BEAMIT

metal additive manufacturing

EXPERIENCE FROM AM OF TITANIUM COMPONENTS

Beamit MISSION

To **consolidate** a leading position in the **European Market.**

BEAMIT acts as a **specialized technology center** in order to support its high end customers development and be part of their growth.

Beamit at a glance

2 production sites and an R&D plant JV with ASI

SITE A
Fornovo di Taro
Strada Prinzera n.17
(PR) - ITALY

COMPETENCE CENTRE
Rubbiano di Solignano
Via Volta n.40
(PR) - ITALY

SITE B
Rubbiano di Solignano
Via Volta n.40
(PR) - ITALY

PLANT 3
SPACE R&D UNIT
in JV with ASI in Rome

Manufacturing Capabilities & Metrics

Production figures
- 31 Additive Manufacturing Systems
  - 25 Metals of which 2 *EBM, 21 SLM*
  - 5 Polymers Additive Systems
  - 7 AM Systems have large dimension
- 2 Vacuum Hardening Furnaces
- 1 Air Furnace
- Post Machining Instruments
- *HIPping (outsourced)*

Performance metrics
- Investments: ~5 mln/€ (2018)
- Total amount machine hours: ~100.000
- Scrap rate: < 5%
- Customer complaint: 0,8%
- Employees: 48 people

Materials & Customer KPIs

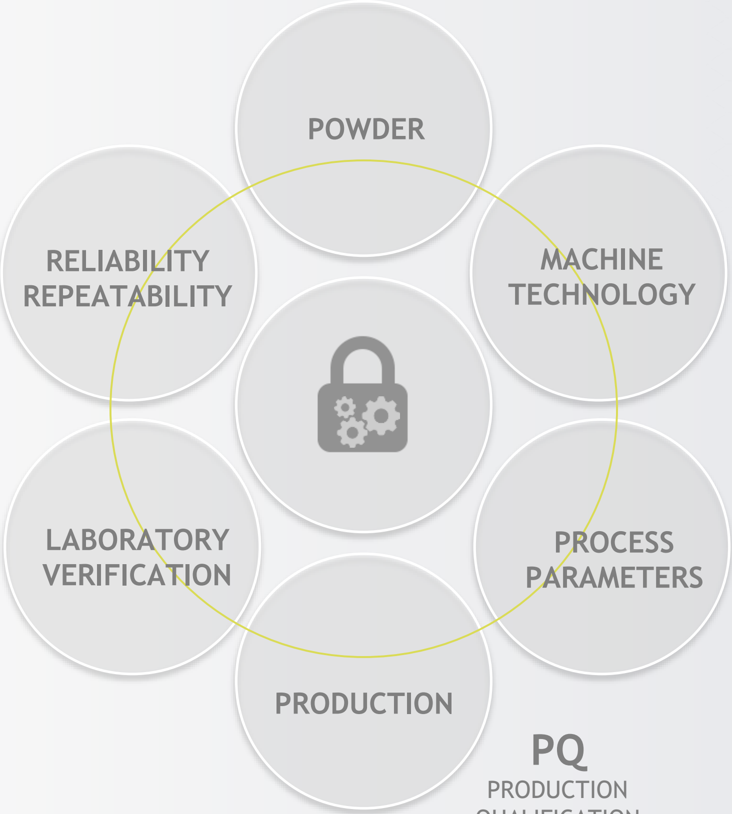
Probably the highest number of materials qualified for a single AM player in Europe:
- 17-4 PH, 15-5 PH, AISI 316L: 25%
- CoCrMo: 1%
- AlSi10Mg: 25%
- Ti6Al4V: 35%
- Inconel 718, Inconel 625, Inconel 939, Hastelloy X: 10%
- Silver, Copper, Polymers: 4%
- CX
- Zirconia (on-going development)

BEAMIT serves the entire chain with a ONE STOP SHOP STRATEGY

TOPOLOGICAL OPTIMIZATION	AM FABRICATION	HEAT TREATMENT	MACHINING	SURFACE FINISHING	QUALITY CONTROLS
- Partnership with *ALTAIR* - Partnership with *MSC SOFTWARE*	- DMLM - SLM - EBM - X-JET	*NADCAP accreditated*	- Deburring - Support removal - 5-axis milling - Turning - EDM wire cutting	- Sandblasting - Shotblasting - Grinding - Surfaces special finishing	- Micrography - NDI - Tomography - Mechanical tests - Fatigue test

FROZEN PROCESSES

SCIENTIFIC DEVELOPMENT of **PROCESSES** and **PARAMETERS**



IQ
INSTALLATION QUALIFICATION

Technical Purchasing Specification Inconel 718

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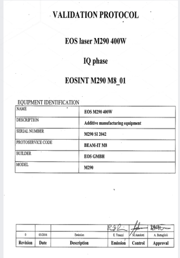


VALIDATION PROTOCOL

EOS laser M290 400W

IQ phase

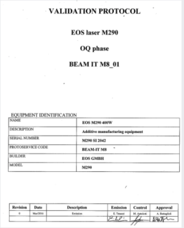
EOSINT M290 M8_01

EQUIPMENT IDENTIFICATION

NAME	EOS M290 400W
DESCRIPTION	Additive manufacturing equipment
SERIAL NUMBER	M290 SI 2042
PROTOSERVICE CODE	BEAM-IT M8
BUILDER	EOS GMBH
MODEL	M290

Revision	Date	Description	Emission	Control	Approval

OQ
OPERATION QUALIFICATION



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EOS laser M290

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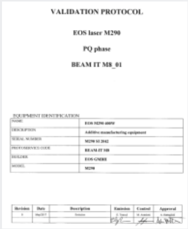


