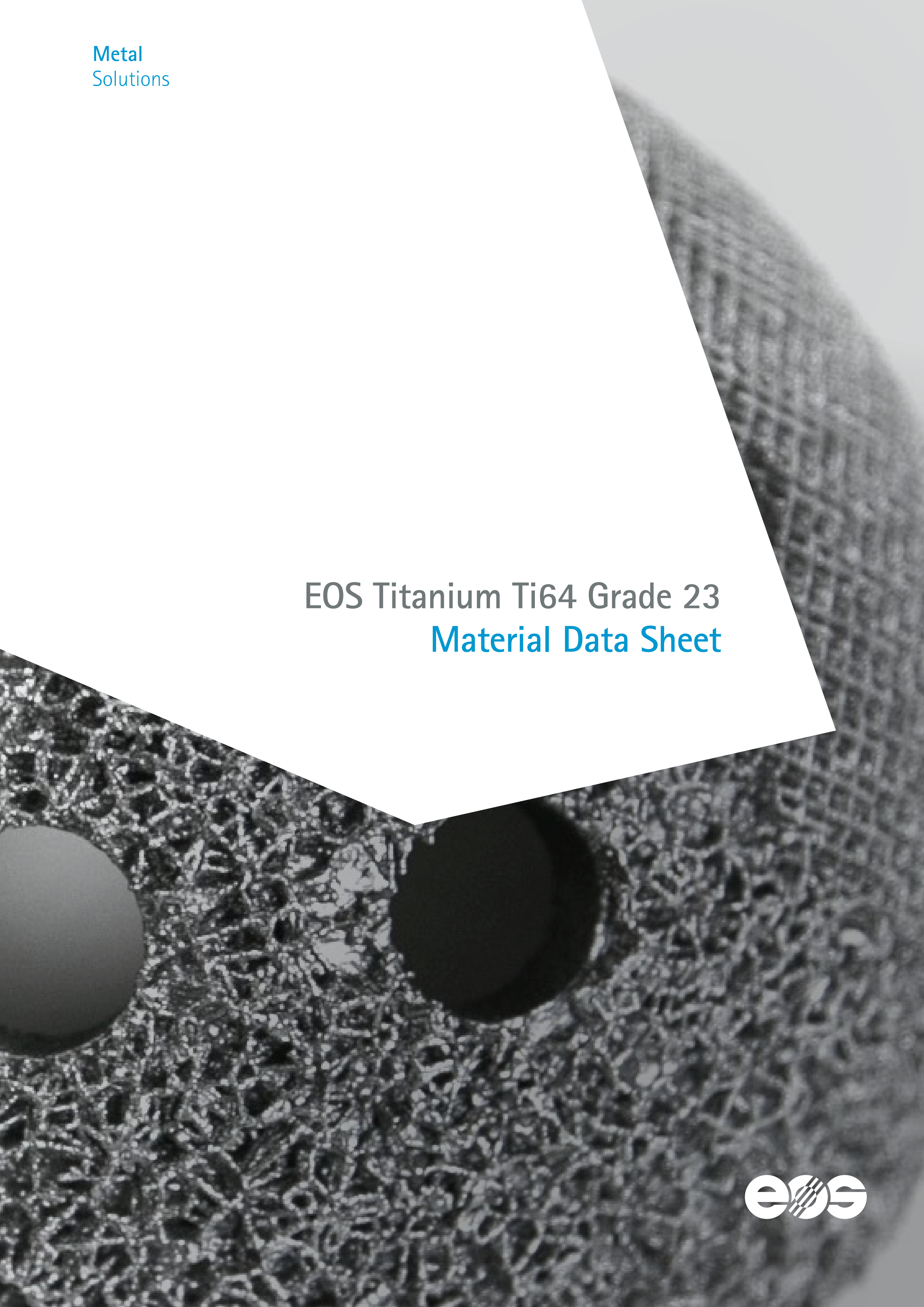
Metal
Solutions

EOS Titanium Ti64 Grade 23
Material Data Sheet



EOS Titanium Ti64 Grade 23

EOS Titanium Ti64 Grade 23 is a Ti6Al4V alloy with lower amount of oxygen and iron compared to the standard Ti64 alloy. The material is well-known for having excellent mechanical properties: low density with high strength and excellent corrosion resistance.
Compared to Ti64, Ti64ELI has better elongation and toughness, but lower strength. Generally, Ti64ELI alloys are considered to be biocompatible and have low specific weight compared to CoCr alloys.

