.
- Providing feedback that supports trainees throughout their learning journey rather than only after task completion (i.e., when they receive a grade).

- Encouraging trainees to take an active role in organizing and monitoring their own learning.

Assessment involves collecting evidence and making judgments to determine whether competency has been achieved. This process confirms that an individual can perform to the standards required in the workplace, as specified in a training package or a vocational education and training (VET) accredited course.

The modular approach allows to perform separately the assessment for each CU. Knowledge assessment will use digital assessment formats appropriate to each module, such as multiple-choice questions to assess factual knowledge. In addition, a reliable learning management system (LMS) or specialised examination software will be implemented to enable secure examination delivery, question randomisation and time management.

See more details in Section II: Examination and Qualification

5.3 E-learning tools

E-learning tools have transformed the education and training landscape, offering several key advantages related to accessibility and interaction:

- Accessibility and flexibility: e-learning tools provide staff with unprecedented convenience, allowing access to training materials anytime, anywhere. This flexibility is especially beneficial for staff with different locations or irregular schedules, as it allows them to learn at their own pace, whether in the factory, in the field or at home.
- Real-time progress tracking: Many e-learning tools include progress tracking features, allowing employers to monitor employee progress in real time. This facilitates a data-driven approach to employee development, allowing areas requiring additional support to be identified and addressed.
- Multimedia resources: e-learning platforms offer versatility by incorporating a variety of multimedia resources such as videos, interactive simulations and 3D models. These tools enhance the learning experience,

allowing staff to better understand complex adhesive bonding processes through visual and interactive means.

5.4 Professional profile

This course is designed for teachers, VET trainers, and specialist who want to learn more about the green welding technologies and how to integrate them in their work.

5.5 General access conditions

The access conditions are the following:

- EQF level 3 in technical areas is required
- The participants should be able to effectively follow lessons, complete quizzes, and undertake examinations.

5.6 Duration of the training program

The course duration is **3 days**, with an estimated workload of **40 hours**.

5.7 Structure of the course

The course is divided into **8 subjects** (Section 6.2, 1.1 – 4.1), each covering a specific topic and having a specific learning objective. Each session consists of the following elements:

- A title, a description, a learning objective, a duration, a list of required resources, and a method of assessment.
- A video lecture, presenting the main concepts and theories related to the topic.
- A reading, providing additional information and examples on the topic.
- A quiz, testing the learners' understanding and retention of the topic.
- A discussion, facilitating the learners' interaction and reflection on the topic.

6. Section I: Theoretical and Practical Education

6.1. Qualification Outcome Descriptors

Table 3. Competences

QUALIFICATION	EWF LEVEL	KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY
Transition to a green welding industry	**SPECIALISED**	Understand and apply the principles and practices of green welding technologies transition to a green economy. Knowledge about how to minimize environmental footprint of preparation and post welding operations. Competence in how to develop a green welding technology for a given product.	Define and explain the concept and the benefits of green welding technologies. Identify and compare the main features of welding technologies in terms of material saving and energy efficiency. Apply preparation of post welding operations to increase the lifetime of welded product and therefore reduce the environmental footprint during the product life cycle. Use various welding technologies to improve the energy efficiency, productivity, and quality. Apply welding safety measures contribution towards green industry	Adapt learning contents where practical skills and theoretical applications can be taught by implementing Transition to a green welding industry Course

6.2. Detailed topics for the main training subjects and their subdivision into individual competence units and subjects

Table 4. CU1: Introduction to green welding technologies

CU1: Introduction to green welding technologies SUBJECT TITLE	CONTACT HOURS
1.1. Introduction to green welding technologies Introduction to green welding technologies (with energy efficiency and no harmful emissions) • Use of eco-friendly materials • Life-cycle assessments • Generation of fumes in welding • Energy consumption • Impact of shielding gases and waste reduction in welding • Sustainable practices and future possibilities	1.5
1.2. Scope, terms and specific definitions in the field • Scope of implementing green welding and NDT technologies • Terms and definitions • Global trends in the green transition	0.5
Total	2
WORKLOAD	**4**

Table 5. Knowledge and skills related to CU1

Subject	Knowledge	Skills
1.1. Introduction to green welding technologies	Have the general knowledge on available green developments in the field of welding and NDT technologies.	Gain knowledge on sustainability practices and future scenario to implementing green technologies in industries. Have the skill to select the correct technology for a specific application according to green indicators.
1.2. Scope, terms and specific definitions in the field	Understand basically the terminology in green welding sector.	Can use correctly these term and terminology.

Teaching methods:

- A video lecture that presents the main concepts and theories related to the topic.
- Readings that offer additional information and examples on the topic.
- A quiz to test learners' understanding and retention of the topic.
- A discussion to encourage learners' interaction and reflection on the topic.

Table 6. CU2: Preparations and post weld treating operations

CU2: Preparations and post weld treating operations	**CONTACT HOURS**
SUBJECT TITLE	
2.1. Green developments in preparation of the materials to be welded	2
2.2. Green developments in thermal treatments related to welding	2
2.3. Green developments in post weld treating of welded joints	2
Total	6
WORKLOAD	**12**

Table 7. Knowledge and skills related to CU2

Subject	Knowledge	Skills
2.1. Green developments in preparation of the materials to be welded	Know advanced and green material processing technologies for the welding joint preparation.	Can apply advanced and green material processing technologies for the joint preparation.
2.2. Green developments in thermal treatments related to welding	Know advanced and green thermal treatment technologies.	Can apply advanced and green thermal treatment technologies for achieving proper mechanical and microstructural characteristics.
2.3. Green developments in post weld treating of welded joints	Have knowledge on material requirements, instruments and systems for post-welded treatment technologies.	Can apply advanced and green post-weld thermal treatment technologies for the enhancement of the mechanical properties, preservation of the geometry of the components and reduction of residual stress.

