

**EWF Guideline for
International Metal AM Coordinator**

**PERSONNEL WITH QUALIFICATION FOR METAL ADDITIVE
MANUFACTURING**



**Minimum Requirements for the Qualification and
Examination**



IAMQS

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**MINIMUM REQUIREMENTS FOR
QUALIFICATION AND EXAMINATION**

**International Metal Additive Manufacturing Coordinator
(I MAM C)**

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

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Preface

The present document consists in International MAM Coordinator 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, 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 M A M C	
	Recommended Contact Hours*	Expected Workload**
CU 00: Additive manufacturing Process Overview	3,5	7
CU 01: DED-Arc Process	42	84
CU 08: DED-LB Process	35	70
CU 15: PBF-LB Process	35	70
CU 25: Post Processing	14	28
CU 34: Process Selection	28	56
CU 35: Metal AM Integration	21	42
CU 36: Coordination Activities	7	14
TOTAL	185	371

* 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>	
CONTACT HOURS	X= (SUM A:C)
Subject Contents	A + B + C

Professional Profile

Metal AM Coordinators are the professionals with the specific knowledge, skills, autonomy and responsibility to assess the technical adequacy of AM processes to part requirements This qualification is for professionals who wish to be responsible for the implementation and coordination of AM activities.

His/her’s main tasks are to:

- Evaluate manufacturing suitability for customers’ requests defining which processes are fit for the request, based on the application, material, design and cost of the part;
- Apply a wide variety of engineering techniques, contributing to projects in a teaming environment and compare procedures, techniques or methods to potential applications;
- Coordinate the tasks distributions between the operators according to the workplan as well as managing the link between them and the management.

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 Metal AM Coordinator Qualification admission are the following:

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

3 Special Requirements

3.1 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 Metal AM Coordinator 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.

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

I.1. Qualification Outcome Descriptors

QUALIFICATION	EWF LEVEL	KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY
International Metal AM Coordinator	ADVANCED	Advanced knowledge and critical understanding of the theory, principles and applicability of metal additive manufacturing processes.	Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical and economical solutions, when selecting metal additive manufacturing processes, in complex and unpredictable conditions	Manage the selection of metal additive manufacturing processes in a highly complex context. Take responsibility in decision making and definition of the metal additive manufacturing personnel's tasks

I.2. Mandatory Competence Units Learning Outcomes

Competence Unit 00: Additive Manufacturing Processes Overview

CU 00: Additive Manufacturing Processes Overview		CONTACT HOURS
SUBJECT TITLE		
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
Total		3,5
WORKLOAD		7

Learning Outcomes – CU00: Additive Manufacturing Processes Overview	
KNOWLEDGE	Basic factual knowledge of: <ul style="list-style-type: none"> - Directed energy deposition - Powder bed fusion - Vat photopolymerization - Material jetting - Binder jetting - Material extrusion - Sheet lamination
SKILLS	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 01: DED-Arc Process

CU 01 DED-Arc Process	RECOMENDED CONTACT HOURS		
	LEVEL	INDEPENDENT (I) (applied to Operators and Engineers)	ADVANCED (A) (applied only to Enginners)
DED-Arc System (Hardware & Software)		5	0
DED-Arc Physical Principles, Processes and Parameters		5	0
DED-Arc Build platform, feedstock and other consumables		3	0
Post processing operations		1	0
DED-Arc Processes		0	14
DED-Arc Build platform, feedstock and other consumables		0	5
DED-Arc Equipment and accessories		0	3
DED-Arc Manufacturing strategy		0	6
	Subtotal Per Level	14	28
	Cumulated Subtotal	14	42
		WORKLOAD	
	PER LEVEL	14	42
	CUMULATED	28	84

LEARNING OUTCOMES – CU 01: DED-Arc Process		
LEVEL	INDEPENDENT (applied to Operators and Engineers)	ADVANCED (applied only to Enginners)
KNOWLEDGE	Factual and broad of: <ul style="list-style-type: none"> – DED-Arc systems – Arc physics – Processable materials with DED-Arc – Processing atmosphere requirements with DED-Arc – Sensors and process controls with DED-Arc 	Advanced knowledge and critical understanding of the theory, principles and applicability of: <ul style="list-style-type: none"> – DED-Arc equipment, accessories, including build platform, feedstock and other consumables – DED-Arc process parameters and variables, including post processing operations
SKILLS	Describe the DED-Arc systems, including the components and their functions Distinguish different types of feedstock Associate the interaction of the process heat source with the feedstock Recognise the DED-Arc parameters and the influence of their adjustment on the as built part (e.g. deformation) Recognise the characteristics of the DED-Arc build platform, feedstock and other consumables Identify the problems associated with inadequate preparation and set-up of the build platform, handling and storage of feedstock and application of the gases used in DED-Arc	Assess the possibility of manufacturing a specific part with DED-Arc based on the characteristics and limitations of the process Relate the influence of the process parameters, build platform, feedstock and other consumables with the properties of the as built part. Implement different methodologies related with to process parameters and deposition strategies for reducing distortion of as built parts 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-Arc parts Define DED-Arc parameters for manufacturing specific parts Adjust process parameters, manufacturing strategy and set up to prevent part defects and process related issues

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 for 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
Subtotal Per Level		14	21
Cumulated Subtotal		14	35
WORKLOAD			
PER LEVEL		14	35
CUMULATED		28	70

