

**EWF Guideline for  
International Metal AM Process Engineer: Directed Energy  
Deposition – Laser Beam**

**PERSONNEL WITH QUALIFICATION FOR METAL ADDITIVE  
MANUFACTURING**



**Minimum Requirements for the Qualification and  
Examination**



**IAMQS**

**IAMQS-QUAL-005r1-21**



MINIMUM REQUIREMENTS FOR  
QUALIFICATION AND EXAMINATION

**International Metal Additive Manufacturing Process Engineer  
Directed Energy Deposition – Laser Beam  
(I MAM PE DED-LB)**

**Guideline - General information for the public and organizations that implement this qualification**

**For more information regarding the Qualifications System, the Management Team or the IAMQS ANB should be contacted**

(see in the EWF site the IAMQS ANB contacts)

Published by: Management Team  
Av. Dr. Mário Soares, 35  
P-2741-901 Porto Salvo  
Portugal  
Management Team

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Phone: +351.21 5815200  
E-mail: ewf@ewf.be  
Website: www.ewf.be

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## **Preface**

The present document consists in International MAM Process Engineer DED-LB Guideline, developed by EWF.

This guideline for the European education, training, examination and qualification of additive manufacturing personnel has been prepared, evaluated and formulated by the EWF International Additive Manufacturing Qualification Council (IAMQC). Contains general information for the public and organizations that implement this qualification.

Copies of this document can be downloaded from EWF website: [www.ewf.be](http://www.ewf.be), requested to IAMQS Authorized Nominated Bodies for Metal Additive Manufacturing (IAMQS ANBs) or Management Team.

**MINIMUM REQUIREMENTS FOR THE EDUCATION, TRAINING, EXAMINATION AND QUALIFICATION OF PERSONNEL**

**Introduction**

This guideline covers the minimum requirements for education and training, which have been agreed upon by all IAMQS ANBs, in terms of Learning Outcomes (Knowledge and Skills) and the recommended contact (teaching) hours to be devoted to achieving them. It will be revised periodically by EWF IAMQC to take into account changes to reflect the "state of the art".

Students successfully completing examinations will be expected to be capable of applying the achieved learning outcomes at a level consistent with the qualification diploma level.

The modular course contents are given in the following structure (overview):

COMPETENCE UNITS	I MAM PE DED-LB	
	Recommended Contact Hours*	Expected Workload**
CU 00: Additive manufacturing Process Overview	3,5	7
CU 08: DED-LB Process	35	70
CU 25: Post Processing	14	28
CU 40: Production of DED-LB parts	21	42
CU 41: Conformity of DED-LB parts	35	70
CU 42: Conformity of facilities featuring DED-LB	14	28
<b>TOTAL</b>	<b>123</b>	<b>245</b>
<b>Optional CUs</b>		
CU 26: Introduction to materials	14	28
CU 35: Metal AM integration	21	42
CU 36: Coordination activities	7	14
<b>TOTAL</b>	<b>165</b>	<b>329</b>
<b>Materials CUs***</b>		
CU 27: AM with steels feedstock (excluding Stainless Steel)	21	42
CU 28: AM with Stainless Steel feedstock	14	28
CU 29: AM with Aluminium feedstock	7	14
CU 30: AM with Nickel feedstock	7	14
CU 31: AM with Titanium feedstock	14	28
CU 32: AM with Tungsten feedstock	3,5	7
CU 33: Biomedical metallic materials	7	14

\* 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 students 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.

\*\*\*A minimum of 2 CUs shall be selected from the list **Materials CUs** in order to successfully complete the qualification

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 III).

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:

<i>Qualification: Example 1</i>	
<b>CONTACT HOURS</b>	<b>X= (SUM A:C)</b>
<b>Subject Contents</b>	<b>A + B + C</b>

**Professional Profile**

DED-LB Process Engineers are the professionals with the specific knowledge, skills, autonomy and responsibility to implement DED-LB process in the manufacturing chain assuring the efficient production and post-processing of additively manufactured parts.

His/her’s main tasks are to:

- Develop and execute DED-LB plans including validation of design, implementation, pre and post processing operations, assurance of parts conformity and identification of the causes and the corrective actions of technical production problems;
- Assuring optimum quality and economical levels for specific DED-LB applications;
- Apply a wide variety of engineering techniques, contributing to projects in a teaming environment and compare, investigate, transfer, and adapt procedures, techniques, or methods to new applications.