Teaching methods:

- A video lecture that presents the main concepts and theories related to the topic.
- Readings that offer additional information and examples on the topic.
- A quiz to test learners' understanding and retention of the topic.
- A discussion to encourage learners' interaction and reflection on the topic.

Table 8 CU3: Welding processes and power sources

CU3: Welding processes and power sources **SUBJECT TITLE**	**CONTACT HOURS**
3.1. Green developments in welding processes	9
3.1.1. Green developments in Gas Metal Arc Welding (GMAW) • Theoretical knowledge (principle, fields of application, wire electrodes, shielding gases) • Arc and it's parameters • Tools, their task (parts of the equipment, power supply, characteristic of power supplies, welding guns and torches, gas supply systems) • Technology (control and regulation system of power sources, the effect of current type and polarity, impulse arc welding) • The effect of modern process variants (impulse techniques, deep integration programs) on productivity, from a green point of view • Environmental protection o emission reduction (use of gas mixtures, exhaust gases and other pollutants) o reduction of used energy (preheating and post-welding heat treatments, power source efficiency, setting, use of greener technologies where possible) • Case studies	2
3.1.2. Green developments in Friction Stir Welding (FSW) • Types of tools used • Materials, welding parameters used and metallurgical aspects • Weldability and imperfections • Green developments related to the process • Industrial applications of the process	1

CU3: Welding processes and power sources SUBJECT TITLE	CONTACT HOURS
3.1.3. Green developments in Gas Tungsten Arc Welding (GTAW) • Principle of GTAW welding (typical areas of application, advantages, limitations and disadvantages of the procedure) • The main parts of GTAW equipment (power sources, characteristic of power sources, design of the welding gun, main parameters, gas lens nozzles, shielding gas supply systems) • Welding materials (properties of shielding gases, Properties and health risks of tungsten electrodes, filler materials of GTAW) • Execution of welding (the technique of manual welding, control system of power sources, effect of current type and polarity, pulsed arc welding • Mechanization and automation options in the aspect of greening (solutions for increasing productivity and performance, energy (efficiency) developments, shielding gas (mixture) optimization), new process variants (gas lens, TIP TIG, orbital welding, SPOT TIG, etc., possibilities of mechanization-automation-robotization, health risk reduction, education, training greening, simulation) • Green comparison of TIG with MIG/MAG welding based on case studies	2
3.1.4. Green developments in Ultrasound Welding (USW) • Basic principle of USW • Recent development in USW • Contribution of USW to the Green Industry • Challenges and Opportunities for USW in the context of Green Industry	1

CU3: Welding processes and power sources SUBJECT TITLE	CONTACT HOURS
3.1.5. Green developments in Laser Beam Welding (LBW) • Green development concept in the laser • Introduction to LBW • Wavelength • Importance of laser welding over conventional welding technique • Types of Lasers • Laser welding parameters • Mechanism of Laser beam welding • Weld discontinuities • Advantages and disadvantages • Applications • Future trends in Green LBW • Case Studies • Health and Safety	1
3.1.6. Green developments in Hybrid Welding Process (GMAW/LBW and GTAW/LBW) • Introduction to laser-arc hybrid welding processes (LW, arc welding, configuration of the LAHW, both processes benefits) • Types of laser-arc hybrid welding processes • Dynamic Behaviour • Effect of shielding gas on LAHW • Weldability of materials • Comparison with conventional welding • green benefits of LAHW • Future directions in green development	1
3.1.7. Green developments in Resistance Spot Welding (RSW) • Characteristics of resistance spot welding • Applications • Key components • Advantages and Limitations • Green aspects	1
3.2. Green developments in welding power sources • Introduction • Basic principle of welding power sources • Types of welding power sources • Recent developments in welding power sources • Welding power sources and their role in industry • Challenges and opportunities for welding power sources	1

CU3: Welding processes and power sources	CONTACT HOURS
SUBJECT TITLE	
Total	10
WORKLOAD	**20**

Table 8. Knowledge and skills related to CU3

Subject	Knowledge	Skills
3.1. Green developments in welding processes	Have the theoretical knowledge on new green trends in welding technologies for environmental protection, reduction of carbon footprints.	Can select the appropriate green welding technology for the related and specific application.
3.2. Green developments in welding power sources	Have knowledge on the new trends in the welding power sources for green developments.	Can select the appropriate welding power sources for specific application.

Teaching methods:

- A video lecture that presents the main concepts and theories related to the topic.
- Readings that offer additional information and examples on the topic.
- A quiz to test learners' understanding and retention of the topic.
- A discussion to encourage learners' interaction and reflection on the topic.

Table 9. CU4: Welding safety measures contribution towards green industry

CU4: Welding safety measures contribution towards green industry	**CONTACT HOURS**
SUBJECT TITLE	
4.1. Welding safety measures contribution towards green industry • Introduction to prevention and protection of the welders and welding operators (fumes: chemical and physical risks) – Hygienic welding • Prevention and protection of the NDT operators • Fume extraction systems • Ergonomics aspects • Thermically stress • Use of eco-friendly consumables • Recycle and waste reductions	2
Total	2
WORKLOAD	**4**

Table 10. Knowledge and skills related to CU4

Subject	Knowledge	Skills
4.1. Welding safety measures contribution towards green industry	Knowledge on the chemical and physical agents related to welding and NDT activities. Knowledge on safety standards and procedures.	Can select and use of the correct personal protection equipment (PPE) to implement proper safety measurements.