Parts built with EOS Titanium Ti64 Grade 23 powder can be machined, shot peened and polished in as manufactured and heat treated states.
Due to the layerwise building method, the parts have a certain anisotropy. Heat treatment is recommended to reduce internal stresses and increase ductility.

EOS Titanium Ti64 Grade 23 powder can be used on the EOS M 290 with a 40 µm and 80 µm process and on the EOS M 400-4 with an 80 µm process.

Main Characteristics:

- Low weight combined with high strength
- Excellent corrosion resistance
- High fatigue resistance compared to other lightweight alloys
- The parts fulfill chemical requirements for Grade 23 alloy

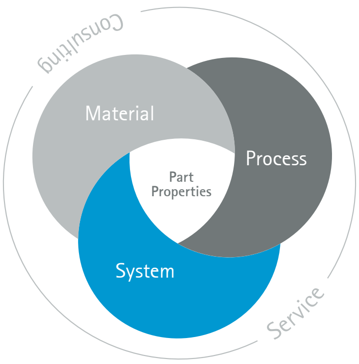
Typical Applications:

- Medical components
- Implants
- Other industrial applications where low weight in combination with high strength are required

The EOS Quality Triangle

EOS uses an approach that is unique in the AM industry, taking each of the three central technical elements of the production process into account: the system, the material and the process – together simply described as the Quality Triangle. EOS focuses on delivering reproducible part properties for the customer.

All of the data stated in this material data sheet is produced according to EOS Quality Management System and international standards.



Powder Properties

EOS Titanium Ti64 Grade 23 powder is classified as Grade 23 titanium alloy according to ASTM B348. The chemical composition is in compliance with standards ASTM F136, ASTM F3001, and ASTM F3302.

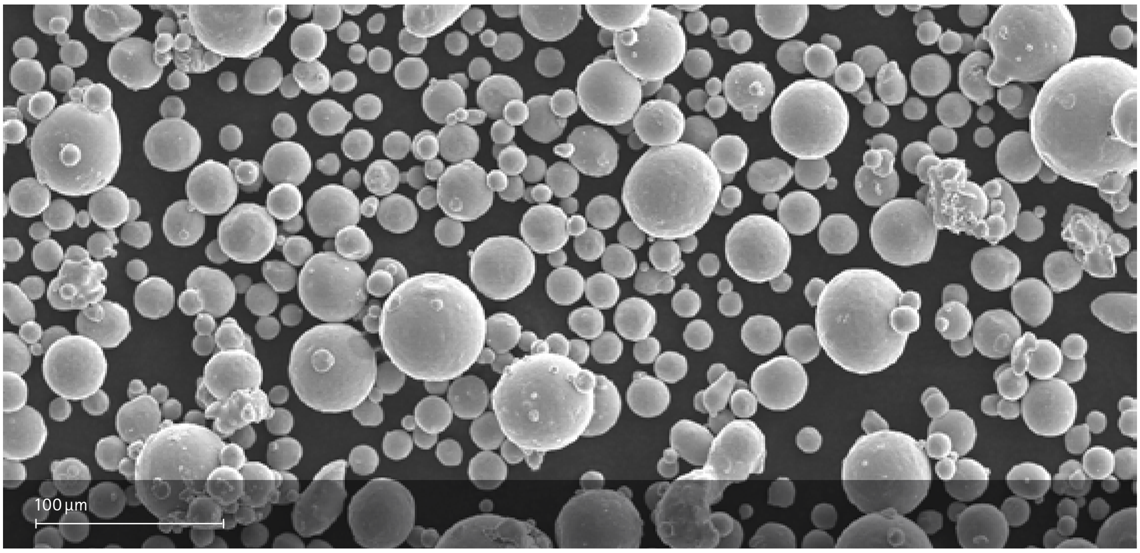
Powder chemical composition (wt.-%)

Element	Min.	Max.
Ti	Balance	
Al	5.50	6.50
V	3.50	4.50
O	–	0.13
N	–	0.05
C	–	0.08
H	–	0.012
Fe	–	0.25
Y	–	0.005
Other elements, each	–	0.10
Other elements, total	–	0.40