## **1 Routes to Qualification**

Two distinct routes to gaining the qualifications described in this document have been agreed.

1. The Standard Route
2. Blended Learning Route

### **1.1 The Standard Route**

The Standard Route requires successful completion of EWF approved courses which are designed to meet all the requirements in this Guideline. This is the route recommended by EWF as offering the fastest, most comprehensive manner in which the detailed knowledge may be covered.

### **1.2 Blended Learning Route**

The Blended Learning Route will depend on the type of Competence Units (Cross-cutting or Functional). The Cross-Cutting Competence Units (theoretical knowledge and skills) may be taught using Distance Learning Programs under the control of the AM ANB and all the Functional Competence Units (practical knowledge and skills) must be taught at the Authorized Training Bodies for Metal Additive Manufacturing (AM ATB) facilities.

## 2. General Access Conditions

The defined access conditions approved by IAMQC are given in detail for all countries participating in the EWF system.

The access conditions to International MAM DED-LB Process Engineer Qualification admission are the following:

- Engineering degree in Mechanical, Materials, Aeronautic, or equivalent.

## 2 Special Requirements

### 2.1 Standard Route

Applicants shall satisfy the access conditions, to be accepted for the attendance of a training course conducted by an IAMQS ATB.

There will be written, oral and practical examinations (where applicable) for the award of the applicable EWF Diploma.

It is not obligatory to follow exactly the order of the Competence Units given in this guideline and choice in the arrangement of the detailed knowledge is permitted, with the exception that **the first Competence Unit to be provided must be CU 00: Additive manufacturing Process Overview.**

In the case of attendance and evaluation of the optional competence unit, **CU26: Introduction to Materials**, this shall be done before lecturing any of the CUs numbered from 27 to 33.

The rules for the conduct of the examinations by the IAMQS ANB are prescribed under Examination and Qualification in each Competence Unit guideline.

Complementary to the Competence Units that are required for the purpose of the International MAM Process Engineer DED-LB Diploma issuing, a set of optional Competence Units that can also be of added value for the student and can be implemented by the IAMQS ATB as a supporting training and education offer.

For these optional Competence Units, separate Records of Achievement will be issued after examination approval. Whenever these optional Competence Units are considered mandatory for a certain EWF Qualification, they can be recognized for the purpose of such Qualification Diploma.

The examination of any Competence Unit for the purpose of being validated individually, not included in a Qualification course, shall be completed within a period of 1 year from the starting day of the Competence Unit.

If the Competence Unit “A” is done as a part of a qualification course, the examination shall be completed within a period of 4 years from the date of the completion of the first Competence Unit from the qualification where Competence Unit “A” is integrated in. Failure in the examination shall require re-examination.

Each Competence Unit has a period of validity of 4 years. When applying for a Qualification course, the period of validity of the completed CUs are at discretion of the IAMQS ANB.

**2.2 Section I: Theoretical and Practical Education – Qualification Descriptors and Learning Outcomes**

**I.1. Qualification Outcome Descriptors**

QUALIFICATION	EWF LEVEL	KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY
<b>International MAM Process Engineer DED-LB</b>	<b>ADVANCED</b>	Advanced knowledge and critical understanding of the theory, principles and applicability of DED-LB additive manufacturing process.	Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical solutions, when applying metal additive manufacturing processes, in complex and unpredictable conditions	Manage metal additive manufacturing DED-LB processes activities in a highly complex context. Take responsibility in decision making and definition of DED-LB procedures and applications

**I.2. Mandatory Competence Units Learning Outcomes**

**Competence Unit 00: Additive Manufacturing Processes Overview**

<b>CU 00: Additive Manufacturing Processes Overview</b>		<b>CONTACT HOURS</b>
<b>SUBJECT TITLE</b>		
Directed energy deposition		0,5
Powder bed fusion		0,5
Vat photopolymerization		0,5
Material jetting		0,5
Binder jetting		0,5
Material extrusion		0,5
Sheet lamination		0,5
<b>Total</b>		<b>3,5</b>
<b>WORKLOAD</b>		<b>7</b>