VALIDATION PROTOCOL

EOS laser M290

PQ phase

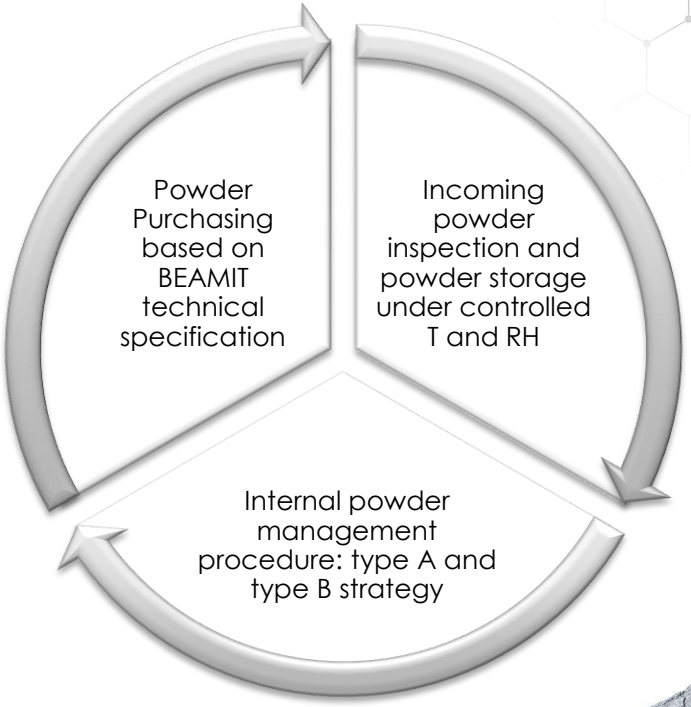
BEAM IT M8_01

PQ
PRODUCTION QUALIFICATION

Everything starts from POWDER…

Powder management for AM is a crucial process:

- Lack of cosciousness from powder manufacturer of main powder-SLM related issues
- Lack of stardard for testing several characteristics (e.g. Powder Moisture)
- Lack of standard for powder re-use and traceabilty
- Many different re-use/sieving solutions from AM machine suppliers (e.g. manual sieving, automatic sieving, etc..)
- Different vocabulary meanings



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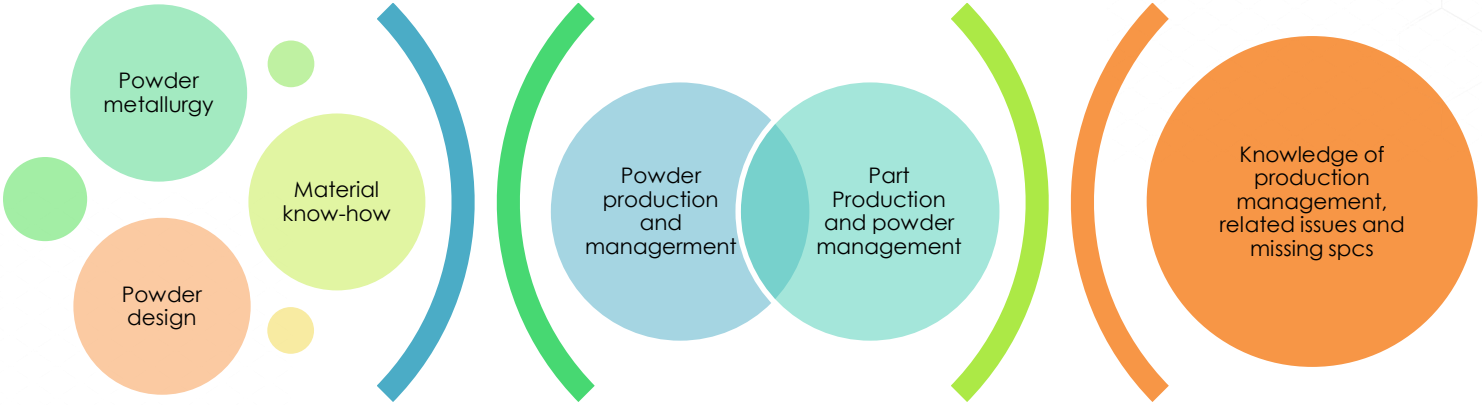


SANDVIK

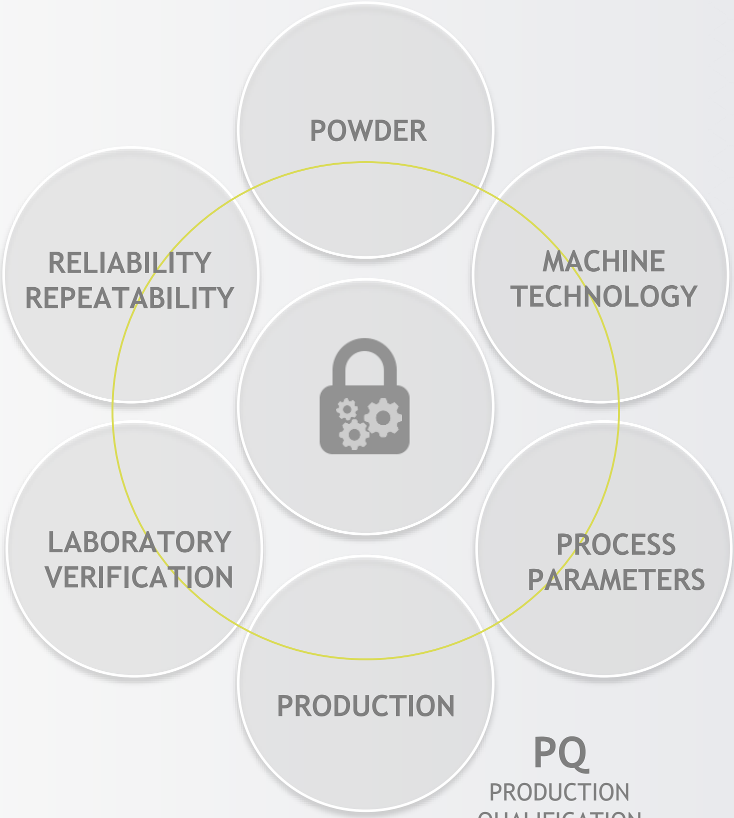
SYNERGIC WORK-EFFECT TO IMPROVE THE PROCESS QUALITY