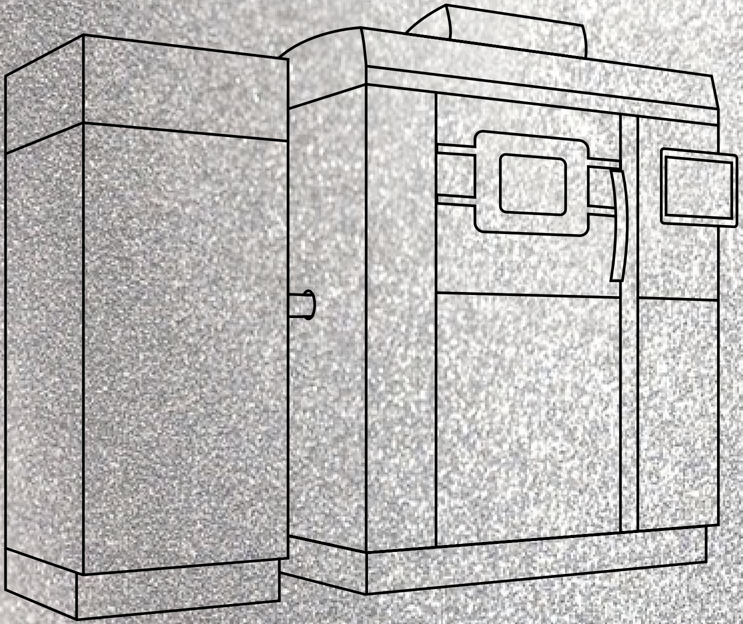
Powder particle size

Generic particle size distribution	20 – 80 µm

SEM picture of EOS Titanium Ti64 Grade 23 powder.



TRL 7
Premium



EOS Titanium Ti64 Grade 23
for EOS M 290 | 40 µm

Process Information
Heat Treatment
Physical Part Properties
Mechanical Properties
Additional Data

V1.0, CR617, 2019-02

EOS Titanium Ti64 Grade 23 for EOS M 290 | 40 µm

High Fatigue Strength without HIP

This process product was developed specifically for the production of parts with high fatigue strength without the need for Hot Isostatic Pressing (HIP).

Main Characteristics:

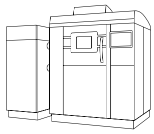
- → Robust production of parts in small series and series production
- → Improved fatigue strength compared to previous generation EOS Titanium Ti64ELI products
- → Possibility for shortened overall production time by avoiding HIP as post-process treatment step

Process Information

System set-up	EOS M 290
EOS ParameterSet	M 290 Ti64 Grade23 040 V1
EOSPAR name	Ti64_Grade23_040_HiPerM291_100
Software requirements	EOSPRINT 2.5 or newer EOSYSTEM 2.8 or newer
Powder part no.	9011-0046
Recoater blade	EOS HSS blade
Nozzle	EOS grid nozzle
Inert gas	Argon
Sieve	90 µm

Additional information	
Layer thickness	40 µm
Volume rate	6.2 mm^3/s
Min. wall thickness	Approx. 0.4 mm

Chemical and Physical Properties of Parts



The chemical composition of parts is in compliance with standards ASTM F136, ASTMF3001, and ASTM F3302. Composition complies with EOS Titanium Ti64 Grade 23 powder.

Heat treated microstructure. Etched according to ASTM E407 modified recipe #190.

The areal defect percentage was determined from cross-cuts of the built parts using optical microscope fitted with a camera and analysis software. The analysis was carried out for a sample area of 15 x 15 mm. The defects were detected and analyzed with an image capture/analysis software with an automatic histogram based filtering procedure on monochrome images. The density of the built specimen was measured according to ISO3369.

Defects	**Result**	**Number of samples**
Average defect percentage	0.01 %	30
Density, ISO3369	**Result**	**Number of samples**
Average density	≥ 4.4 g/cm^3	10

Heat Treatment

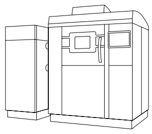
As manufactured microstructure for additively manufactured Ti64ELI consists of fully acicular alpha prime (α') phase. Standard heat treatments for titanium do not necessarily produce desired microstructures due to this different starting microstructure.

Heat treatment is recommended to relieve stresses and to increase ductility. Use of vacuum furnace is highly recommended to avoid the formation of alpha case on the surface of the parts.

Heat Treatment Description:
120 min (± 30 min) at 800 °C (± 10 °C) measured from the part in vacuum (1.3 x 10^{-3}-1.3 x 10^{-5} mbar) followed by cooling under vacuum or argon quenching. Material mechanical properties are relatively insensitive to changes in heating and cooling rates, but longer treatment times may result in decreased strength and increased elongation.

