CLLAIM

# Final Conference Piloting Professional Profiles: Operator

DVS – German Welding Society, Marvin Keinert M.Sc. IWE

---

Project title: **C**reating know**L**edge and skil**L**s in **A**dd**I**tive **M**anufacturing

Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

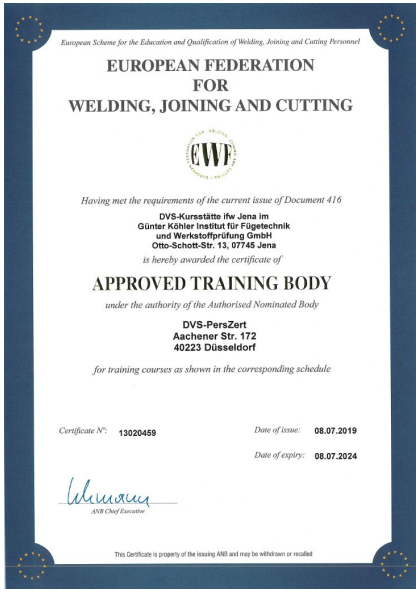
Co-funded by the Erasmus+ Programme of the European Union

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# DVS-PersZert Authorised Nominated Body (ANB)

## Certificate Authorised Training Body (ATB)


European Scheme for the Education and Qualification of Welding, Joining and Cutting Personnel

EUROPEAN FEDERATION FOR WELDING, JOINING AND CUTTING

EWF

Having met the requirements of the current issue of Document 416

DVS-Kursstätte ifw Jena im
Günter Köhler Institut für Fügetechnik
und Werkstoffprüfung GmbH
Otto-Schott-Str. 13, 07745 Jena

is hereby awarded the certificate of

APPROVED TRAINING BODY

under the authority of the Authorised Nominated Body

DVS-PersZert
Aachener Str. 172
40223 Düsseldorf

for training courses as shown in the corresponding schedule

Certificate N°: 13020459 Date of issue: 08.07.2019

Date of expiry: 08.07.2024

ANB Chief Executive

This Certificate is property of the issuing ANB and may be withdrawn or recalled


iiw

International System for the Education, Examination and Qualification of Welding Personnel

INTERNATIONAL INSTITUTE OF WELDING

Having met the requirements of the current issue of Document IAB-001

DVS-Kursstätte ifw Jena im
Günter Köhler Institut für Fügetechnik
und Werkstoffprüfung GmbH
Otto-Schott-Str. 13, 07745 Jena

is hereby awarded the certificate of

IIW Approved Training Body

under the authority of the Authorised Nominated Body

DVS-PersZert

in the Country of

Germany

for training courses as shown in the corresponding Schedule

Certificate N°. 13020459 Date of issue: 08.07.2019

Date of expiry: 08.07.2024

ANB Chief Executive

This Certificate is the property of the issuing ANB and may be withdrawn or recalled

**Accreditation**
DIN EN ISO/IEC 17024:2012-11 Conformity assessment - General requirements for bodies operating certification of persons

Co-funded by the Erasmus+ Programme of the European Union

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# Course Contents

## Competence Units PBF-LB Operator

| COMPETENCE UNITS | EO PBF-LB | |
|---|---|---|
| | Recommended Contact Hours* | Expected Workload** |
| CU 00: Additive manufacturing Process Overview | 7 | 14 |
| CU 15: PBF-LB Process | 14 | 28 |
| CU 16: Quality Assurance (QA) in PBF-LB | 7 | 14 |
| CU 17: Health, Safety and Environment (HSE) in PBF-LB | 3,5 | 7 |
| CU 18: Hardware, software and build file set-up for PBF-LB | 14 | 28 |
| CU 19: Monitoring and managing the manufacturing of PBF-LB parts | 3,5 | 7 |
| CU 20: Post-processing of PBF-LB parts | 7 | 14 |
| CU 21: Maintenance of PBF-LB systems | 7 | 14 |
| Subtotal (without optional CUs) | 63 | 126 |
| CU 48: Powder Handling | 14 | 28 |
| CU 49: Laser Beam Characterisation | 7 | 14 |
| Total | 84 | 168 |

**General Access Conditions**

The access conditions to European Metal AM Operator Qualification admission are the following:

**– National compulsory school diploma**

Draft ISO/ASTM WD 52926-2:2020 Additive Manufacturing — Qualification principles — Part 2: Qualification of Machine operators for metallic parts production for PBF-LB

- Although the hours indicated in the above table are merely recommended, it is mandatory that in total the qualification has a minimum of 40 contact hours.