LEARNING OUTCOMES – CU 08: DED-LB Process		
LEVEL	INDEPENDENT (applied to Operators and Engineers)	ADVANCED (applied only for Enginners)
KNOWLEDGE	Factual and broad of: <ul style="list-style-type: none"> – DED-LB systems – Laser Characteristics – Build platform – Powder/wire – Gases – Processable materials with DED-LB 	Advanced knowledge and critical understanding of the theory, principles and applicability of: <ul style="list-style-type: none"> – DED-LB equipment, accessories, including build platform, feedstock and other consumables – DED-LB process parameters and variables, including post processing operation
SKILLS	Describe the DED-LB systems, including the components 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 preparation 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 15: PBF-LB Process

CU 15: PBF-LB Process		RECOMENDED CONTACT HOURS	
	LEVEL	INDEPENDENT (I) (applied to Operators and Engineers)	ADVANCED (A) (applied only to Enginners)
PBF-LB Process Principles		2	0
PBF-LB System – Hardware and Software		4	0
PBF-LB Parameters		3	0
PBF-LB Feedstock		2	0
PBF-LB Consumables		2	0
Post Processing		1	0
PBF-LB Processes		0	7
PBF-LB Build substrate, feedstock and other consumables		0	5
PBF-LB Equipment and accessories		0	2
PBF-LB Manufacturing strategy		0	7
	Subtotal Per Level	14	21
	Cumulated Subtotal	14	35
WORKLOAD			
	PER LEVEL	14	35
	CUMULATED	28	70

LEARNING OUTCOMES – CU 15: PBF-LB Process		
LEVEL	INDEPENDENT (applied to Operators and Engineers)	ADVANCED (applied only for Enginners)
KNOWLEDGE	Factual and broad knowledge of: <ul style="list-style-type: none"> – PBF-LB systems – Laser characteristics – Build platform – Powder – Gases – Processable materials with PBF-LB 	Advanced knowledge and critical understanding of the theory, principles and applicability of: <ul style="list-style-type: none"> – PBF-LB equipment, accessories, including build platform, feedstock and other consumables – PBF-LB process parameters and variables, including post processing operation
SKILLS	Describe the PBF-LB systems, including the components and their functions Recognise the characteristics of the PBF-LB build platform, feedstock and other consumables Recognise the PBF-LB parameters and the influence of their adjustment on the as built part Recognise the interaction of the process heat source with the feedstock Identify the problems associated with inadequate preparation and setup of the build platform, handling and storage of feedstock and application of the gases used in PBF-LB	Explain how the PBF-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 PBF-LB parts Identify the variables used to define the PBF-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
	Total	14
	WORKLOAD	28

Learning Outcomes – CU 25: Post Processing	
KNOWLEDGE	<p>Advanced knowledge and critical understanding of the theory, principles and applicability of:</p> <ul style="list-style-type: none"> – Post processing methods (heat treatment, cold work methods, subtractive manufacturing, finishing operations)
SKILLS	<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 34: Process selection

CU 34: Process Selection		CONTACT HOURS
SUBJECT TITLE		
Economics and productivity		7
AM Job analysis		21
Total		28
WORKLOAD		56

CU	EQF/ EWF LEVEL	JOB FUNCTIONS	JOB REQUIRED ACTIVITIES	CONTACT HOURS	WORKLOAD
Process selection	6 ADVANCED	Evaluate, for a specific part, which AM processes can be used for its production	Analysing manufacturing suitability of a client's specific requests	28	56
			Proposing AM processes based on part design (in the conceptual design phase, together with the Design Engineer), materials, other manufacturing operations, required properties and applications		
			Ensuring liaison with other technical areas (design, materials, etc.) to guarantee manufacturability of AM parts		
			Using cost models to establish comparisons between different AM processes/materials and other required processes considering the full manufacturing chain		
			Estimating manufacturing times according to each process		

Learning Outcomes – CU 34: Process selection	
KNOWLEDGE	<p>Advanced knowledge and critical understanding of the theory, principles and applicability of:</p> <ul style="list-style-type: none"> - Technical adequacy of AM processes to part requirements - Costing and manufacturing time assessment
SKILLS	<p>Relate supply chain strategies to their effects on the performance of a manufacturing organisation</p> <p>Define the objectives, principles, terminology and systems of management accounting, including costing</p> <p>Elaborate quotations for clients, calculating the cost of a product made by AM, including labour costs, overhead costs, and consumable costs.</p> <p>Compare AM production costs to traditional manufacturing costs determining the return on investment.</p> <p>Estimate manufacturing duration based on the process and part designs specifications</p> <p>Recommend AM processes for specific applications based on job requirements analysis</p>

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
Total		21
WORKLOAD		42

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	
KNOWLEDGE	<p>Advanced knowledge and critical understanding of the theory, principles and applicability of:</p> <ul style="list-style-type: none"> – AM processes adoption on a company’s business model – Technical and commercial implementation plans for AM production
SKILLS	<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
Total	7
WORKLOAD	14

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	
KNOWLEDGE	Advanced knowledge and critical understanding of the theory, principles and applicability of: <ul style="list-style-type: none"> – Communications and coordination procedures – Document handling and control
SKILLS	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

Appendix I: EWF Systems Framework

FIELD OF ACTIVITY		EQF LEVELS	EFW PROFICIENCY LEVEL	KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY
COORDINATORS/MANAGERS	WELDERS & OPERATORS	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.
		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.