BEAMIT
metal additive manufacturing


PowderFlowKit:
- Flowability
• Hall funnel (ASTM B213)
• Carney funnel (ASTM B964)
- Apparent density
• With Hall funnel (ASTM B212)
• With Carney funnel (ASTM B417)
Tap density
ASTM B525
Powder Granulometry by LASER diffraction
ASTM B822
Powder Morfology
Powder Granulometry with Sieve Analysis
ASTM B212
VIETATO FUMARE
POWDERFLOW

FROZEN PROCESSES

SCIENTIFIC DEVELOPMENT of **PROCESSES** and **PARAMETERS**



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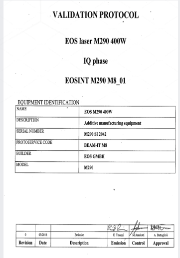
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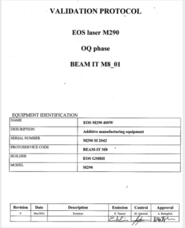
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EOS laser M290

OQ phase

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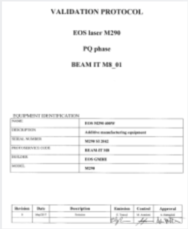
VALIDATION PROTOCOL

EOS laser M290

PQ phase

BEAM IT M8_01

PQ
PRODUCTION QUALIFICATION

INSTALLATION QUALIFICATION

- ➢ To Check the installation results
- ➢ To Compile the installation qualification report

VALIDATION PROTOCOL

EOS laser M290 400W

IQ phase

EOSINT M290 M8_01

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0	05/2016	Emission	E. Trauzzi	M.Annoletti	A. Battaglioli
Revision	Date	Description	Emission	Control	Approval

SLM SOLUTIONS | Form sheet Technical Inspection Report and Quality Certificate SLM®500HL | FB-60 (3-FAT) Page 1 of 16 V.13 – 2019/07/25

Customer information

Customer	BEAMIT	Customer #	71007
Address	Strada Prinzera 17 I-43045 Formovo di Taro	Customer order #	Partner Agreement No.2
		Internal order #	1040220
		Project #	75401
Contact	-	Order date	2019/09/17

System information

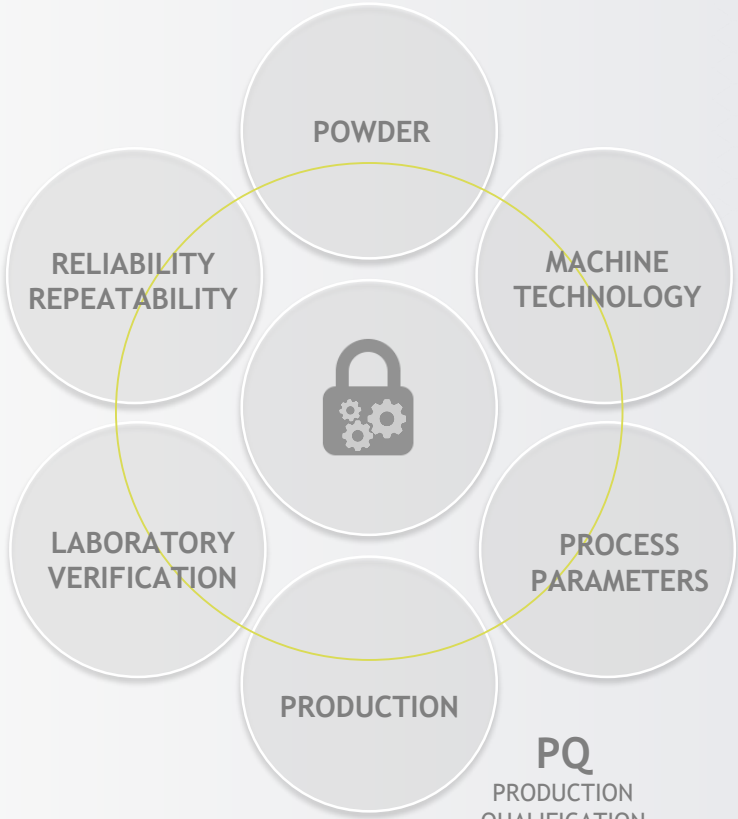
System	SLM 500 Quad+PSV+PRS	Serial #	50.17.0238
Description	Selective Laser Melting System	Condition	☒ new
DIN-VDE inspection norm	DIE VDE 0113 EN60204-1		☐ refurbished
Manual version	SLM-BA_SLM500 1.1-PSV-PRS-2018-09-11_it	Year of manufacture	2017/12
Circuit diagram #	SLM500_1.1.002		

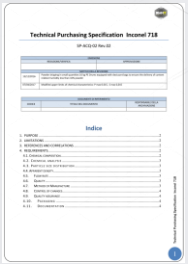
SLM® - Selective Laser Melting
Quality assurance summary

SLM Solutions Group AG, Telefon: +49 451 4060-3000. Fax: +49 451 4060-3250. E-Mail: info@slm-solutions.com