<b>Learning Outcomes – CU00: Additive Manufacturing Processes Overview</b>	
<b>KNOWLEDGE</b>	Basic factual knowledge of: <ul style="list-style-type: none"> <li>– Directed energy deposition</li> <li>– Powder bed fusion</li> <li>– Vat photopolymerization</li> <li>– Material jetting</li> <li>– Binder jetting</li> <li>– Material extrusion</li> <li>– Sheet lamination</li> </ul>
<b>SKILLS</b>	Distinguish parts produced by different AM processes List the advantages and limitations of AM processes from a manufacturing process chain point of view Name the applicability of different AM processes, according to the characteristics of each process

**Competence Unit 08: DED-LB Process**

CU 08: DED-LB Process		RECOMENDED CONTACT HOURS	
	LEVEL	INDEPENDENT (I) (applied to Operators and Engineers)	ADVANCED (A) (applied only to Enginners)
DED-LB System (Hardware & Software)		5	0
DED-LB Physical Principles		2	0
DED-LB Parameters		3	0
Build platform, feedstock and other consumables		3	0
Post processing operations		1	0
DED-LB Processes		0	7
DED-LB Build platform, feedstock and other consumables		0	5
DED-LB Equipment and accessories		0	2
DED-LB Manufacturing strategy		0	7
<b>Subtotal Per Level</b>		<b>14</b>	<b>21</b>
<b>Cumulated Subtotal</b>		<b>14</b>	<b>35</b>
<b>WORKLOAD</b>			
<b>PER LEVEL</b>		28	42
<b>CUMULATED</b>		<b>28</b>	<b>70</b>

LEARNING OUTCOMES – CU 08: DED-LB Process		
LEVEL	INDEPENDENT (applied to Operators and Engineers)	ADVANCED (applied only to Enginners)
<b>KNOWLEDGE</b>	Factual and broad of: <ul style="list-style-type: none"> <li>– DED-LB systems</li> <li>– Laser Characteristics</li> <li>– Build platform</li> <li>– Powder/wire</li> <li>– Gases</li> <li>– Processable materials with DED-LB</li> </ul>	Advanced knowledge and critical understanding of the theory, principles and applicability of: <ul style="list-style-type: none"> <li>– DED-LB equipment, accessories, including build platform, feedstock and other consumables</li> <li>– DED-LB process parameters and variables, including post processing operation</li> </ul>
<b>SKILLS</b>	Describe the DED-LB systems, including the com-ponents and their functions Distinguish different types of feedstock Associate the interaction of the process heat source with the feedstock Recognise the DED-LB parameters and the influence of their adjustment on the as built part (e.g. deformation) Recognise the characteristics of the DED-LB build platform, feedstock and other consumables Identify the problems associated with inadequate prepa-ration and set-up of the build platform, handling and storage of feedstock and application of the gases used in DED-LB Recognise the basic principles of 3D CAD systems and machine control software	Explain how the DED-LB process works Explain the influence of modifying process parameters on the as built part Discuss the influence of build platform, feedstock and other consumables characteristics on part manufacturing Identify areas that will need thermal compensation Identify the cause of defects and propose methods for their mitigation Discuss the adequacy of selected equipment and accessories on the part manufacturing Distinguish the different regimes and processes of failure and describe the factors controlling them and the boundaries and limits between them Select specific materials for different applications to meet part requirements Identify specific metallurgical aspects of DED-LB parts Identify the variables used to define the DED-LB manufacturing strategy

**Competence Unit 25: Post Processing**

Erro! A origem da referência não foi encontrada.CU 25: Post Processing		CONTACT HOURS
SUBJECT TITLE		
General considerations		2
Thermal treatment		4
Plastic deformation methods		2
Subtractive manufacturing		2
Finishing operations		2
Practical application		2
	<b>Total</b>	<b>14</b>
	<b>WORKLOAD</b>	<b>28</b>

Learning Outcomes – CU 25: Post Processing	
<b>KNOWLEDGE</b>	<p>Advanced knowledge and critical understanding of the theory, principles and applicability of:</p> <ul style="list-style-type: none"> <li>– Post processing methods (heat treatment, cold work methods, subtractive manufacturing, finishing operations)</li> </ul>
<b>SKILLS</b>	<p>Discuss methods to reduce distortion, using different post processes, for a variety of part geometries and AM processes.</p> <p>Explain the applicable post processing methods to several AM processes as built parts.</p> <p>Describe the effect of different heat treatments on microstructure, mechanical properties, residual stress and defects.</p> <p>Explain the requirements that the as built part needs to have/comply according to each post process.</p>

