Harmonized Laser Technology Training across Europe

Guideline

EUROPEAN LASER WELDING OFFICER

EUROPEAN LASER WELDING OFFICER

MINIMUM REQUIREMENTS FOR THE EDUCATION, TRAINING, EXAMINATION AND QUALIFICATION OF PERSONNEL IN LASER WELDING

It is designed to provide the basic core education in LASER technology required for persons interested in working on industrial sector performing job tasks focused on laser applications.

For basic level no access conditions apply, but experience in welding or allied activities for at least one year is recommended. A European Laser Welding Officer is able to read and understand working instructions and is well informed about production methods concerning laser welded products.

This guideline was prepared by the consortium of LaserTech Project and is based on EWF's Guidelines. It covers the minimum requirements for theoretical education and training in terms of themes, keywords and times devoted to them. For the practical training it indicates the range of hours considered necessary to achieve the qualification.

Students having successfully completed this course of education will be expected being capable of applying Laser welding technology as covered by this guideline.

A "teaching hour" shall contain at least 50 minutes of direct teaching and choice in the arrangement of the syllabus is permitted. The depth to which each topic is dealt with is indicated by the number of hours allocated to it in the guideline

Overview of the structure of the training course

European Laser Welding	
Modules	Hours
1: Basics of laser technology	8
2: Fundamentals of laser-matter interaction and materials behaviour	6
3: Technological aspects of the principal types of Laser Welding	8
4. Introduction to the Design of laser welded joints	6
5: Technological assessment of Laser Welding in industry	6
6: Quality assurance and safety in laser processing	6
TOTAL	**40**

The course consists of theoretical training and practical training. Applicants must pass theoretical and practical exam.

The theoretical education given to the students aims at a basic understanding of the appropriate welding process and the materials behaviour including standards and safety regulations. The themes and keywords are given as 'scope' in the module descriptions, together with the 'Objective' and the

'Learning Outcomes'.

The practical training advised in this Guideline is from 16 hours to 32 hours, depending on the trainee's curriculum. It will bring the students to the comprehensive skill, required for practical work in industry. It may be carried out in the Training Centres facilities or, depending on the resources available, in other places such as customer facilities, industrial companies or equipments manufacturers or suppliers. A close cooperation with local/national industry makes easier to accomplish with this part.

Access to the course

Applicants shall have a level of health, and physical and mental capability, to undergo the training for which they are applying.

For entry to the European Laser Welding Course a minimum age of 16 is necessary. Basic skills in material processing are required otherwise a basic training is recommended. Course attendees and teachers shall have a good command of a common language; so that they can successfully participate in instruction and take part in theoretical tests.

COURSE CONTENT OVERVIEW: THEORETICAL AND PRACTICAL EDUCATION WITH HOURS

THEORETICAL EDUCATION	***Hours***
Module 1: BASICS OF LASER TECHNOLOGY	**8**
M 1.1 Presentation of the program and introduction to laser techniques	1
M 1.2 Principles of laser emission, key parameters and laser types	3
M 1.3 Laser beam propagation and guiding	2
M 1.4 Laser systems, equipment and procedures	2
Module 2: FUNDAMENTALS OF LASER-MATTER INTERACTION AND MATERIALS BEHAVIOUR	**6**
M 2.1 Laser-Matter Interaction Fundamentals	2
M 2.2 Characteristics regimes in Laser Welding. Key parameters	2
M 2.3. Basic aspects of the behaviour of different materials in Laser Welding	2
Module 3: TECHNOLOGICAL ASPECTS OF THE PRINCIPAL TYPES OF LASER WELDING	**8**
M 3.1 Conduction Laser Welding	2
M 3.2 Deep penetration Laser Welding	3
M 3.3 Laser/Arc Hybrid Welding	3
Module 4: INTRODUCTION TO THE DESIGN OF LASER WELDED JOINTS	**6**
M 4.1 Basic parameters in the calculation and design of Laser Welded joints	2
M4.2 Design for static and dynamic loading in laser welded structures	2
M 4.3 Predictive assessment of the performance of laser welded joints	2
Module 5: TECHNOLOGICAL ASSESSMENT OF LASER WELDING IN THE INDUSTRY	**6**
M 5.1 Analysis of laser welding against competitive technologies in industry	3
M 5.2 Analysis of relevant case studies of industrial application of laser welding	3
Module 6: QUALITY ASSURANCE AND SAFETY IN LASER WELDING	**6**
M 6.1 Quality Standard applicable to laser welding	2
M 6.2 Methods for laser welding quality assurance. Typical defects	2
M 6.3 Methods for laser welding on-line monitoring and control	2
M 6.4 Personnel Qualification and Safety in laser welding applications	Complementary

