EWF Guideline for
International Metal AM Designer for PBF Processes

PERSONNEL WITH QUALIFICATION FOR METAL ADDITIVE MANUFACTURING

Minimum Requirements for the Qualification and Examination

IAMQS

IAMQS-QUAL-011r1-21

MINIMUM REQUIREMENTS FOR
QUALIFICATION AND EXAMINATION

International Metal Additive Manufacturing Designer for PBF Processes (I MAM D-PBF)

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
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Preface

The present document consists in International Metal AM Designer for PBF Processes 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 downloded 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 EWF 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	E/I D-PBF	
	Recommended Contact Hours*	Expected Workload**
CU 00: Additive manufacturing Process Overview	3.5	7
CU 25: Post Processing	14	28
CU 59: Relevant principles of PBF Processes for Design	21	42
CU 60: Design Metal AM parts for PBF Processes	28	56
CU 61: Simulation Analysis	21	42
Subtotal (without optional CUs)	**91**	**182**
CU 62: Simulation Execution	14	28
Total	**105**	**210**

* Recommended 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.

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:

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

Professional Profile

Metal AM Designers for PBF Processes are the professionals with the specific knowledge, skills, autonomy and responsibility to design metal AM solutions for PBF Processes. His/her's main tasks are to:

- Design Metal AM solutions for PBF Processes ensuring and validating that parts can be made cost-effective and efficiently.
- Close PBF Processes design projects by verifying requirements for production with engineer as well as process requirements, ensuring liaison with other technical areas to sign of drawings.
- Contribute to projects in a teaming environment cooperation with AM Team.

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 IAMQS ANB and all the Functional Competence Units (practical knowledge and skills) must be taught at the Authorized Training Bodies for Metal Additive Manufacturing (IAMQS 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 Metal AM Designer for PBF Processes admission are the following:

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

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.**

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 Additive Manufacturing Designer for PBF processes 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 MAM Designer-PBF	**ADVANCED**	Advanced knowledge and critical understanding of the theory, principles and applicability of metal additive manufacturing design for PBF processes.	Advanced problem-solving skills including critical evaluation and design thinking, allowing to choose the proper technical and economical solutions, when designing parts to be manufactured by PBF metal additive manufacturing processes, in complex and unpredictable conditions	Manage complex PBF processes design projects, taking responsibility for decision-making in unpredictable PBF processes design applications.

I.2. Mandatory Competence Units Learning Outcomes

Competence Unit 00: Additive Manufacturing Processes Overview

CU00: Additive Manufacturing Processes Overview	RECOMMENDED 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	Factual and broad knowledge of theory, principles and applicability of: – Directed energy deposition – Powder bed fusion – Vat photopolymerization – Material jetting – Binder jetting – Material extrusion – Sheet lamination
SKILLS	Distinguish parts produced by different AM processes Recognise the advantages and limitations of AM processes from a manufacturing process chain point of view Identify the applicability of different AM processes, according to the characteristics of each process

Competence Unit 25: Post Processing

CU 25: Post Processing SUBJECT TITLE	RECOMMENDED CONTACT HOURS
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	Advanced knowledge and critical understanding of the theory, principles and applicability of: – Post processing methods (heat treatment, cold work methods, subtractive manufacturing, finishing operations)
SKILLS	Discuss methods to reduce distortion, using different post processes, for a variety of part geometries and AM processes. Explain the applicable post processing methods to several AM processes as built parts Describe the effect of different heat treatments on microstructure, mechanical properties, residual stress and defects Explain the requirements that the as built part needs to have/comply according to each post process

Competence Unit 59: Relevant principles of PBF Processes for Design

CU59: Relevant principles of PBF Processes for Design	RECOMMENDED CONTACT HOURS
SUBJECT TITLE	
PBF process capabilities	7
PBF process limitations	7
Design Considerations	7
Total	21
WORKLOAD	**42**

Learning Outcomes –CU59: Relevant principles of PBF Processes for Design	
KNOWLEDGE	Specialised, factual and theoretical of theory, principles and applicability of metal PBF processes and related technologies: – Capabilities and limitations of PBF processes influence in design – Design considerations required for PBF parts design – Post processing influences in design
SKILLS	Associate the degrees of freedom of a PBF machine to the possibilities in terms of design Relate the capabilities and limitations of PBF to design considerations Determine dimensional constraints and geometric tolerances required for PBF parts design Provide solution-based approaches to redefine design problems (Design thinking) within PBF processes and parts