Teaching methods:

- A video lecture that presents the main concepts and theories related to the topic.
- Readings that offer additional information and examples on the topic.
- A quiz to test learners' understanding and retention of the topic.
- A discussion to encourage learners' interaction and reflection on the topic.

7. Section II: Examination and Qualification

7.1. Examination Planning

- Examination objectives clearly align with the Transition to a green welding industry course's learning outcomes across CU1: Introduction to green welding technologies, CU2: Preparations and post weld treating operations, CU3: Welding processes and power sources, CU4: Welding safety measures contribution towards green industry.
- Use appropriate digital assessment formats for each module, such as multiple-choice questions for factual knowledge.
- Develop and compile a bank of questions and tasks that thoroughly test both theoretical understanding and practical application.
- Ensure the questions are diverse and inclusive, catering to different learning styles and digital proficiency levels.

7.2. Examination Scheduling

- Schedule online examinations that can be taken within a flexible window to accommodate different time zones and personal circumstances of remote learners.
- Define specific time limits for different sections of the exam based on their complexity and the expected time to complete them fairly.

7.3. Examination Administration

- Utilize a reliable Learning Management System (LMS) or specialized examination software that supports secure test-taking, question randomization, and time management.

- Implement virtual proctoring tools where necessary to maintain academic integrity. This may include webcam monitoring, screen sharing, and activity tracking.
- Provide detailed instructions about the examination process, rules, and technical requirements prior to the exam through the course portal and via email.

7.4. Examination Execution

- Ensure technical support is available throughout the examination period to assist with any software issues or connectivity problems.
- Establish a clear protocol for trainees to report and resolve issues during the examination, with contingency plans for extended time or rescheduling if technical problems occur.

7.5. Examination Processes

- Automatically collect and secure digital submissions within the LMS or examination platform. Ensure data is backed up and protected against unauthorized access.
- Use automated tools for objective questions and detailed rubrics for subjective assessments to ensure consistency and fairness in grading.
- Provide opportunities for trainees to review their results and receive feedback through the digital platform.
- Schedule live feedback sessions if needed to discuss performance and clarify doubts.

7.6. Results Compilation and Distribution

- Analyse results to identify trends, areas for improvement, and achievements.
- Use analytics tools provided by the LMS to assess class performance comprehensively.
- Prepare and distribute digital certificates or credentials through the LMS, verifying successful course completion and mastery of specific skills.
- Feedback from trainees will be collected to help improve the course and the teaching process. A questionnaire will be developed and given to trainees at the end of the course to collect their opinions and impressions on the competences and knowledge acquired, as well as to identify possible areas for improvement. The approach adopted will be designed to assess the strengths and weaknesses of the course and allow for continuous improvement.

7.7. Examination and Evaluation

There will be written examination for the award of the applicable COVE-WENDT Green Welding Industry Diploma.

Participants in the training program are eligible to take the examination if they can demonstrate attendance of at least 80% of the lessons.

Participants that have more than 60% correct answers will be granted the COVE-WENDT Green Welding Industry Diploma. If the result is between 50% and 60% percent the participate need to pass an oral examination.

7.7.1 Written examination

For each Competence Unit, a writing examination consists in a list of multiple-choice questions. A minimum of 1 question per recommended teaching hour is required.

For each question:

- 1 good answer is expected among 4 proposed answers.
- 1 minute is allowed to the candidate to answer.

In order to pass a Competence Unit's examination, candidates shall achieve at least 60% of the maximum possible mark.

The final decision has to be given by the chairman of the Board of Examiners.

7.7.2 Re-examination

Failure in any individual module of the examination shall require re-examination only in the module failed.

Candidates who fail in any of the Competence Unit three times, must retake the classes and the full examination of the Competence Unit without approval.

8. Conclusion

The document prepared and evaluated by the COVE-WENDT consortium, summarizes all the essential elements of the training titled "Transition to a green welding industry". The training course duration is 3 days, with an estimated workload of 40 hours.

The curriculum and the guidelines focus on technical skill and key competence required for transition to green welding sector.

The curriculum is structured around a modular approach, with the use of e-learning tools to ensure efficiency. The course topics are divided into 8 subjects, each covering a specific topic and having a specific learning objective.

Participants who meet the conditions may pass a written exam at the end of the training. Those persons who pass the exam will be awarded a "COVE-WENDT Digital Welding Diploma".