Co-funded by the Erasmus+ Programme of the European Union

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# Equipement

## 3 Commercial PBF-LB Systems, 1 Experimantal Glove Box

| *Parameter* | *SLM 250$^{HL}$* | *SlaVaM* | *Glove-Box* | *TruPrint 3000* |
|---|---|---|---|---|
| Laser Power in W | 0...400 | 0...200 | 0...500 (1,06 µm), cw and pulsed 0...500 (10,6 µm), cw | 0...500 |
| Scang velocity in mm/s | 0...~3000 | 0...~3000 | 0...~3000 | 0...~5000 |
| Hatch Distance in mm | (0,5...0,9) * $S_A$ | (0,5...0,9) * $S_A$ | free | (0,5...0,9) * $S_A$ |
| Focal diameter in µm | 80...300 | 80...300 | 80...500 | 100...500 |
| Scanning strategy | Area, chess board, meander, etc. | Area, meander | free (for simple geometries) Area, chess board, meander, etc. | Area, chess board, meander, etc. |
| Platform Heating in °C | 200 | 1.100 | RT | 200 |


**e.g. CU 48: Powder Handling**

- Automated Sieving station PSM 100
- Analytical Sieve Shakers AS200

**e.g. CU 15: PBF-LB Process**
**Available and qualified materials**

- Fe-base alloys
- Tool Steels (e.g. 1.2709, 1.2343)
- Corrosion-resistant Steels (e.g. 1.4404)
- Ni-Base Alloys (e.g. IN718, IN625)
- Ti-Base Alloys (e.g. TiAl6V4, TiAl6Nb7)
- Al-Base Alloys (e.g. AlSi10Mg, AlSi12)

Co-funded by the Erasmus+ Programme of the European Union

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# Time Table

## PBF-LB course from September 7 to 11, 2020

Day 1

- CU00 Additive Manufacturing Processes Overview
- CU15 PBF-LB Process

Day 2

- CU15 PBF-LB Process

Day 3

- CU18 Hardware, software and build file set-up for PBF-LB
- CU19 Monitoring and managing the manufacturing of PBF-LB parts
- CU16 Quality Assurance (QA) in PBF-LB

Examination Part 1

Day 4

- CU48 Powder Handling

Day 5

- CU21 Maintenance of PBF-LB Systems
- CU49 Laser Beam Characterisation
- CU20 Post processing of PBF-LB Systems
- CU17 Health, Safety and Environment (HSE) in PBF-LB

Examination Part 2

## Blended Learning Route

The Cross-Cutting Competence Units (theoretical knowledge and skills) may be taught using Distance Learning Programs under the requirement of European harmonized system and all the Functional Competence Units (practical knowledge and skills) must be taught at the facilities of a Training Centre that has the capacity to do so.

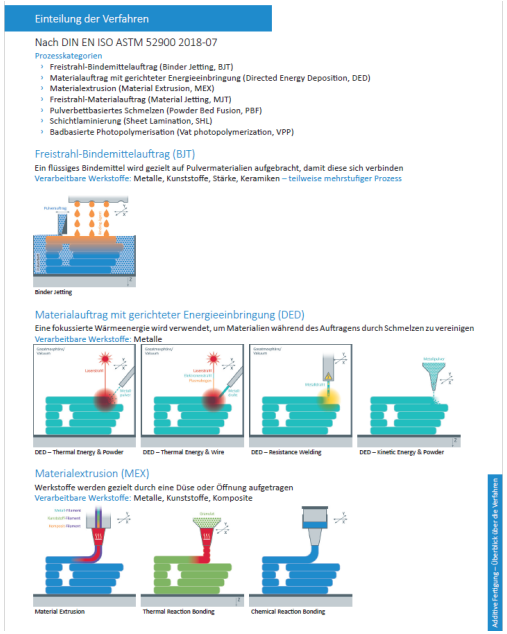
Co-funded by the Erasmus+ Programme of the European Union

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# Teaching Materials Presentation and Script

## e.g. CU 00: Additive Manufacturing Process Overview




Script

DIN EN ISO 17296-2 Additive manufacturing – General principles – Part 2: Overview of process categories and feedstock (ISO 17296-2:2015)

| CU 00: Additive Manufacturing Processes Overview | RECCOMMENDED CONTACT HOURS |
|---|---|
| SUBJECT TITLE | |
| Directed energy deposition | 1 |
| Powder bed fusion | 1 |
| Vat photopolymerization | 1 |
| Material jetting | 1 |
| Binder jetting | 1 |
| Material extrusion | 1 |
| Sheet lamination | 1 |
| Total | 7 |
| WORKLOAD | 14 |