**Competence Unit 26: Introduction to materials**

CU 26: Introduction to materials		CONTACT HOURS
SUBJECT TITLE		
Structure and properties of metals and alloys		3
Solidification and Phase Diagrams		3
Solid state transformations and TTT diagrams		4
Failure mechanisms: fracture, fatigue, creep		4
<b>Total</b>		<b>14</b>
<b>WORKLOAD</b>		<b>28</b>

Learning Outcomes – CU 26: Introduction to materials	
<b>KNOWLEDGE</b>	<p>Advanced knowledge and critical understanding of the theory, principles and applicability of:</p> <ul style="list-style-type: none"> <li>– Structure and properties of metals and alloys;</li> <li>– Solidification and solid-state transformations</li> <li>– Microstructures</li> <li>– Degradation and Failure</li> </ul>
<b>SKILLS</b>	<p>Describe the structures of pure metals and alloys.            Explain, in detail, the principles of transformation and conditions of structure under which it occurs.            Interpret in detail the phase diagrams information and apply phase diagrams to define microstructures, mechanical properties and alloys.            Realise the mechanical properties of metallic materials according to their structures.            Describe the differences between elastic, plastic, cold and hot deformation that can occur in metals.            Explain the advantages and disadvantages of metals recrystallization, work hardening and strain ageing.            Interpret crystalline lattice distortion from given alloying elements and subsequent structural changes.            Compare the mechanisms of precipitation, types of precipitates and their location within the microstructure.            Explain the effect of loading conditions and temperature on the mechanical properties of metallic materials.            Explain in detail the differences between cracks and fractures comparing the mechanisms of different types of failures.            Assess types of failures.</p>

**Competence Unit 27: AM with Steels feedstock (excluding Stainless Steel)**

CU27: AM with Steels feedstock (excluding Stainless Steel)		CONTACT HOURS
SUBJECT TITLE		
Characteristics and classification of Low alloy Carbon Steels		3
Characteristics and classification of Cr-Mo steels		2
Characteristics and classification of Maraging steels		1,5
Characteristics and classification of High strength steels		1,5
Behaviour in AM – General considerations		2
Behaviour in AM of Low alloy Carbon Steels		2
Behaviour in AM of Cr-Mo steels		2
Behaviour in AM of Maraging steels		2
Behaviour in AM of High strength steels		2
Cracking phenomena in parts processed by AM		3
	<b>Total</b>	<b>21</b>
	<b>WORKLOAD</b>	<b>42</b>

Learning Outcomes – CU 27:AM with Steels feedstock (excluding Stainless Steel)	
<b>KNOWLEDGE</b>	<p>Advanced knowledge and critical understanding of the theory, principles and applicability of:</p> <ul style="list-style-type: none"> <li>– Different types of Steels as feedstock for producing AM parts, namely: carbon steels, Cr-Mo, maraging and high strength steels</li> </ul>
<b>SKILLS</b>	<p>Describe the theory, principles and applicability of steels:</p> <ul style="list-style-type: none"> <li>– Describe processability with AM, including obtained properties and their relation with process parameters</li> <li>– Describe main causes of cracking and how to avoid</li> <li>– Identify possible imperfections, including metallurgical imperfections, and how to avoid</li> <li>– Select types of heat treatments when necessary</li> </ul> <p>For the following types of steels: low alloy, Cr-Mo, maraging and high strength steels:</p> <ul style="list-style-type: none"> <li>– Explain in detail the effects of micro-alloying, relating grain refinement to mechanical properties.</li> <li>– Discuss the AM conditions for a certain part taking into account the material ability for AM</li> <li>– Discuss carbon equivalent (CE), t 8/5 concept and preheating temperature</li> <li>– Discuss hardenability and maximum cooling rate</li> <li>– Identify the type of heat treatments requirements for a certain part, inferring the heat treatment conditions (depending of the shape and size of the part, the application and the code).</li> </ul>

**Competence Unit 28: AM with Stainless Steel feedstock**

CU 28: AM with Stainless Steel feedstock	CONTACT HOURS
<b>SUBJECT TITLE</b>	
Characteristics and classification of Stainless Steels – general considerations	2
Characteristics and classification of Austenitic Stainless Steels	1
Characteristics and classification of Martensitic Ferritic Stainless Steels	1
Characteristics and classification of Duplex Stainless Steels	1
Characteristics and classification of Precipitation hardened SS	1
Behaviour in AM of Austenitic Stainless Steels	2
Behaviour in AM of Martensitic Ferritic Stainless Steels	2
Behaviour in AM of Duplex Stainless Steels	1
Behaviour in AM of Precipitation hardened Stainless Steels	1
Cracking phenomena in Stainless Steel parts processed by AM	2
<b>Total</b>	<b>14</b>
<b>WORKLOAD</b>	<b>28</b>