9. Appendix I: EWF Systems Framework

FIELD OF ACTIVITIY		EQF LEVELS	EWF PROFICIENCY LEVEL	KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY
COORDINATORS/MANAGERS		7	EXPERT	Highly specialised and forefront knowledge including original thinking, research and critical assessment of theory, principles and applicability of metal additive manufacturing or welding related technologies.	Highly specialised problem- solving skills including critical and original evaluation, allowing to define or develop the best technical and economical solutions, when applying metal additive manufacturing or welding related technologies, in complex and unpredictable conditions	Manage and transform the metal additive manufacturing or welding and related technologies processes in a highly complex context. Fully responsible for the definition and revision of personnel's tasks.
		6	ADVANCED	Advanced knowledge and critical understanding of the theory, principles and applicability of metal additive manufacturing or welding and related technologies.	Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical and economical solutions, when applying metal additive manufacturing or welding and related technologies, in complex and unpredictable conditions	Manage the applications of metal additive manufacturing or welding and related technologies in a highly complex context. Act autonomously in decision making and definition in the definition of the metal additive manufacturing or welding and related personnel's tasks.
		5	SPECIALIZED	Specialised, factual and theoretical of theory, principles and applicability of metal additive manufacturing or welding and related technologies	Specialised range of cognitive and practical skills, allowing to develop solutions or choose the appropriate methods, when applying metal additive manufacturing or welding and related technologies, in common/regular problems.	Manage and supervise common or standard metal additive manufacturing or welding applications and related technologies, in an unpredictable context. Take responsibility in standard work and supervise the metal additive manufacturing or welding and related personnel's tasks.
	WELDERS & OPERATORS	4	INDEPENDENT	Factual and broad concepts in the field of metal additive manufacturing or welding technology	Fundamental cognitive and practical skills required to develop proper solutions and application of procedures and tools on simple and specific metal additive manufacturing or welding problems.	Self-manage of professional activities and simple standard applications of metal additive manufacturing or welding and related technologies in predictable contexts but subject to change. Supervise routine tasks and similar function workers, as well as take responsibility for decision making in basic work.
		3	BASIC	Basic facts, principles, processes and general concepts of welding, joining and related technologies	Be able to check and follow the information on the welding procedure specification, to produce butt and fillet welds in plates and or tubes, and or profiles in a variety of geometries and positions to the required quality and of specified dimensional accuracy	Work under supervision, taking personal responsibility for own actions and for the quality and accuracy of the work produced.
		2	ELEMENTARY	Elementary principles of welding, joining and related technologies	Able to check and follow the information on the welding procedure or adhesive bounding specification, and to produce weld/joints in a variety of geometries and positions to the required quality and of specified dimensional accuracy	Work under supervision.

10. Appendix II: The form of "COVE-WENDT Green Welding Industry Diploma”

cove wendt

GREEN WELDING DIPLOMA

European VET COVE network

THIS CERTIFICATE IS PROUDLY PRESENTED TO:

LOREUM IPSIUM

This certificate certifies that its holder completed the **Transition to a green welding industry** training and and fulfilled its requirements. This course aims to provide learners with the knowledge and skills to understand an apply green welding technologies including the preparation operations before welding and post weld treating, green welding processes and safety measures. The duration of the course was 20 contact hours. The course was developed within the Centre of Vocational Excellence in Welding and Non-Destructive Testing (COVE-WENDT) project.

Issue Date | Organization | Signature

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Curriculum

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2. List of Tables

3. List of Abbreviations

AI: Artificial Intelligence

CR: Computed radiography

CT: Computed Tomography

CU: Competence Unit

DRT: Digital Radiographic Testing

EACEA: European Education and Culture Executive Agency

EWF: European Federation for Welding, Joining and Cutting

IoT: Internet of Things

LMS: learning management system

MT: Magnetic Particle Test

NDT: non-destructive testing

PAUT: Phased Array Ultrasonic Testing

PT: Penetration Testing

RT: Radiographic Testing

TOFD: Time-of-Flight Diffraction

UT: Ultrasonic Testing

VET: vocational education and training

VT: Visual Testing

4. Executive Summary

The curriculum and the guideline focus on technical skill and key competence required for digitalisation of welding sector. The course aims to provide learners with the knowledge and skills to understand the digitalization opportunities in the field of welding and related materials testing in respond to the challenges of Industry 4.0/5.0. The topics of the course are as follows:
(i) Introduction to digital world;

(ii) Specific digital training tools to improve learning efficiency;

(iii) Digital training for welding industry;

(iv) Physical simulation, digital twins, artificial intelligence;

(v) Fabrication, measurement and control systems.

The curriculum is structured around a modular approach, with the use of e-learning tools to ensure efficiency. The course topics are divided into 8 subjects, each covering a specific topic and having a specific learning objective. The applied teaching methods are as follows: (i) A video lecture that presents the main concepts and theories related to the topic; (ii) Readings that offer additional information and examples on the topic; (iii) A quiz to test learners' understanding and retention of the topic; (iv) A discussion to encourage learners' interaction and reflection on the topic.

There will be a written exam at the end of the training. Participants in the training program are eligible to take the examination if they can demonstrate attendance of at least 80% of the lessons. Participants that have more than 60% correct answers will be granted the „COVE-WENDT Digital Welding Diploma". If the result is between 50% and 60% percent the participant need to pass an oral examination.

The course duration is 3 days, with an estimated workload of 40 hours.

5. Minimum Requirement for the Education, Training, Examination, and Qualification Personnel

5.1 Course Description

This course aims to provide learners with the knowledge and skills to understand the digitalization opportunities in the field of welding and related materials testing in respond to the challenges of Industry 4.0/5.0. The course covers the following topics:

- Introduction to digital world
- Specific digital training tools to improve learning efficiency
- Digital training for welding industry (welding technologies, related NDT technologies)
- Physical simulation, digital twins, artificial intelligence
- Fabrication, measurement and control systems (Industry 4.0/5.0)

Introduction Trainees who successfully pass the examinations are expected to be able to apply the achieved learning outcomes at a level in line with the level of the qualification diploma.
The contents of the modular course are presented in Table 1 according to the following structure (overview).