FROZEN PROCESSES

SCIENTIFIC DEVELOPMENT of **PROCESSES** and **PARAMETERS**

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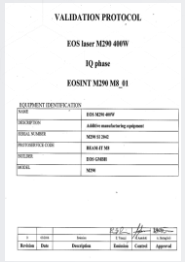
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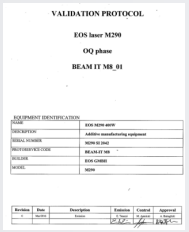
EOS laser M290 400W

IQ phase

EOSINT M290 MB_01

OQ
OPERATION QUALIFICATION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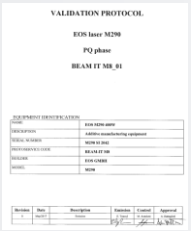
BEAM IT MB_01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EOS laser M290

PQ phase

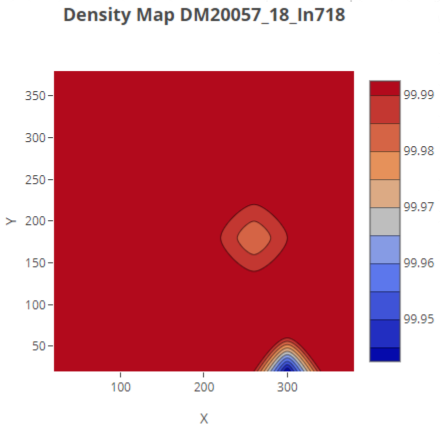
BEAM IT MB_01

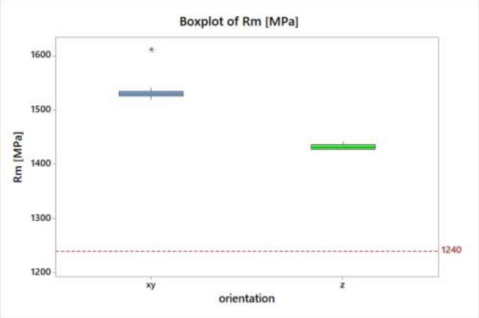
PQ
PRODUCTION QUALIFICATION

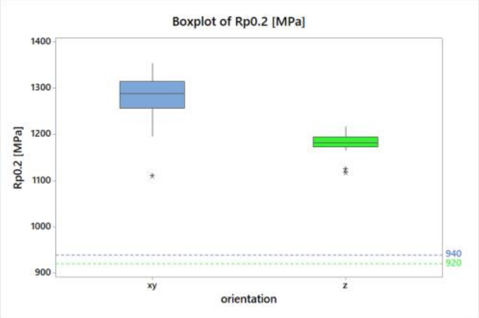
OPERATION QUALIFICATION

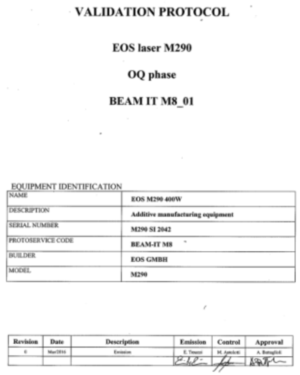
- To Check the system performance:
  - Density map analysis
  - Tensile test

- To Compile the operation qualification report









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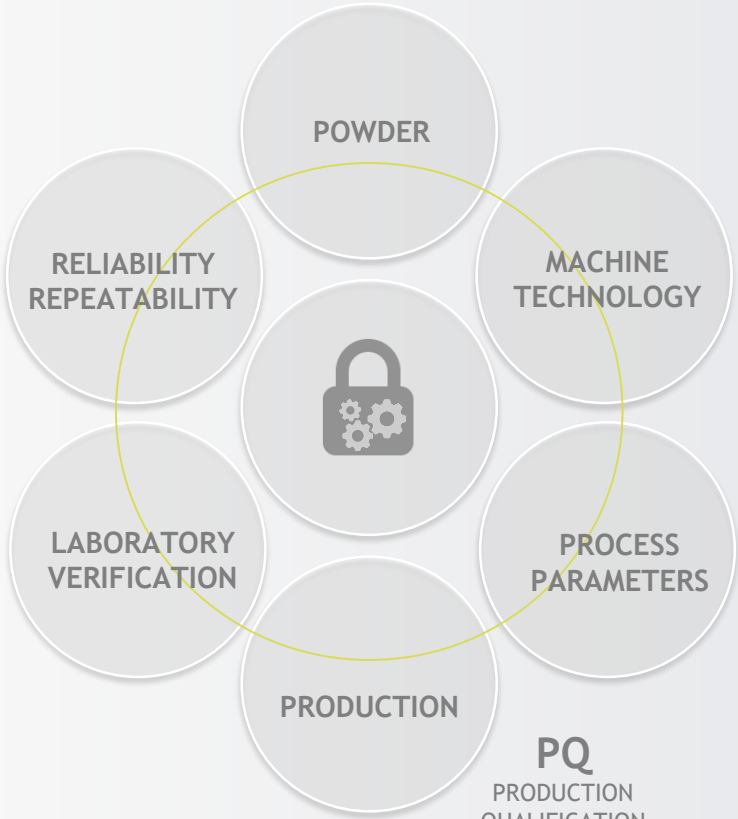

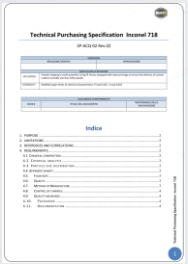
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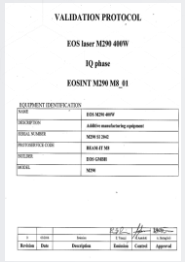
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IQ phase