QUALIFICATION DESCRIPTION

QUALIFICATION: EUROPEAN LASER WELDING OFFICER

KNOWLEDGE: Factual and theoretical knowledge of the principles and applicability of the laser welding technology

SKILLS: Fundamental/basic range of cognitive and practical skills required to identify/choose proper solutions in basic and specific laser welding problems.

COMPETENCES: Self-manage within the work procedures and the applications of laser welding in a predictable context, but subject to change. Take responsibility without full autonomy for decision making in basic work and supervise basic tasks of laser welding and related personnel.

EQF LEVEL (EQF L): 4

WORKLOAD (WL): 60 – 80 hours
TEACHING HOURS: 40 contact hours

ECVET POINTS: 2,5

1 Module 1: Basics of laser technology 8

1.1. Presentation of the program and introduction to laser techniques	**1**
Objective: Understand key terms and abbreviations and be acquainted with basic laser types and techniques.	
Qualification Teaching hours	1
1.2 Principles of laser emission, key parameters and laser types	**3**
Objective: Be acquainted with laser emission	
Qualification Teaching hours	3
1.3 Laser beam propagation and guiding	**2**
Objective: Understand how different kind of laser types work and how the beam guidance is done in those systems	
Qualification Teaching hours	2
1.4 Laser systems, equipment and procedures	**2**
Objective: Be Introduced to use and identify laser systems and internal & external equipment.	
Qualification Teaching hours	2

ACTIONS/ ACHIEVEMENTS	PERFORMANCE CRITERIA	KNOWLEDGE	SKILLS	COMPETENCES
Apply basic knowledge of the main different laser welding techniques, types and processes	Demonstrate theoretical knowledge and skills in pointing out the major differences between each type of laser systems, equipments and processes	Basic knowledge of definitions and terminology related to types of laser, their processes and applications Explain the generation of laser light and the properties of laser beam. Fundamental knowledge of laser as light; wavelength; resonators structure and operational principle. Basic knowledge of laser parameter overview Basic knowledge of Laser types. Fundamental knowledge of beam characteristics:	Name the terminology and definitions used in this course Associate the most common types of LASER welding to their common abbreviation Outline the range of application of most common LASER welding processes providing concrete examples for each range of application Identify various laser types based on proper terminology:	Evaluate with a limited autonomy a given laser welding fabrication and, under guidance, pointing out the possible types of laser welding, the equipment and processes to be applied to.

ACTIONS/ ACHIEVEMENTS	PERFORMANCE CRITERIA	KNOWLEDGE	SKILLS	COMPETENCES
		propagation; focusability; power density distribution Fundamental knowledge of beam transfer: mirrors and lenses; scanning optics and fiber Basic knowledge of beam quality and beam control/observation Basic knowledge of: Laser work stations. Gases in laser processes. Fundamental knowledge of optional accessories Basic knowledge of most relevant laser beam parameters; Beam guiding and focusing optics and welding fixtures	CO2-laser; Nd:YAG-laser; Diode-laser; Fiber-laser; Disc-laser; Excimer laser Classify various types of laser processes based on proper terminology. Relate suitable wavelengths used in different laser applications and different materials. List the optical components in laser system Explain the working principles of the most common laser types. Outline difference between laser types. Explain the structure of laser types. Recognise the basic reasons for different types of laser beam delivery method Explain the basics of beam properties, manipulations and guidance. Define the basics of the gases and fumes used or formed in laser processes. Relate the additional value of optional accessories. Name most common optional accessory in laser systems. Identify most relevant laser beam parameters Explain proper	

ACTIONS/ ACHIEVEMENTS	PERFORMANCE CRITERIA	KNOWLEDGE	SKILLS	COMPETENCES
			selection of welding fixtures Explain the method for choosing most suitable focusing optics for different laser processes	