Table 1. Overview of competence units

COMPETENCE UNITS	Inputs	
	Contact Hours*	Workload Hours**
CU1: Introduction to digital world	6	12
CU2: Digital developments for welding technologies	4	8
CU3: Digital developments for welding related NDT technologies	8	16
CU4: Simulation and measurement	2	4
TOTAL	20	40

* Contact Hours are the minimum recommended teaching hours for the Standard Routes.

A contact hour shall contain at least 50 minutes of direct teaching time.

** Workload is calculated in hours, corresponds to an estimation of the time trainees typically need to complete all learning activities required to achieve the defined learning outcomes in formal learning environments plus the necessary time for individual study.

Within EWF´s qualifications, there are two types of Competence Units:

Cross-cutting Competence Unit - A competence unit whose learning outcomes are not directly linked with one job function since the knowledge and skills achieved will be mobilized in several job functions and activities.

Functional Competence Unit - A competence unit whose learning outcomes are directly linked with at least one job function and in which the knowledge and skills achieved will be mobilized in specific job functions and related activities.

The expected learning outcomes are described in two ways: generic outcome descriptors organized in knowledge, skills, autonomy and responsibility; and in detail for each competence unit, organized in job functions and related activities, knowledge and skills corresponding to a specific proficiency level within EWF´s Systems Framework levels (see Appendix I).

On each Competence Unit, objectives and scope are defined for a specific depth of knowledge and skills.

Recommended contact hours are distributed between theoretical (A), assigned projects/exercises (B), practical workshop training(C), as showed in the following example (Table 2).

Table 2. Qualification: Example 1

Qualification: **Example 1**	
CONTACT HOURS	**X= (SUM A:C)**
Subject Contents	A + B + C

5.2 Competency-based learning

The modular approach is a growing trend in educational philosophy that shifts from traditional instruction to an outcome-based learning model. This approach divides the curriculum into small, distinct, and independent units or modules that are typically brief and non-sequential. By adopting a modular approach, learners gain more control over their learning process and take on greater responsibility. This method emphasizes the importance of learner autonomy, making it particularly suitable for more mature trainees. In a modular system, all necessary competencies for performance are closely connected, and tasks are organized into cohesive sets.

Moreover, the core principle of modularization is placing learners at the centre of the teaching-learning process. This approach requires a classroom environment where trainees actively participate in constructing knowledge. It also transforms the teacher's role from a transmitter of knowledge to a facilitator of learning. Additionally, modularization demands continuous monitoring and assessment of trainees' progress throughout each module. Effective continuous assessment enables instructors to adjust their teaching methods based on assessment results. This process also provides trainees with feedback on their learning and guidance on how to improve further.

The modular approach must emphasize:

- Designing assessment tasks as integral parts of the learning process.
- Providing feedback that supports trainees throughout their learning journey rather than only after task completion (i.e., when they receive a grade).
- Encouraging trainees to take an active role in organizing and monitoring their own learning.

Assessment involves collecting evidence and making judgments to determine whether competency has been achieved. This process confirms that an individual can perform to the standards required in the workplace, as

specified in a training package or a vocational education and training (VET) accredited course.

The modular approach allows to perform separately the assessment for each CU. Knowledge assessment will use digital assessment formats appropriate to each module, such as multiple-choice questions to assess factual knowledge. In addition, a reliable learning management system (LMS) or specialised examination software will be implemented to enable secure examination delivery, question randomisation and time management.

See more details in Section II: Examination and Qualification

5.3 E-learning tools

E-learning tools have transformed the education and training landscape, offering several key advantages related to accessibility and interaction:

- Accessibility and flexibility: e-learning tools provide staff with unprecedented convenience, allowing access to training materials anytime, anywhere. This flexibility is especially beneficial for staff with different locations or irregular schedules, as it allows them to learn at their own pace, whether in the factory, in the field or at home.
- Real-time progress tracking: Many e-learning tools include progress tracking features, allowing employers to monitor employee progress in real time. This facilitates a data-driven approach to employee development, allowing areas requiring additional support to be identified and addressed.
- Multimedia resources: e-learning platforms offer versatility by incorporating a variety of multimedia resources such as videos, interactive simulations and 3D models. These tools enhance the learning experience, allowing staff to better understand complex adhesive bonding processes through visual and interactive means.

5.4 Professional profile

This course is designed for teachers, VET trainers, and specialist who want to learn more about the digitalization in welding and related non-destructive testing (NDT) and how to integrate them in their work.

5.5 General access conditions

The access conditions are the following:

- EQF level 3 in technical areas is required
- The participants should be able to effectively follow lessons, complete quizzes, and undertake examinations.

5.6 Duration of the training program

The course duration is **3 days**, with an estimated workload of **40 hours**.

5.7 Structure of the course

The course is divided into **8 subjects** (Section 6.2, 1.1 – 4.2), each covering a specific topic and having a specific learning objective. Each session consists of the following elements:

- A title, a description, a learning objective, a duration, a list of required resources, and a method of assessment.
- A video lecture, presenting the main concepts and theories related to the topic.
- A reading, providing additional information and examples on the topic.
- A quiz, testing the learners' understanding and retention of the topic.
- A discussion, facilitating the learners' interaction and reflection on the topic.