<b>Learning Outcomes – CU 28:AM with Stainless Steel feedstock</b> Erro! A origem da referência não foi encontrada.	
<b>KNOWLEDGE</b>	<p>Advanced knowledge and critical understanding of the theory, principles and applicability of:</p> <ul style="list-style-type: none"> <li>– Different types of Stainless Steels as feedstock for producing AM parts, namely: Austenitic, Ferritic, Martensitic, Duplex and Precipitation hardened</li> </ul>
<b>SKILLS</b>	<p>Identify stainless steels type: austenitic, ferritic, martensitic, precipitation hardened, duplex and its ability to be processed by AM in all processes with different feedstock</p> <p>Identify main problems for each Stainless Steel when AM processed by different AM processes and feedstock</p> <p>Identify the material processability with AM, the type of heat source and feedstock</p> <p>Discuss and predict how to prevent major cracking phenomena</p> <p>Decide the type of post treatment required for a certain part (according to the type of stainless steel, the shape and size of the part, the application and any relevant documentation)</p>

**Competence Unit 29: AM with Aluminium feedstock**

CU 29: AM with Aluminium feedstock	CONTACT HOURS
<b>SUBJECT TITLE</b>	
Characteristics and classification of Aluminium and its alloys	2
Aluminium and aluminium alloys and their behaviour in AM	3
Cracking phenomena in parts processed by AM	2
<b>Total</b>	<b>7</b>
<b>WORKLOAD</b>	<b>10</b>

Learning Outcomes – CU 29: AM with Aluminium feedstock	
<b>KNOWLEDGE</b>	<p>Highly specialised knowledge and critical assessment of theory, principles and applicability of:</p> <ul style="list-style-type: none"> <li>– Aluminium alloys and their processability with AM</li> <li>– Main causes of cracking and how to avoid</li> <li>– Types and objectives of heat treatment techniques</li> </ul>
<b>SKILLS</b>	<p>For the following metal and alloys – Aluminium:</p> <ul style="list-style-type: none"> <li>– Interpret the processability with AM for each alloy with different AM processes and feedstock</li> <li>– Discuss the applications, recommending processing parameters and shielding gases to achieve quality requirements for a specific part</li> <li>– Distinguish heat treatable and non-heat treatable alloys and problems in AM</li> <li>– Recommend methods to avoid cracking phenomena and solid-state micro fissures, providing alternatives where necessary.</li> </ul>

**Competence Unit 30: AM with Nickel feedstock**

CU30: AM with Nickel feedstock	CONTACT HOURS
<b>SUBJECT TITLE</b>	
Characteristics and classification of Nickel and its alloys	2
Nickel and nickel alloys and their behaviour in AM	3
Cracking phenomena in parts processed by AM	2
<b>Total</b>	<b>7</b>
<b>WORKLOAD</b>	<b>14</b>

Learning Outcomes – CU 30: AM with Nickel feedstock	
<b>KNOWLEDGE</b>	Highly specialised knowledge and critical assessment of theory, principles and applicability of: <ul style="list-style-type: none"> <li>– Nickel processability with AM</li> <li>– Main causes of cracking and how to avoid</li> <li>– Types and goals of heat treatment techniques</li> </ul>
<b>SKILLS</b>	For the following metal and alloys – Nickel: <ul style="list-style-type: none"> <li>– Interpret the processability with AM for each alloy with different AM processes and feedstock</li> <li>– Discuss the applications, recommending processing parameters and shielding gases to achieve quality requirements for a specific part</li> <li>– Recommend methods to avoid cracking phenomena and solid-state micro fissures, providing alternatives where necessary.</li> </ul>

**Competence Unit 31: AM with Titanium feedstock**

CU31: AM with Titanium feedstock	CONTACT HOURS
<b>SUBJECT TITLE</b>	
Characteristics and classification of Titanium and its alloys	4
3Titanium and titanium alloys and their behaviour in AM	6
Cracking phenomena in parts processed by AM	4
<b>Total</b>	<b>14</b>
<b>WORKLOAD</b>	<b>28</b>