EOSINT M290 MB_01

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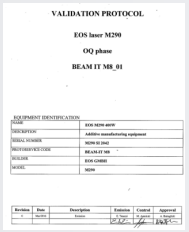
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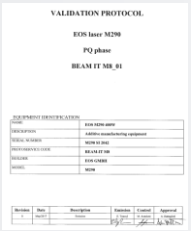

VALIDATION PROTOCOL

EOS laser M290

PQ phase

BEAM IT MB_01

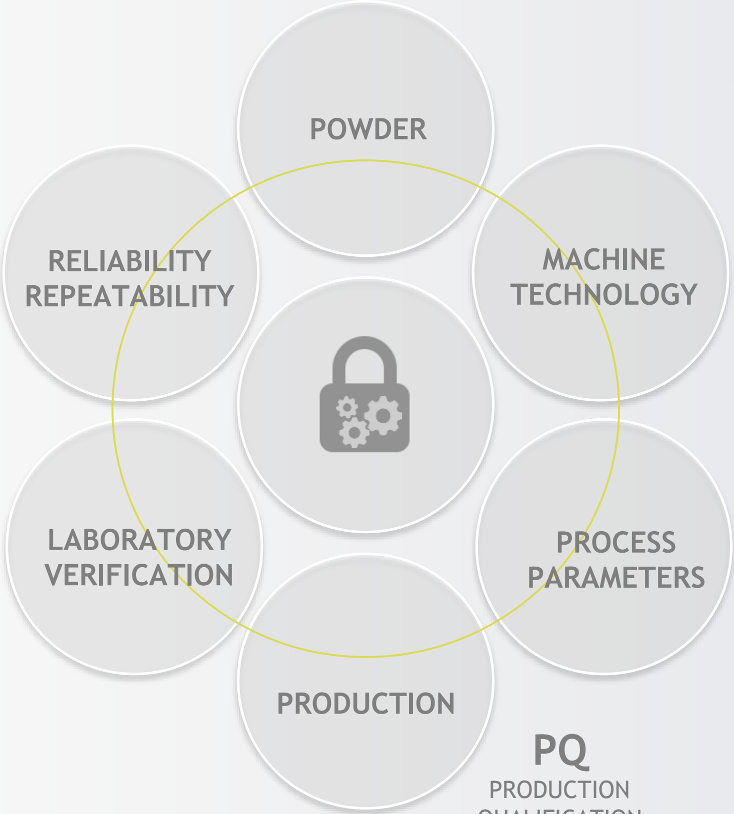
PQ
PRODUCTION QUALIFICATION

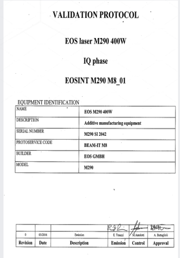
PRODUCTION QUALIFICATION

- Configuration control for serial production requires the following criteria:
  - Process parameter, parts orientation and support definition
  - First start of production needs in-deep control analyses (tensile tests, part cut-up, CT scan, FAI, etc)
  - Definition of controls needed for serial production
  - Validation report emission

FROZEN PROCESSES

SCIENTIFIC DEVELOPMENT of **PROCESSES** and **PARAMETERS**





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INSTALLATION QUALIFICATION

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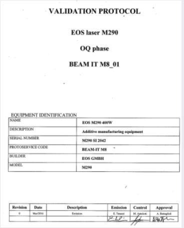


PQ
PRODUCTION QUALIFICATION

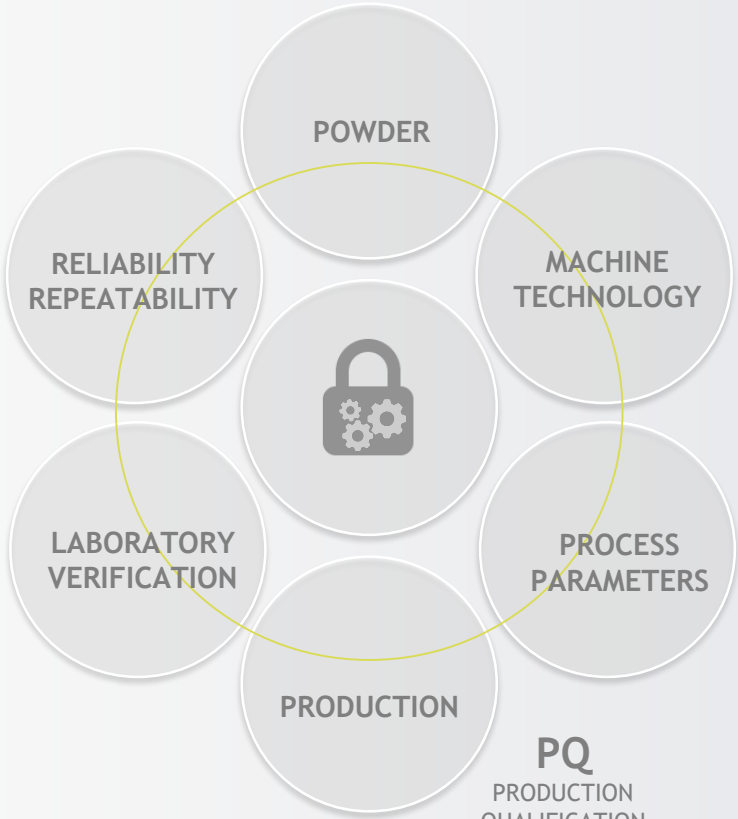
LABORATORY VERIFICATION

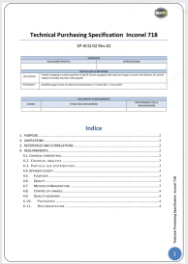
Metallographic Laboratory
- Material density measurement
- Metallographic analysis