CLLAIM Guideline

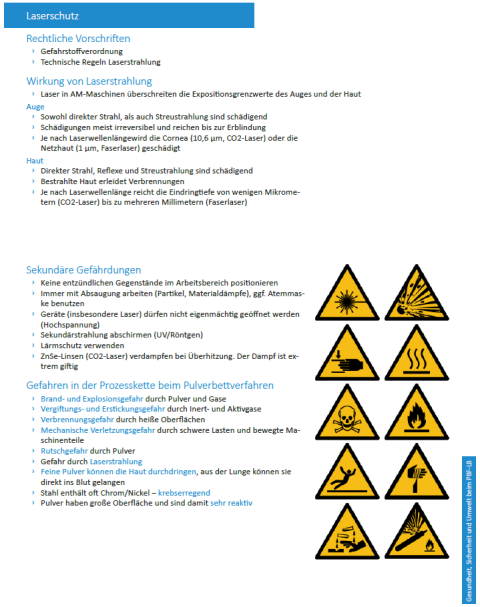
Co-funded by the Erasmus+ Programme of the European Union

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# Teaching Materials Presentation and Script

## e.g. CU 17: Health, Safety and Environment (HSE) in PBF-LB


Laserschutz

Rechtliche Vorschriften
- Gefahrstoffverordnung
- Technische Regeln Laserstrahlung

Wirkung von Laserstrahlung
- Laser in AM-Maschinen überschreiten die Expositionsgrenzwerte des Auges und der Haut

Auge
- Sowohl direkter Strahl, als auch Streustrahlung sind schädigend
- Schädigungen meist irreversibel und reichen bis zur Erblindung
- Je nach Laserwellenlängewird die Cornea (10,6 µm, CO2-Laser) oder die Netzhaut (1 µm, Faserlaser) geschädigt

Haut
- Direkter Strahl, Reflexe und Streustrahlung sind schädigend
- Bestrahlte Haut erleidet Verbrennungen
- Je nach Laserwellenlänge reicht die Eindringtiefe von wenigen Mikrometern (CO2-Laser) bis zu mehreren Millimetern (Faserlaser)

Sekundäre Gefährdungen
- Keine entzündlichen Gegenstände im Arbeitsbereich positionieren
- Immer mit Absaugung arbeiten (Partikel, Materialdämpfe), ggf. Atemmaske benutzen
- Geräte (insbesondere Laser) dürfen nicht eigenmächtig geöffnet werden (Hochspannung)
- Sekundärstrahlung abschirmen (UV/Röntgen)
- Lärmschutz verwenden
- ZnSe-Linsen (CO2-Laser) verdampfen bei Überhitzung. Der Dampf ist extrem giftig

Gefahren in der Prozesskette beim Pulverbettverfahren
- Brand- und Explosionsgefahr durch Pulver und Gase
- Vergiftungs- und Erstickungsgefahr durch Inert- und Aktivgase
- Verbrennungsgefahr durch heiße Oberflächen
- Mechanische Verletzungsgefahr durch schwere Lasten und bewegte Maschinenteile
- Rutschgefahr durch Pulver
- Gefahr durch Laserstrahlung
- Feine Pulver können die Haut durchdringen, aus der Lunge können sie direkt ins Blut gelangen
- Stahl enthält oft Chrom/Nickel – krebserregend
- Pulver haben große Oberfläche und sind damit sehr reaktiv

Sicherheit, Schutz und Umwelt beim PBF-LB

Script

| CU17: Health, Safety and Environment (HSE) in PBF-LB | RECCOMMENDED |
|---|---|
| SUBJECT TITLE | CONTACT HOURS |
| Health, Safety and Environment | 3,5 |
| Total | 3,5 |
| WORKLOAD | 7 |

| Learning Outcomes – CU17: Health, Safety and Environment (HSE) in PBF-LB | |
|---|---|
| KNOWLEDGE | Factual and broad of:<br>– Health, Safety and Environment related to PBF-LB |
| SKILLS | Identify the main hazards and safety measures associated with PBF-LB systems |