2 Module 2: Fundamentals of laser-matter interaction and materials behaviour 6

2.1 Laser-matter interaction fundamentals	**2**
Objective: Know the fundamentals of laser-matter interaction.	
Qualification Teaching hours	2
2.2 Characteristic regimes in Laser Welding. Key parameters	**2**
Objective: Understand the most common laser welding processes used in industry. Understand the key parameters applied to laser welding processes,	
Qualification Teaching hours	2
2.3 Basic aspects of the behaviour of different materials in Laser welding	**2**
Objective: Understand the behaviour mechanisms of materials in Laser welding.	
Qualification Teaching hours	2

ACTIONS/ ACHIEVEMENTS	PERFORMANCE CRITERIA	KNOWLEDGE	SKILLS	COMPETENCES
Apply fundamental knowledge of the main processes of materials interaction in laser welding	Demonstrate theoretical knowledge on the fundamentals of laser-matter interaction	Fundamental knowledge of Laser material interaction parameters (LMIP) Identify some phenomena related to the spot size Identify plasma effects Basic knowledge of laser parameter selection and its effects Fundamental knowledge of laser welding applications Explain laser welding benefits Explain laser welding issues Basic knowledge of materials behaviour mechanisms: hardening, softening Fundamental knowledge of thermal cycle principles and measurements Basic knowledge of materials behaviour mechanisms applied to Laser welding	Describe the laser process and its Interaction with the material Recognise what conditions affect absorptivity and reflectivity and how. Compare the concept of absorption coefficient with absorptivity. Relate the effective absorptivity or process efficiency with laser intensity. Recognise laser welding techniques: conduction mode and keyhole welding. Describe spot size effects Relate suitable wavelengths used in different laser applications and different materials. Identify materials behaviour mechanisms Exemplify effects of materials behaviour mechanisms	Associate materials behaviour to laser welding interaction processes in a given laser welding fabrication and, under guidance, point out the effects obtained.

3 Module 3: Technological aspects of the principal types of Laser Welding 8

3.1 Conduction Laser Welding	**2**
Objective: Know conduction laser welding, its properties and application.	
Qualification Teaching hours	2
3.2 Deep penetration Laser Welding	**3**
Objective: Know the deep penetration Laser welding characteristics and applications.	
Qualification Teaching hours	3
3.3 Laser/Arc Hybrid Welding	**3**
Objective: Understand the arc hybrid welding processes, parameters and applications	
Qualification Teaching hours	3

ACTIONS/ ACHIEVEMENTS	PERFORMANCE CRITERIA	KNOWLEDGE	SKILLS	COMPETENCES
Apply basic understanding of technological aspects of the main types of laser welding, including parameters and applications	Demonstrate fundamental knowledge in identifying the main aspects of different types of laser welding	Understand basics of thermal conduction process Fundamental knowledge of welding thermal cycle and the variables influencing it Name LASER process regimes Fundamental knowledge of conduction laser welding List characteristics of the deep penetration Laser welding Exemplify Laser deep penetration application Basic knowledge of LASER–GMAW hybridization LASER–ARC interaction; Hybrid welding parameters and applications of the hybrid process	Recognise laser welding techniques: conduction mode and keyhole welding. Summarize application of conduction Laser welding. Explain the beam properties between conduction-, keyhole- and hybrid welding. Understand purpose of beam parameters in conduction, keyhole and hybrid welding applications. Explain factors of reflections in welding applications. Understand laser welding and hybrid welding phenomena. Explain the beam properties between conduction-, keyhole- and hybrid welding. Understand purpose of beam parameters in conduction-, keyhole- and hybrid welding applications. Explain factors of reflections in welding applications. Understand laser welding and hybrid welding phenomena.	Identify the main types of Laser welding and under guidance define the process of application.