Mechanical test Laboratory
- Hardness tests (NADCAP ACCREDITED)
- Tensile tests

FROZEN PROCESSES

SCIENTIFIC DEVELOPMENT of **PROCESSES** and **PARAMETERS**

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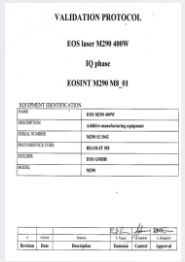
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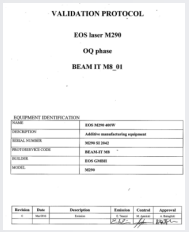
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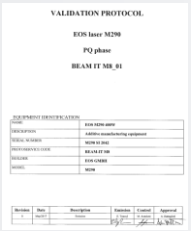
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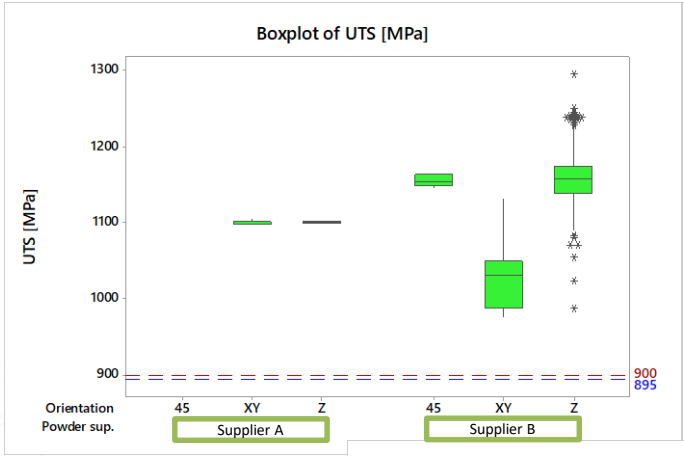
PRODUCTION QUALIFICATION

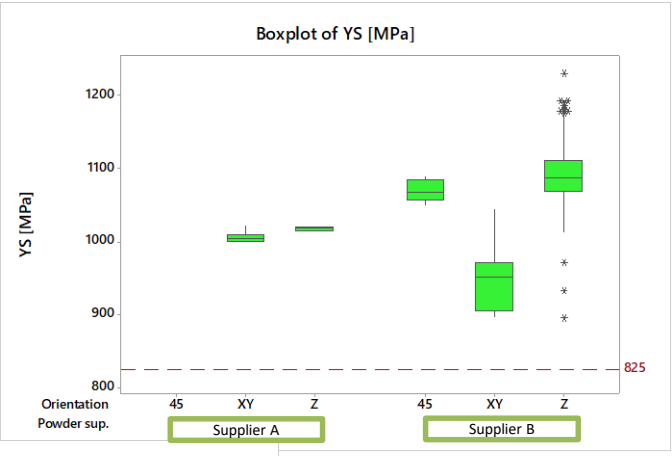
BEAMIT

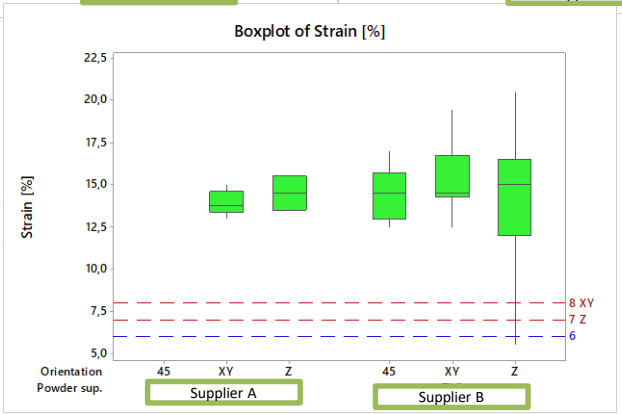
metal additive manufacturing

TI6AL4V MECHANICAL CHARACTERIZATION

ADDITIVE MANUFACTURED Ti6Al4V







- ASTM F2924

- Ti64 qualified on EOS M290 and M400-4
- Two different qualified powder supplier

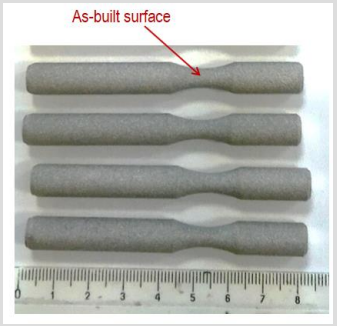
*5 years long statistic

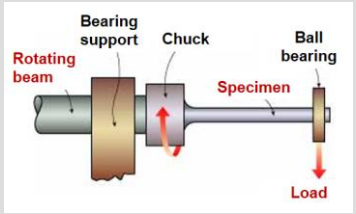
FATIGUE TESTING USING STANDARD SPECIMENS