Competence Unit 60: Design Metal AM parts for PBF Processes

CU 60: Design Metal AM parts for PBF Processes SUBJECT TITLE	RECOMMENDED CONTACT HOURS
Parts requirements	3
CAD Models & Software	12
Part optimisation	4
Designing parts	4
Design to cost	2
Data preparation for production	3
Total	28
WORKLOAD	**56**

CU	EQF/ EWF LEVEL	JOB FUNCTIONS	JOB REQUIRED ACTIVITIES	RECOMMENDED CONTACT HOURS	WORKLOAD
Design Metal AM parts for PBF Processes	**6/ADVANCED**	Design PBF Metal parts	Interpreting parts requirements	**28**	**56**
			Specifying lattice structures		
			Determining parts orientation (consider powder spreading and curl effect)		
			Redesigning parts		
			Assessing Costs in Design		
			Closing design project		

Learning Outcomes – CU 60: Design Metal AM parts for PBF Processes	
KNOWLEDGE	Advanced knowledge and critical understanding of: – Influence of Parts requirements in design; – Orientation and positioning of parts in the build chamber; – Design optimisation.
SKILLS	Verify and analyse requirements for production providing initial propositions and constraints Analyse relevant costs considering the requirements, materials, machine hour rate and manual preparations to ensure the most efficient design Test additively manufactured parts to assess the need for redesign (for example, when the part design is completed, and its performance needs to be tested. If it fails, some redesign may be needed.) Carry out reengineering design using metal AM to design parts previously produced by conventional processes/methods Ensure liaison with other technical areas (process, production, etc.) Sign off (ESO) drawings (STL/AMF files included)

Competence Unit 61: Simulation Analysis

CU 61: Simulation Analysis SUBJECT TITLE	RECOMMENDED RECOMMENDED CONTACT HOURS
Evaluation of Topology Optimization (TO)	3
Mechanical Analysis	3
Fatigue	2
Chemical	3
Thermal Analysis	2
Build Evaluation	2
Documentation	2
Case studies	4
Total	21
WORKLOAD	**42**

CU	EQF/ EWF LEVEL	JOB FUNCTIONS	JOB REQUIRED ACTIVITIES	RECOMMENDED CONTACT HOURS	WORKLOAD
Simulation Analysis	**6/ADVANCED**	Analyse simulation results	Evaluating Topology Optimization (TO) Interpreting finite element (FE) simulation results Documenting technical conclusions deriving from simulation results	**21**	**42**

Learning Outcomes – CU 61: Analysis Simulation	
KNOWLEDGE	Advanced knowledge and critical understanding of the theory, principles and applicability of: – Topology Optimization – Stress and Strain Analysis – Phase transformations
SKILLS	Verify compliance between part requirements and simulation results Run topology optimization considering part requirements interpretation in terms of in-service conditions Define part design improvements based on simulation results Elaborate simulation analysis reports proposing production strategies

Competence Unit 62: Simulation Execution

CU 62: Simulation Execution	RECOMMENDED CONTACT HOURS
SUBJECT TITLE	
Pre-Processing	7
Processing	7
Validation	7
Total	21
WORKLOAD	**42**

CU	EQF/ EWF LEVEL	JOB FUNCTIONS	JOB REQUIRED ACTIVITIES	RECOMMENDED CONTACT HOURS	WORKLOAD
Simulation Execution	**6/ADVANCED**	Simulate and predict impressions	Execute/perform Topology Optimization	**21**	**42**
			Creating finite simulation models (FEM)		
			Debugging modelling optimization		

Learning Outcomes – CU 62: Simulation Analysis	
KNOWLEDGE	Advanced knowledge and critical understanding of the theory, principles and applicability of: – Validation and Calibration strategies – Application of the relevant Material properties, Boundary conditions and mesh characteristics
SKILLS	Choose appropriate CAD file extension to export geometry to the FEA software workspace Judge the type of Simulation Analysis (e.g. Structural, CFD, etc.) according to the problem characteristics Assign physical properties (e.g. material, Boundary conditions, etc) to the geometry to reproduce the in- service solicitations Select proper element type, size, solver and time step to generate a computationally time effective mesh Appraise the quality of the model by comparing physical aspects between the simulation and reality Perform an analysis to assess the converging characteristics of the model Elaborate simulation reports specifying part geometry, boundary conditions, mesh characteristics, material model

Appendix I: EWF Systems Framework

FIELD OF ACTIVITIY		EQF LEVELS	EWF 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 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.

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