Learning Outcomes – CU31: AM with Titanium feedstock	
<b>KNOWLEDGE</b>	<p>Highly specialised knowledge and critical assessment of theory, principles and applicability of:</p> <ul style="list-style-type: none"> <li>– Titanium processability with AM</li> <li>– Main causes of cracking and how to avoid</li> <li>– Types and goals of heat treatment techniques</li> </ul>
<b>SKILLS</b>	<p>Describe in detail the theory, principles and applicability of:</p> <ul style="list-style-type: none"> <li>– Titanium processability with AM</li> <li>– Main causes of cracking and how to avoid</li> <li>– Heat treatments- types and techniques</li> </ul> <p>For the following metal and its alloys – Titanium:</p> <ul style="list-style-type: none"> <li>– Interpret the processability with AM</li> <li>– Discuss the applications, recommending heat input, shielding gases to achieve quality requirements for a specific part</li> <li>– Recommend methods to avoid cracking phenomena and solid-state micro cracks, providing alternatives where necessary.</li> </ul>

**Competence Unit 32: AM with Tungsten feedstock**

CU 32: AM with Tungsten feedstock	CONTACT HOURS
<b>SUBJECT TITLE</b>	
Characteristics and classification of Tungsten	1
Tungsten behaviour in Additive Manufacturing	1.5
Cracking phenomena in parts processed by Additive Manufacturing	1
<b>Total</b>	<b>3.5</b>
<b>WORKLOAD</b>	<b>7</b>

Learning Outcomes – CU 32: AM with Tungsten feedstock	
<b>KNOWLEDGE</b>	Highly specialised knowledge and critical assessment of theory, principles and applicability of: <ul style="list-style-type: none"> <li>– Tungsten processability with Additive Manufacturing</li> <li>– Main causes of cracking and how to avoid</li> </ul>
<b>SKILLS</b>	For Tungsten: <ul style="list-style-type: none"> <li>– Interpret the processability of W with different Additive Manufacturing processes and feedstock</li> <li>– Discuss the applications, recommending processing parameters and shielding gases to achieve quality requirements for a specific part</li> </ul>

**Competence Unit 33: Biomedical metallic materials**

CU 33: Biomedical metallic materials	CONTACT HOURS
<b>SUBJECT TITLE</b>	
Metallic alloys used for biomedical applications	1
Noble metals (Au, Ag, Pd, Pt)	1
Pure Ti, Pure Mg	1
Alloys: Ti6Al7Nb, Ti13Zr13Nb, NiTi, 316L stainless steel Co-Cr-Mo,	1
Ability to AM	3
<b>Total</b>	<b>7</b>
<b>WORKLOAD</b>	<b>10</b>

Learning Outcomes –CU 33: Biomedical metallic materials	
<b>KNOWLEDGE</b>	<p>Highly specialised knowledge and critical assessment of theory, principles and applicability of:</p> <ul style="list-style-type: none"> <li>– Biomedical metallic materials processability with AM</li> <li>– Main causes of cracking and how to avoid</li> </ul>
<b>SKILLS</b>	<p>Describe in detail the theory, principles and applicability of</p> <ul style="list-style-type: none"> <li>– Biomedical metallic materials processability with AM</li> <li>– Main causes of cracking and how to avoid</li> <li>– Heat treatments- types and techniques</li> </ul> <p>For the Biomedical metallic materials</p> <ul style="list-style-type: none"> <li>– Interpret the processability with AM</li> <li>– Discuss the applications, recommending heat input, shielding gases to achieve quality requirements for a specific part</li> <li>– Recommend methods to avoid cracking phenomena and solid-state micro cracks, providing alternatives where necessary.</li> </ul>

**Competence Unit 35: Metal AM integration**

CU 35: Metal AM integration		CONTACT HOURS
SUBJECT TITLE		
Production Management		7
AM Commercial Integration		3,5
Case studies		10,5
<b>Total</b>		<b>21</b>
<b>WORKLOAD</b>		<b>42</b>

CU	EQF/ EWF LEVEL	JOB FUNCTIONS	JOB REQUIRED ACTIVITIES	CONTACT HOURS	WORKLOAD
Metal AM integration	6 ADVANCED	Support the continuous technical and commercial integration of Metal AM in an industrial environment	Providing inputs for the design of production management procedures, based on the advantages and limitations of Metal AM processes	21	42
			Providing feedback to the management concerning Metal AM costs (e.g. collected from the production by the specialized engineers)		
			Promoting AM capability to relevant stakeholders within the company, for its range of products		