AS-BUILT VS MACHINED SURFACES

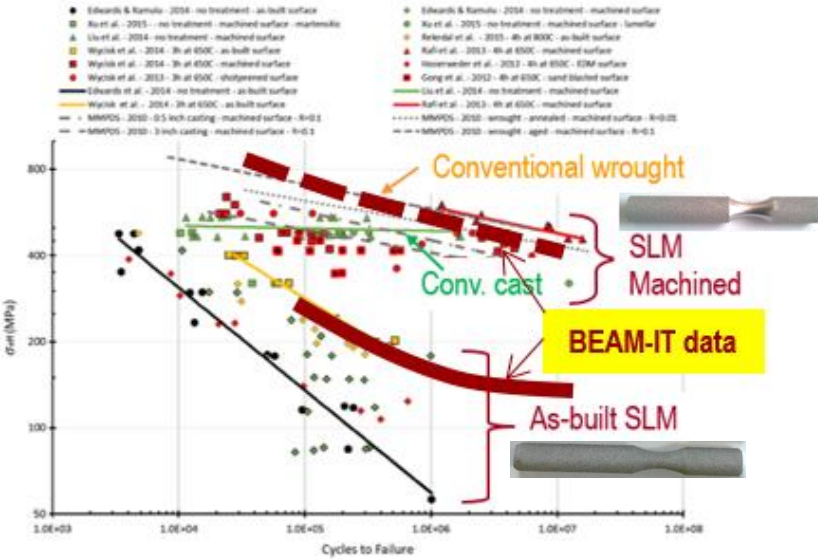
CONVENTIONAL SPECIMEN AND TEST METHOD

- Standard smooth geometry
- Min diameter: 6 mm
- Axis paralle to build (Z)
- Rotating bending (R=-1)
- Frequency: 50 Hz
- Runout: 10^7 cycles

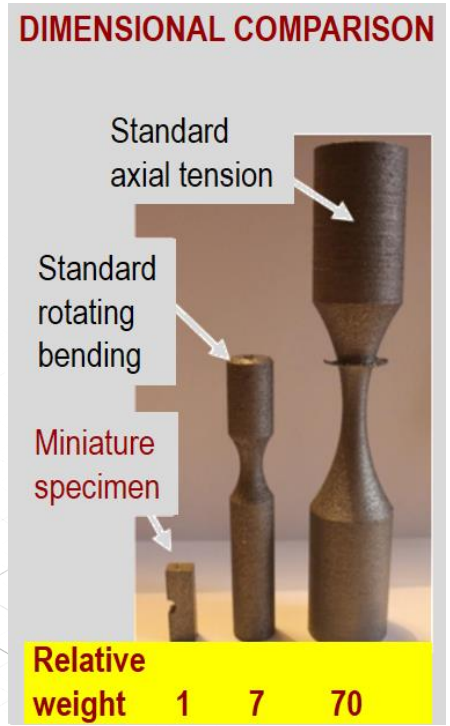




LITERATURE DATA VS BEAM-IT DATA

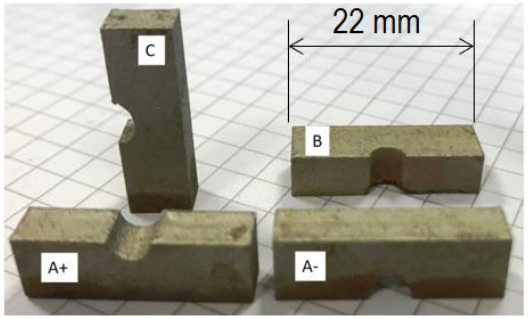


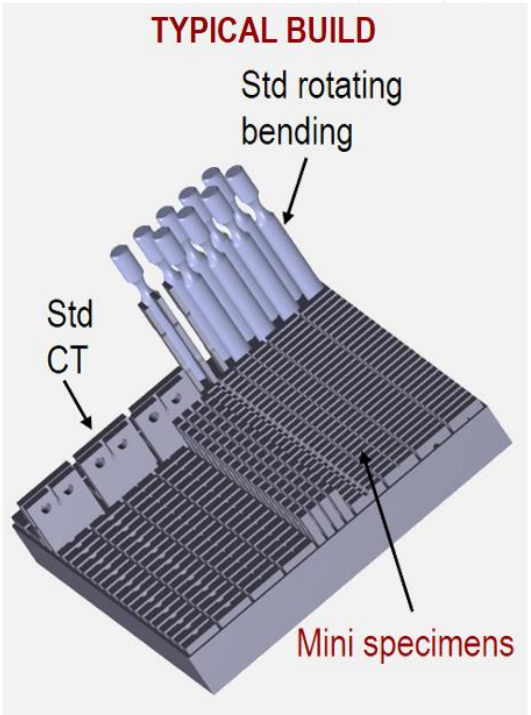
INNOVATIVE testing method-> MINIATURE SPECIMENS



DETAILS OF SPECIMEN

- Dimensions: 22 x 7 x 5 mm^3
- Round notch R 2 mm
- Different orientations with respect to build