6. Section I: Theoretical and Practical Education

6.1. Qualification Outcome Descriptors

Table 3. Competences

QUALIFICATION	EWF LEVEL	KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY
Digital training for welding engineers, technicians, welders and operators	**SPECIALISED**	Understand and apply the principles and practices of digitalization in welding. Knowledge about the applicable digital tools in welding, NDT, and measurement and control. Competence about the scope, terms and specific definitions of digitalization.	Define and explain the concept and the benefits of digitalization in welding. Identify and compare the main features of NDT methods in the aspect of digital tools. Apply several digital tools in the welding technology and measurement. Use various digital training tools to improve learning efficiency.	Adapt learning contents where practical skills and theoretical applications can be taught by implementing Digital training for welding engineers, technicians, welders and operator's course.

6.2. Detailed topics for the main training subjects and their subdivision into individual competence units and subjects

Table 4. CU1: Introduction to digital world

CU1: Introduction to digital world **SUBJECT TITLE**	**CONTACT HOURS**
1.1. Introduction to digital world, artificial intelligence	1.5
1.2. Scope, terms and specific definitions in the field	0.5
1.3. Specific digital training tools to improve learning efficiency • E-learning platforms • Collaborative tools for communication and collaboration • Evaluation/assessment and feedback tools • Open Educational Resources (OER) • Content Creation tools • Gamification and interactive learning tools • Adaptive learning technologies • Cloud Storage and file sharing • Challenges and tendency in educational technologies	4
Total	6
WORKLOAD	**12**

Table 5. Knowledge and skills related to CU1

Subject	Knowledge	Skills
1.1. Introduction to digital world	General knowledge on available digital tools in the field of training.	Gain knowledge for developing of a digital course. Skill to find the correct tool for a specific application.
1.2. Scope, terms and specific definitions in the field	Basic understanding of the terminology in digital world.	Correct use of these term and terminology.
1.3. Specific digital training tools to improve learning efficiency	Knowledges and requirements on the proper use of digital tools for improving learning efficiency.	Using of digital tools and instruments for training activities.

Teaching methods:

- A video lecture that presents the main concepts and theories related to the topic.
- Readings that offer additional information and examples on the topic.
- A quiz to test learners' understanding and retention of the topic.
- A discussion to encourage learners' interaction and reflection on the topic.

Table 6. CU2: Digital developments for welding technologies

CU2: Digital developments for welding technologies	**CONTACT HOURS**
SUBJECT TITLE	
2.1. Digital developments for welding technologies • The role of AI in welding quality management • Digitalization in welding quality management • Blockchain in welding quality management • Data collection and processing • Cloud data storage • AI for process simulation and digital twins • AI-powered defect detection • AI in process optimization • AI in quality assurance and standards compliance • Cybersecurity in welding quality management • Introduction to digital welding technologies • Automation and robotics in welding • IoT and smart welding systems • Data analytics and cloud integration welding • Additive manufacturing and hybrid welding technologies • Virtual Reality (VR) and Augmented Reality (AR) in welding • Case studies	4
Total	4
WORKLOAD	**8**

Table 7. Knowledge and skills related to CU2

Subject	Knowledge	Skills
2.1. Digital developments for welding technologies	Knowledge on software for improving welding quality and efficiency. Informed about software for welding simulation and process optimisation. Knowing the tools for data collection, storage in safety condition.	With technical proficiency capable for using of tools for virtual training, simulations of material behaviour during the welding process. Capable for data analysis and consider cybersecurity. Having the capability for individual skill development in the field of digital welding technologies.

Teaching methods:

- A video lecture that presents the main concepts and theories related to the topic.
- Readings that offer additional information and examples on the topic.
- A quiz to test learners' understanding and retention of the topic.
- A discussion to encourage learners' interaction and reflection on the topic.

Table 8. CU3: Digital developments for NDT technologies

CU3: Digital developments for NDT technologies SUBJECT TITLE	CONTACT HOURS
3.1. Classical NDT methods: VT, PT, MT, UT, RT • Introduction to NDTs terms and definitions reference standards qualification and certification of personnel involved in NDTs • Visual testing: Principles of visual testing Testing techniques Instruments for direct visual testing Instruments for remote visual testing Main reference standards Opportunities for digital developments in visual testing • Penetrant testing: principles of penetrant testing testing techniques testing equipment main field of application main reference standards health and safety in penetrant testing opportunities for digital developments in penetrant testing • Magnetic particle testing: principles of magnetic particle testing testing techniques testing equipment main field of application main reference standards health and safety in magnetic particle testing opportunities for digital developments in penetrant testing • Ultrasonic testing: principles of ultrasonic testing testing techniques testing equipment main field of application main reference standards opportunities for digital developments in ultrasonic testing • Radiographic testing:	4

principles of radiographic testing testing techniques testing equipment main field of application main reference standards health and safety in radiographic testing opportunities for digital developments in radiographic testing	
3.2. Advanced NDT methods: PAUT, TOFD, DRT/CR, industrial CT • Phased Array Ultrasonic Testing (PAUT) The physical basis of PAUT Principle of the PAUT technology Comparison of UT and PAUT Phased array imaging scans: A, B, C, S, linear Advantages of PAUT compared to UT Phased array ultrasound as a replacement for radiography Opportunities for digital developments in the PAUT Case studies • Time-of-Flight Diffraction (TOFD) The physical basis of TOFD Principle of the TOFD technology Comparison of UT and TOFD Options for the implementation of the investigation (TOFD technics, TOFD equipment, Advantages of TOFD compared to UT) Opportunities for digital developments in the TOFD Case studies • Digital Radiographic Testing (DRT) and Computed radiography (CR) Trends in industrial radiography Variants of DRT and CR Characteristics of DRT compared to RT Characteristics of CR compared to RT Comparison of DRT and CR Opportunities for digital developments in the DRT and CR Case studies • Industrial Computed Tomography (industrial CT) Characteristics of the industrial CT Configurations of the industrial CT Characteristics of the detectors and the equipment Opportunities for digital developments in the industrial CT Weld inspections (in general)	4
Total	8
WORKLOAD	**16**