Learning Outcomes – CU 35: Metal AM integration	
<b>KNOWLEDGE</b>	<p>Advanced knowledge and critical understanding of the theory, principles and applicability of:</p> <ul style="list-style-type: none"> <li>– AM processes adoption on a company’s business model</li> <li>– Technical and commercial implementation plans for AM production</li> </ul>
<b>SKILLS</b>	<p>Analyse all the manufacturing processes existing in the company comparing AM with other manufacturing processes</p> <p>Design AM cells including selection of AM machine and methods to manipulate the part, fixturing and sensing of the part, equipment for loading and unloading.</p> <p>Design a factory layout that incorporates all required manufacturing operations</p> <p>Provide inputs for a factory layout design that incorporates all required manufacturing operations</p> <p>Recommend procedures for integration of AM processes within the company’s manufacturing chain</p> <p>Discuss the commercial aspects related to the integration of AM fostering the involvement of internal and external stakeholders in the adoption of AM</p>

**Competence Unit 36: Coordination activities**

CU 36: Coordination activities		CONTACT HOURS
SUBJECT TITLE		
Communications and coordination		3
Documentation		4
<b>Total</b>		<b>7</b>
<b>WORKLOAD</b>		<b>14</b>

CU	EQF/ EWF LEVEL	JOB FUNCTIONS	JOB REQUIRED ACTIVITIES	CONTACT HOURS	WORKLOAD
Coordination activities	6 ADVANCED	Coordinate the work with the AM team	Ensuring the link with external suppliers, as well as management, staff and other company departments	7	14
			Managing documentation related with the AM process		

Learning Outcomes – CU 36: Coordination activities	
<b>KNOWLEDGE</b>	Advanced knowledge and critical understanding of: <ul style="list-style-type: none"> <li>– Communications and coordination procedures</li> <li>– Document handling and control</li> </ul>
<b>SKILLS</b>	Manage communications across all actors involved in the AM manufacturing chain Establish procedures for information control and traceability Control all the information generated within a given AM

**Competence Unit 40: Production of DED-LB parts**

CU 40: Production of DED-LB parts		CONTACT HOURS
SUBJECT TITLE		
DED-LB process simulation		7
DED-LB part production		7
Case studies		7
<b>Total</b>		<b>21</b>
<b>WORKLOAD</b>		<b>42</b>

CU	EQF/ EWF LEVEL	JOB FUNCTIONS	JOB REQUIRED ACTIVITIES	CONTACT HOURS	WORKLOAD
Production of DED-LB parts	7/Expert	Specify the process chain for the DED-LB parts	Interpreting reports of simulation results	21	42
			Run simple simulations in toolpath planning		
			Establishing manufacturing plan (e.g. toolpath generation, Laser parameters, feedstock, gas, building plate, build file, post processing operations, standards)		
			Providing technical counselling to the decision of the acquisition of AM equipment		
			Defining the production of DED-LB parts together with other staff (e.g. including providing inputs to designers to optimize the shape of AM products)		
			Specifying post processing operations (e.g. subtractive manufacturing, heat treatment, surface finishing and treatment) to fulfil the product requirements		
			Design the tooling concept		
			Defining AM staff's tasks distribution according to the workplan		

Learning Outcomes – CU 40: Production of DED-LB parts	
<b>KNOWLEDGE</b>	Highly specialised knowledge and critical assessment of: <ul style="list-style-type: none"> <li>– DED-LB part production specifications, including simulation information, process parameters, pre and post manufacturing operations and work instructions</li> </ul>
<b>SKILLS</b>	<p>Discuss Design for AM features with other AM staff.</p> <p>Adapt CAD files to build files (e.g. toolpath)</p> <p>Interpret reports of finite element analysis and numerical modelling to AM (e.g. topology optimisation, distortion, residual stresses)</p> <p>Apply workflows for virtual pre-processing (e.g. part orientation)</p> <p>Demonstrate competency in working with toolpath creation software</p> <p>Select specific materials for different applications to meet part requirements</p> <p>Propose a suitable toolpath for a given part and identify the areas that will need thermal compensation.</p> <p>Propose methods to reduce distortion for a variety of part geometries and processes.</p> <p>Identify the cause of defects and propose methods for their mitigation.</p> <p>Identify the most suitable post processing technique for a specific AM process and application</p> <p>Create a DED-LB AMPS</p> <p>Produce work instructions for the DED-LB Operator</p>