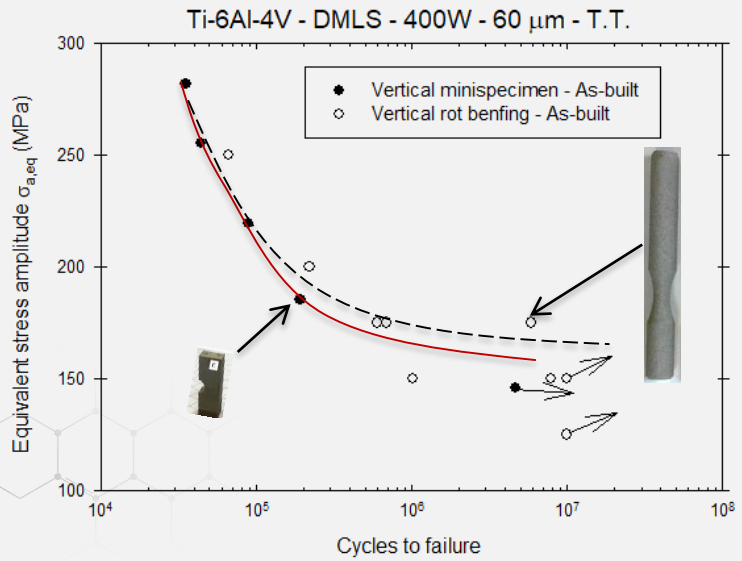


Source: G. Nicoletto, Int J Fatigue, 2017

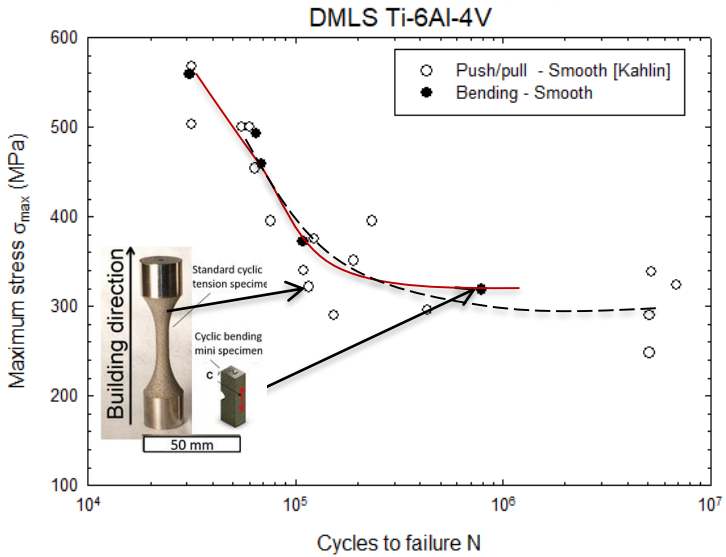
NEW TEST METHOD VALIDATION

FATIGUE OF L-PBF Ti6Al4V

PLANE BENDING VS. ROTATING BENDING



PLANE BENDING VS. CYCLIC TENSION



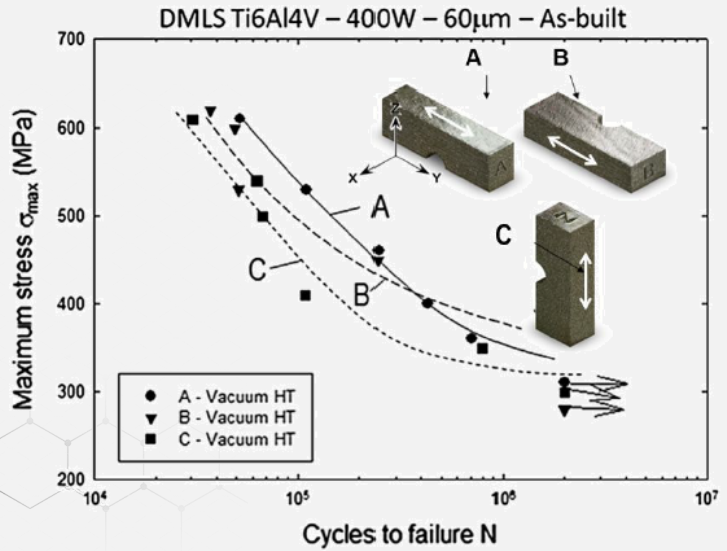
Smooth cyclic tension : M. Kahlin – SAAB /Univ. Linkoeping

Source: **G. Nicoletto (2017)** "Anisotropic high cycle fatigue behavior of Ti–6Al–4V obtained by powder bed laser fusion", **International Journal of Fatigue**, Vol. 94, 255-262

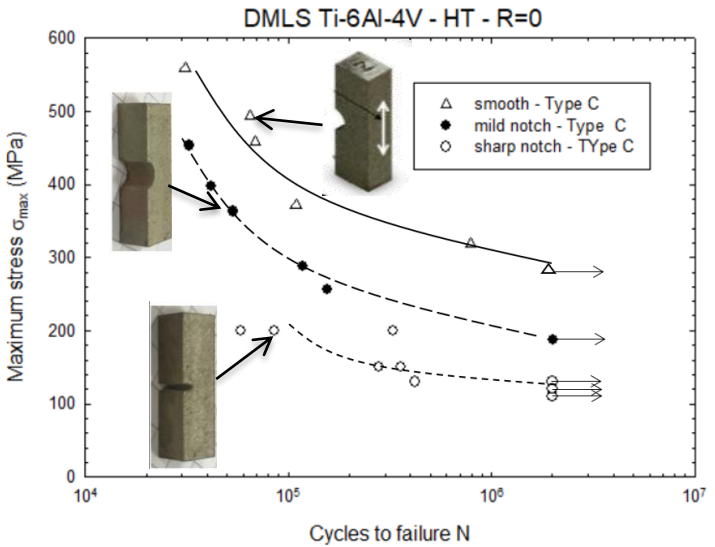
NEW KNOWLEDGE IN FATIGUE OF TI64

FATIGUE OF L-PBF Ti6Al4V

DIRECTIONAL SMOOTH FATIGUE BEHAVIOR



NOTCH FATIGUE BEHAVIOR



Source: **G. Nicoletto (2018)**, "Directional and notch effects on the fatigue behavior of as-built DMLS Ti6Al4V" **International Journal of Fatigue**, Vol. 106, 124-131

TI6AL4V APPLICATION EXAMPLE

BEAMIT

metal additive manufacturing

HIGH-END INDUSTRY PERSPECTIVE

MOTORSPORT

Customer	**HAAS F1**
Project	VF-19
Starting date	04/2014
Purpose	DfAM, process qualification and manufacturing of a roll cage (E.G. ROLL HOOP - CRITICAL)
Deliverable	Specimens => 12pcs total (Tensile) 1 P/N Qualified => 25 parts delivered (2016-2017-2018-2019)
Material	Ti6Al4V
Process	EOS M400-4
TRL	6
MRL	6
ON TIME	96%
ON QUALITY	100%
FORECAST	5 per year

The Lunar Project

BEAMIT

metal additive manufacturing