CLLAIM Guideline

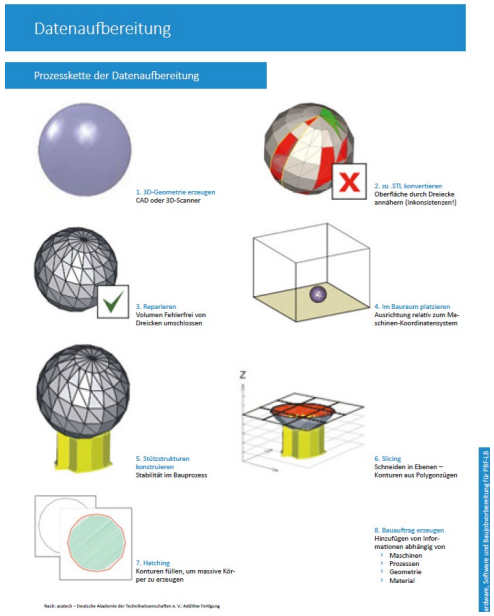
Co-funded by the Erasmus+ Programme of the European Union

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# Teaching Materials Presentation and Script

## e.g. CU 18: Hardware, software and build file set-up for PBF-LB




Script

| CU 18: Hardware, software and build file set-up for PBF-LB | RECOMENDED CONTACT HOURS |
|---|---|
| SUBJECT TITLE | |
| PBF-LB machine set-up requirements | 4 |
| Pre-build check list | 3 |
| Consumables, feedstock & substrate | 3 |
| Build files | 1 |
| Work documentation | 2 |
| Practical implementation of HSE procedures (while fit and set up the machine) | 1 |
| Total | 14 |
| WORKLOAD | 28 |

CLLAIM Guideline

Co-funded by the Erasmus+ Programme of the European Union

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# Statistical Evaluation of Questions

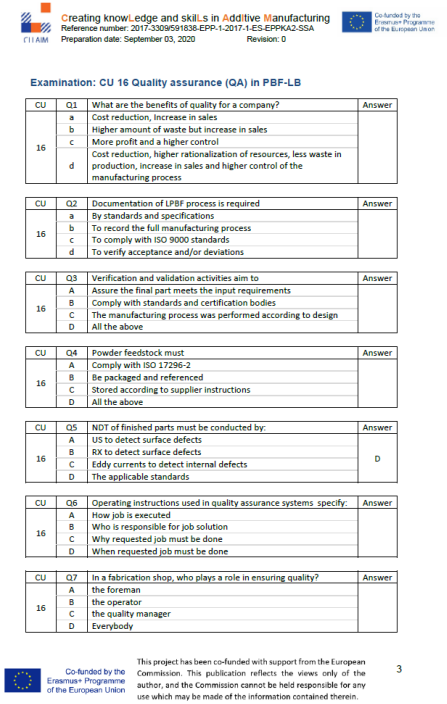
## e.g. CU 16: Quality Assurance (QA) in PBF-LB

| | | Paricipants | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Questions | 1 | 2 | 3 | 4 | 5 | 6 | Right [%] | Wrong [%] |
| CU16 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 100 | 0 |
| | 2 | 0 | 1 | 0 | 1 | 1 | 1 | 67 | 33 |
| | 3 | 1 | 0 | 1 | 1 | 1 | 1 | 83 | 17 |
| | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 100 | 0 |
| | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 100 | 0 |
| | 7 | 1 | 1 | 1 | 0 | 1 | 0 | 67 | 33 |

Legend

> = 50% of the participants answered this question wrong

| CU 16: Quality Assurance (QA) in PBF-LB | RECCOMMENDED |
|---|---|
| SUBJECT TITLE | CONTACT HOURS |
| General QA principles | 2,5 |
| AM Machine QA | 1,5 |
| AM Parts QA | 1 |
| Visual Inspection Overview | 2 |
| Total | 7 |
| WORKLOAD | 14 |



Creating knowLedge and skilLs in Additive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA
Preparation date: September 03, 2020 Revision: 0

Examination: CU 16 Quality assurance (QA) in PBF-LB

| CU | Q1 | What are the benefits of quality for a company? | Answer |
|---|---|---|---|
| 16 | a | Cost reduction, Increase in sales | |
| | b | Higher amount of waste but increase in sales | |
| | c | More profit and a higher control | |
| | d | Cost reduction, higher rationalization of resources, less waste in production, increase in sales and higher control of the manufacturing process | |

| CU | Q2 | Documentation of LPBF process is required | Answer |
|---|---|---|---|
| 16 | a | By standards and specifications | |
| | b | To record the full manufacturing process | |
| | c | To comply with ISO 9000 standards | |
| | d | To verify acceptance and/or deviations | |