**Competence Unit 41: Conformity of DED-LB parts**

CU 41: Conformity of DED-LB parts		CONTACT HOURS
<b>SUBJECT TITLE</b>		
Quality Assurance and Quality Control		7
Inspection and Testing Plan		21
Production chain qualification		7
<b>Total</b>		<b>35</b>
<b>WORKLOAD</b>		<b>70</b>

CU	EQF/ EWF LEVEL	JOB FUNCTIONS	JOB REQUIRED ACTIVITIES	CONTACT HOURS	WORKLOAD
Conformity of DED-LB parts	7/Expert	Ensure the conformity of the AM process and AM parts	Preparing QA/QC procedures (e.g. reception, handling and storage of feedstock, manufacturing process monitoring)	35	70
			Supporting the development of testing and inspection plan (including acceptance criteria for NDT and DT)		
			Troubleshooting for causes of non-conformity in the production of AM parts		
			Determining corrective actions for eliminating defects (e.g. metallurgical, deformation, warping) based on technical reports (e.g. DT, NDT)		
			Ensuring the compliance of the AM production process and the AM parts with the relevant documents (e.g. standards, product specifications, legislation)		
			Identifying requirements in terms of AM training		
			Implementing AM process and AM parts certification procedures		
			Developing procedures to repair parts (e.g. parts damaged in service; together with the client)		
			Ensuring production chain qualification (i.e. equipment, operations, staff)		

Learning Outcomes – CU 41: Conformity of DED-LB parts	
<b>KNOWLEDGE</b>	Highly specialised knowledge and critical assessment of: <ul style="list-style-type: none"> <li>– Quality Management</li> <li>– Methods for DT and NDT, monitoring control and inline control systems</li> <li>– Certification of DED-LB parts</li> <li>– Repair procedures</li> </ul>
<b>SKILLS</b>	Apply the principles of quality management to process and part qualification Evaluate feedstock characteristics required to qualify a part Develop AM procedures according to appropriate standards and other documentation Select Non-Destructive Testing and Destructive Testing methods to characterise a part Interpret Destructive and Non-Destructive Testing reports Adapt AMPS based on results from testing results Integrate troubleshooting techniques in manufacturing process chain Propose methods to perform the repair and re-certification of a damaged DED-LB part Guarantee process conformity to client’s requests, standards and other requirements Define the manufacturing and approval of test artefacts Interpret inline control and monitoring systems data and define correction strategies

**Competence Unit 42: Conformity of facilities featuring DED-LB**

CU 42: Conformity of facilities featuring DED-LB		CONTACT HOURS
SUBJECT TITLE		
Health, Safety & Environment in DED-LB		10
Infrastructures/Facility Requirements		3
Group work		1
<b>Total</b>		<b>14</b>
<b>WORKLOAD</b>		<b>28</b>

CU	EQF/ EWF LEVEL	JOB FUNCTIONS	JOB REQUIRED ACTIVITIES	CONTACT HOURS	WORKLOAD
Conformity of facilities featuring DED-LB	6/Advance	Support the implementation of the facility conformity procedures featuring DED-LB	Supporting the design of Health, Safety and Environment (HSE) procedures featuring DED-LB (e.g. Control of Substances Hazardous to Health (COSHH), risk analysis, mitigation plans)	14	28
			Providing safety requirements to be implemented to ensure people’s safety on the shop floor		
			Providing inputs for waste management		
			Preparing incident reports		

Learning Outcomes – CU 42: Conformity of facilities featuring DED-LB	
<b>KNOWLEDGE</b>	Highly specialised knowledge and critical assessment of: <ul style="list-style-type: none"> <li>– HSE in the DED-LB process</li> </ul>
<b>SKILLS</b>	Explain in detail the health and safety hazards associated with Laser, electricity, gases, fumes, fire, radiation and noise, grinding, spatter, flame, fire, combustion. Predict the hazards, defining the health and safety requirements and working procedures, including the definition of the necessary PPE. Recommend healthy and safe workplace practices to be implemented in a manufacturing plant.

**Appendix I: EWF Systems Framework**

FIELD OF ACTIVITY		EQF LEVELS	EFW 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 bonding 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.

**General reference descriptors transversal to all qualifications. Each Qualification has its own specific descriptors in terms of Knowledge, skills, autonomy and responsibility.**