Table 9. Knowledge and skills related to CU3

Subject	Knowledge	Skills
3.1. Classical NDT methods: VT, PT, MT, UT, RT	Having general knowledge on existing NDT methods and new development for transition toward a green industry.	Capable to using proper NDT methods, equipment and consumables for detection of welding imperfection.
3.2. Advanced NDT methods: PAUT, TOFD, DRT/CR, industrial CT	Having the knowledge to understand advanced NDT methodologies.	Capable to use the proper NDT advanced methods, equipment and consumables for detection of welding imperfection.

Teaching methods:

- A video lecture that presents the main concepts and theories related to the topic.
- Readings that offer additional information and examples on the topic.
- A quiz to test learners' understanding and retention of the topic.
- A discussion to encourage learners' interaction and reflection on the topic.

Table 10. CU4: Simulation and measurement

CU4: Simulation and measurement SUBJECT TITLE	CONTACT HOURS
4.1. Physical simulation, digital twins • Definition of physical simulation • Introduction of physical simulators • Welding-related applications of physical simulation • Correlation between physical and numerical simulation • Case studies • Digital twins • Introduction to digital twin technology in welding • Digital twin in welding process optimisation • Monitoring the welded component throughout its life • Predictive maintenance based on digital twin data • Digital twin in welding repair and repurposing • Integration for predictive and adaptive monitoring • Advanced monitoring with embedded sensors	1
4.2. Fabrication, measurement and control systems (Industry 4.0/5.0) • Overview of Industry 4.0 and 5.0 in welding • Human centred approach in welding: Industry 5.0 principles • Real-time monitoring: automation and human interaction • Enhancing worker safety and ergonomics with cobots • Advanced welding automation in industry 4.0 • Human-machine symbiosis in industry • The future of human-machine collaboration in welding	1
Total	2
WORKLOAD	**4**

Table 11. Knowledge and skills related to CU4

Subject	Knowledge	Skills
4.1. Physical simulation	Knowledge about the welding-related application possibilities of physical simulators and numerical simulations. Knowledge on digital Twin in Welding Process Optimisation.	Can select the appropriate tools for various physical and numerical simulations.
4.2. Measurement and control (Industry 4.0/5.0)	Knowledge on standards, sensors actuators and controllers, data collecting systems. Being aware of human-machine collaboration in industry 5.0	Capability for the selection and proper use of the elements related to the measurement and control systems.

Teaching methods:

- A video lecture that presents the main concepts and theories related to the topic.
- Readings that offer additional information and examples on the topic.
- A quiz to test learners' understanding and retention of the topic.
- A discussion to encourage learners' interaction and reflection on the topic.

7. Section II: Examination and Qualification

7.1. Examination Planning

- Examination objectives clearly align with the Digital training for welding engineers, technicians, welders and operator's courses learning outcomes across CU1: Introduction to digital world, CU2: Digital developments for welding technologies, CU3: Digital developments for NDT technologies, CU4: Simulation and measurement.
- Use appropriate digital assessment formats for each module, such as multiple-choice questions for factual knowledge.
- Develop and compile a bank of questions and tasks that thoroughly test both theoretical understanding and practical application.
- Ensure the questions are diverse and inclusive, catering to different learning styles and digital proficiency levels.

7.2. Examination Scheduling

- Schedule online examinations that can be taken within a flexible window to accommodate different time zones and personal circumstances of remote learners.
- Define specific time limits for different sections of the exam based on their complexity and the expected time to complete them fairly.

7.3. Examination Administration

- Utilize a reliable LMS or specialized examination software that supports secure test-taking, question randomization, and time management.
- Implement virtual proctoring tools where necessary to maintain academic integrity. This may include webcam monitoring, screen sharing, and activity tracking.

- Provide detailed instructions about the examination process, rules, and technical requirements prior to the exam through the course portal and via email.

7.4. Examination Execution

- Ensure technical support is available throughout the examination period to assist with any software issues or connectivity problems.
- Establish a clear protocol for trainees to report and resolve issues during the examination, with contingency plans for extended time or rescheduling if technical problems occur.

7.5. Examination Processes

- Automatically collect and secure digital submissions within the LMS or examination platform. Ensure data is backed up and protected against unauthorized access.
- Use automated tools for objective questions and detailed rubrics for subjective assessments to ensure consistency and fairness in grading.
- Provide opportunities for trainees to review their results and receive feedback through the digital platform.
- Schedule live feedback sessions if needed to discuss performance and clarify doubts.

7.6. Results Compilation and Distribution

- Analyse results to identify trends, areas for improvement, and achievements.
- Use analytics tools provided by the LMS to assess class performance comprehensively.

- Prepare and distribute digital certificates or credentials through the LMS, verifying successful course completion and mastery of specific skills.
- Feedback from trainees will be collected to help improve the course and the teaching process. A questionnaire will be developed and given to trainees at the end of the course to collect their opinions and impressions on the competences and knowledge acquired, as well as to identify possible areas for improvement. The approach adopted will be designed to assess the strengths and weaknesses of the course and allow for continuous improvement.