| CU | Q3 | Verification and validation activities aim to | Answer |
|---|---|---|---|
| 16 | A | Assure the final part meets the input requirements | |
| | B | Comply with standards and certification bodies | |
| | C | The manufacturing process was performed according to design | |
| | D | All the above | |

| CU | Q4 | Powder feedstock must | Answer |
|---|---|---|---|
| 16 | A | Comply with ISO 17296-2 | |
| | B | Be packaged and referenced | |
| | C | Stored according to supplier instructions | |
| | D | All the above | |

| CU | Q5 | NDT of finished parts must be conducted by: | Answer |
|---|---|---|---|
| 16 | A | US to detect surface defects | |
| | B | RX to detect surface defects | D |
| | C | Eddy currents to detect internal defects | |
| | D | The applicable standards | |

| CU | Q6 | Operating instructions used in quality assurance systems specify: | Answer |
|---|---|---|---|
| 16 | A | How job is executed | |
| | B | Who is responsible for job solution | |
| | C | Why requested job must be done | |
| | D | When requested job must be done | |

| CU | Q7 | In a fabrication shop, who plays a role in ensuring quality? | Answer |
|---|---|---|---|
| 16 | A | the foreman | |
| | B | the operator | |
| | C | the quality manager | |
| | D | Everybody | |

Co-funded by the Erasmus+ Programme of the European Union

This project has been co-funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

3

Co-funded by the Erasmus+ Programme of the European Union

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# Test Results and Recommendations

**Summary**

- 10 Competence Units
- 84 Questions
- 6 Participants
- Average result 79,62 %
- One failed competence unit with less than 60% of the right points
- in the future there should only be one question per contact hour
- **40 contact hours and 40 questions**

**PBF-LB Operator understands the entire process chain**

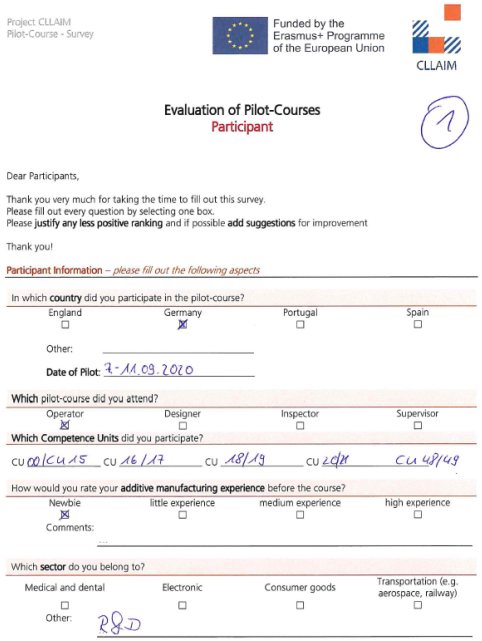
# Evaluation of Pilot-Courses and Comments

## Evaluation

- the teaching materials were elaborated in detail and comprehensibly
- the lecturers were very well prepared
- all questions during the presentations were answered in detail

## Comments

- a comparison between additive manufacturing and conventional processes should be presented
- too many exam questions were asked



Project CLLAIM
Pilot-Course - Survey

Funded by the Erasmus+ Programme of the European Union

CLLAIM

Evaluation of Pilot-Courses
Participant

1

Dear Participants,

Thank you very much for taking the time to fill out this survey.
Please fill out every question by selecting one box.
Please **justify any less positive ranking** and if possible **add suggestions** for improvement

Thank you!

**Participant Information** – *please fill out the following aspects*

In which **country** did you participate in the pilot-course?
England ☐ Germany ☒ Portugal ☐ Spain ☐
Other:
**Date of Pilot:** 7-11.09.2020

**Which** pilot-course did you attend?
Operator ☒ Designer ☐ Inspector ☐ Supervisor ☐

**Which Competence Units** did you participate?
CU 00/CU 15 CU 16/17 CU 18/19 CU 20/21 CU 48/49

How would you rate your **additive manufacturing experience** before the course?
Newbie ☒ little experience ☐ medium experience ☐ high experience ☐
Comments:

Which **sector** do you belong to?
Medical and dental ☐ Electronic ☐ Consumer goods ☐ Transportation (e.g. aerospace, railway) ☐
Other: R&D

Project title: Creating knowLedge and skilLs in AddItive Manufacturing
Reference number: 2017-3309/591838-EPP-1-2017-1-ES-EPPKA2-SSA

CLLAIM

# Many thanks for your attention

Marvin Keinert. M.Sc. IWE

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union