4 Module 4: Introduction to the design of Laser welded joints 6

4.1 Basic parameters in the calculation an design of Laser welded joints	**2**
Objective: To be introduced to product design for laser- and hybrid welding.	
Qualification Teaching hours	2
4.2 Design for static and dynamic loadings on laser welded structures	**2**
Objective: Become familiar with different kind of stress and loads and how these can be noticed/addressed the design of Laser welded joints.	
Qualification Teaching hours	2
4.3 Predictive assessment of the performance of Laser welded joints	**2**
Objective: Become acquainted with most common assessment methods on Laser welding applications.	
Qualification Teaching hours	2

ACTIONS/ ACHIEVEMENTS	PERFORMANCE CRITERIA	KNOWLEDGE	SKILLS	COMPETENCES
Apply basic understanding of parameters and main procedures for the design of laser welding	knowledge on the required design rules of Laser welded joints	Understand basics of laser welding design parameters and characteristics Name differences between design for static and dynamic loadings in laser welded joints Basic knowledge of: Joint design; tolerances; multi beam an multi spot applications; welding position; distortion and strength of weld	Describe the procedure for designing laser welded joint, how it is calculated and consequences of miscalculations Understand the possibilities of using the materials and structures that laser welding can offer. Explain different joint design and their potentials. Choose the right joint design for different applications. Understand the tolerances and other limitations. Illustrate the influence of manufacturing tolerances on the final design of structure. Understand standards and rules for beam welding structures. Utilize different joint types for different applications.	Identify the main requirements and considerations related to the design and assessment of Laser welded joints

5 Module 5: Technological assessment of Laser welding in the industry 6

5.1 Analysis of Laser welding against competitive technologies in industry	**3**
Objective: Understand the economical aspect of laser processing compared with other joining processes	
Qualification Teaching hours	3
5.2 Analysis for relevant case studies of industrial application of Laser welding	**3**
Objective: Become familiar with application cases of laser welding in industrial context.	
Qualification Teaching hours	3

ACTIONS/ ACHIEVEMENTS	PERFORMANCE CRITERIA	KNOWLEDGE	SKILLS	COMPETENCES
Apply basic understanding of investment of Laser welding compared with other techniques	Demonstrate basic knowledge related to the costs involved in Laser welding systems	Basic knowledge of: Investment, operating and unit cost of laser system Recognize advantages and disadvantages of laser welding Compare Laser welding with competing welding techniques Fundamental knowledge of Laser welding systems concepts applied to industry	Explain the reasons of suitable laser system selecting. Estimate the investment and operational costs when purchasing laser system. Estimate the unit cost for different products. Choose the correct workstation and system. Understand the economical difference between laser types Considering a specified industrial application for laser welding: List the specific advantages and disadvantages of laser welding; Make an estimation of cost; Compare to apply other welding techniques; Identify critical aspects of the laser welding process to be considered; Sketch a concept of a suitable Laser welding system	Identify the main aspects of applying Laser welding technology regarding the investment needed and cost assessment compared to other joining techniques.

6 Module 6: Quality assurance and safety in laser processing 6

6.1 Quality standards applicable to Laser welding	**2**
Objective: Be acquainted with laser-quality requirements, assurance and control of laser processing	
Qualification Teaching hours	2
6.2 Methods for Laser welding quality assurance. Typical defects	**2**
Objective: Basic knowledge of standards related to laser processing	
Qualification Teaching hours	2
6.3 Methods for Laser welding on-line monitoring and control	**2**
Objective: Obtain fundamental knowledge of requirements for Laser welding monitoring	
Qualification Teaching hours	2
6.4 Personnel qualification and safety in Laser welding applications	**Complementary**
Objective: Become aware of safety risks in laser processing	
Qualification Teaching hours	2

ACTIONS/ ACHIEVEMENTS	PERFORMANCE CRITERIA	KNOWLEDGE	SKILLS	COMPETENCES

Apply fundamental understanding of monitoring and control of Laser welding process	Demonstrate fundamental knowledge related to the quality control of Laser welding applications	Basic concepts of quality assurance and quality control. Fundamental knowledge of common defects in laser processing. Outline Laser process monitoring and control Basic knowledge of methods for Laser welding quality assurance Fundamental knowledge of standards on laser processing quality assurance and on laser welding procedure specification Knowledge of basic risks (eye and skin) in laser processing Describe the level/classification of risk	Understand the meaning of quality requirements, assurance and control of laser processing Describe the reason on formation of different defects in laser processing Choose appropriate monitoring process and inspection techniques. Understand the requirements of standards for different processes Define correct welding procedure specifications Choose correct tests for welding procedure qualification Identify on-line/in process monitoring and control Recognize process signals on Laser welding control such as acoustic emission techniques and optical detector Recognize and avoid the risks in laser processing Identify the risks and hazards in laser processing	Identify the main aspects of implementing a Laser welding monitoring and control, including standards to be followed, the procedures and risks involved