7.7. Examination and Evaluation

There will be written examination for the award of the applicable COVE-WENDT Digital Welding Diploma.

Participants in the training program are eligible to take the examination if they can demonstrate attendance of at least 80% of the lessons.

Participants that have more than 60% correct answers will be granted the COVE-WENDT Digital Welding Diploma. If the result is between 50% and 60% percent the participant need to pass an oral examination.

7.7.1 Written examination

For each Competence Unit, a writing examination consists in a list of multiple-choice questions. A minimum of 1 question per recommended teaching hour is required.

For each question:

- 1 good answer is expected among 4 proposed answers.
- 1 minute is allowed to the candidate to answer.

For the approval of Competence Unit's examination, candidates shall achieve at least 60% of the maximum possible mark.

The final decision has to be given by the chairman of the Board of Examiners.

7.7.2 Re-examination

Failure in any individual module of the examination shall require re-examination only in the module without approval.

Candidates who fail in any of the Competence Unit three times, must retake the classes and the full examination of the Competence Unit failed.

8. Conclusion

The document prepared and evaluated by the COVE-WENDT consortium, summarises all the essential elements of the training titled "Digital training for welding engineers, technicians, welders and operators". The training course duration is 3 days, with an estimated workload of 40 hours.

The curriculum and the guidelines focus on technical skill and key competence required for transition to green welding sector. The course aims to provide learners with the knowledge and skills to understand the digitalization opportunities in the field of welding and related materials testing in respond to the challenges of Industry 4.0/5.0.

The curriculum is structured around a modular approach, with the use of e-learning tools to ensure efficiency. The course topics are divided into 8 subjects, each covering a specific topic and having a specific learning objective.

Participants who meet the conditions may pass a written exam at the end of the training. Those persons who pass the exam will be awarded a "COVE-WENDT Digital Welding Diploma".

9. Appendix I: EWF Systems Framework

FIELD OF ACTIVITIY		EQF LEVELS	EWF PROFICIENCY LEVEL	KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY
COORDINATORS/MANAGERS		7	EXPERT	Highly specialised and forefront knowledge including original thinking, research and critical assessment of theory, principles and applicability of metal additive manufacturing or welding related technologies.	Highly specialised problem- solving skills including critical and original evaluation, allowing to define or develop the best technical and economical solutions, when applying metal additive manufacturing or welding related technologies, in complex and unpredictable conditions	Manage and transform the metal additive manufacturing or welding and related technologies processes in a highly complex context. Fully responsible for the definition and revision of personnel's tasks.
		6	ADVANCED	Advanced knowledge and critical understanding of the theory, principles and applicability of metal additive manufacturing or welding and related technologies.	Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical and economical solutions, when applying metal additive manufacturing or welding and related technologies, in complex and unpredictable conditions	Manage the applications of metal additive manufacturing or welding and related technologies in a highly complex context. Act autonomously in decision making and definition in the definition of the metal additive manufacturing or welding and related personnel's tasks.
		5	SPECIALIZED	Specialised, factual and theoretical of theory, principles and applicability of metal additive manufacturing or welding and related technologies	Specialised range of cognitive and practical skills, allowing to develop solutions or choose the appropriate methods, when applying metal additive manufacturing or welding and related technologies, in common/regular problems.	Manage and supervise common or standard metal additive manufacturing or welding applications and related technologies, in an unpredictable context. Take responsibility in standard work and supervise the metal additive manufacturing or welding and related personnel's tasks.
	WELDERS & OPERATORS	4	INDEPENDENT	Factual and broad concepts in the field of metal additive manufacturing or welding technology	Fundamental cognitive and practical skills required to develop proper solutions and application of procedures and tools on simple and specific metal additive manufacturing or welding problems.	Self-manage of professional activities and simple standard applications of metal additive manufacturing or welding and related technologies in predictable contexts but subject to change. Supervise routine tasks and similar function workers, as well as take responsibility for decision making in basic work.
		3	BASIC	Basic facts, principles, processes and general concepts of welding, joining and related technologies	Be able to check and follow the information on the welding procedure specification, to produce butt and fillet welds in plates and or tubes, and or profiles in a variety of geometries and positions to the required quality and of specified dimensional accuracy	Work under supervision, taking personal responsibility for own actions and for the quality and accuracy of the work produced.
		2	ELEMENTARY	Elementary principles of welding, joining and related technologies	Able to check and follow the information on the welding procedure or adhesive bounding specification, and to produce weld/joints in a variety of geometries and positions to the required quality and of specified dimensional accuracy	Work under supervision.

10. Appendix II: The form of "COVE-WENDT Digital Welding Diploma”

DIGITALIZATION IN WELDING DIPLOMA

European VET COVE network

THIS CERTIFICATE IS PROUDLY PRESENTED TO:

LOREUM IPSIUM

This certificate certifies that its holder completed the **Digital training for welding engineers, technicians, welders and operators** training and and fulfilled its requirements. This course aimed to provide learners with the knowledge and skills to understand the digitalization opportunities in the field of welding and related materials testing in respond to the challenges of Industry 4.0/5.0. The duration of the course was 20 contact hours. The course was developed within the Centre of Vocational Excellence in Welding and Non-Destructive Testing (COVE-WENDT) project.

Issue Date | Organization | Signature

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