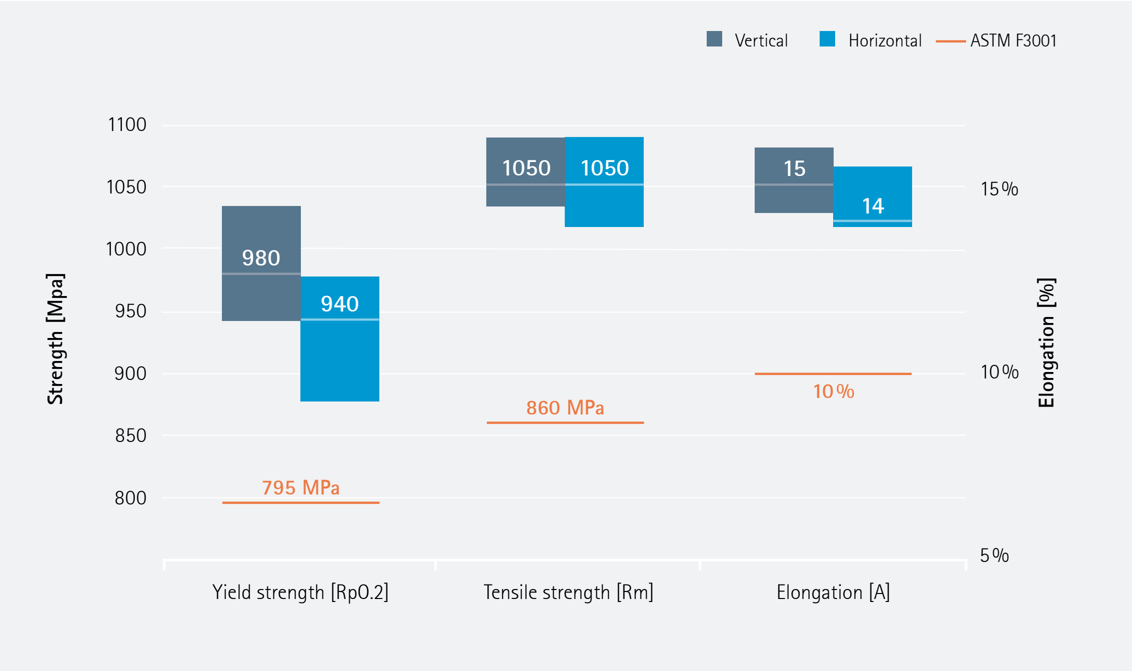
Parts heat treated according to the recommended heat treatment have a microstructure consisting of fine alpha + beta (α + β) phase.

Mechanical Properties in Heat Treated State

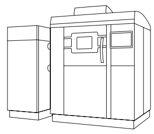


Mechanical properties ISO6892-1

	Yield strength Rp0.2 [MPa]	Tensile strength Rm [MPa]	Elongation at break A [%]	Reduction of area Z [%]	Number of samples
Vertical	980	1050	15	≥ 25	84
Horizontal	940	1050	14	≥ 25	72



Additional Data

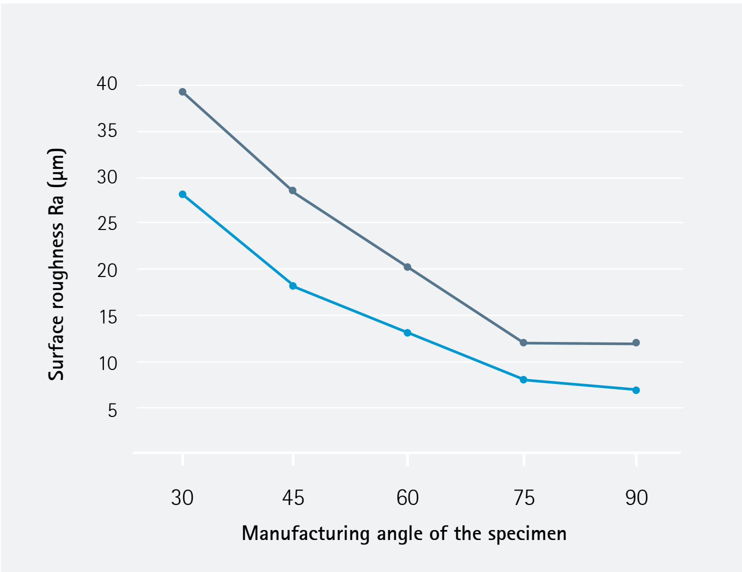


Fatigue Strength

Fatigue strength determines a stress level where specimen fails at a defined number of stress cycles [ISO 12107]. Fatigue strength was estimated statistically according to ISO 12107. Testing was done according to ASTM E466. Fatigue results typically show large deviations due to the nature of the fatigue process [ISO 12107].

Fatigue strength at 1 x 10^7 cycles in heat treated state	
Fatigue strength, MPa	589 MPa

Surface Roughness



The surface quality was characterized by optical measurement method from down-facing surfaces according to internal procedure. The 90 degree angle corresponds to vertical surface.

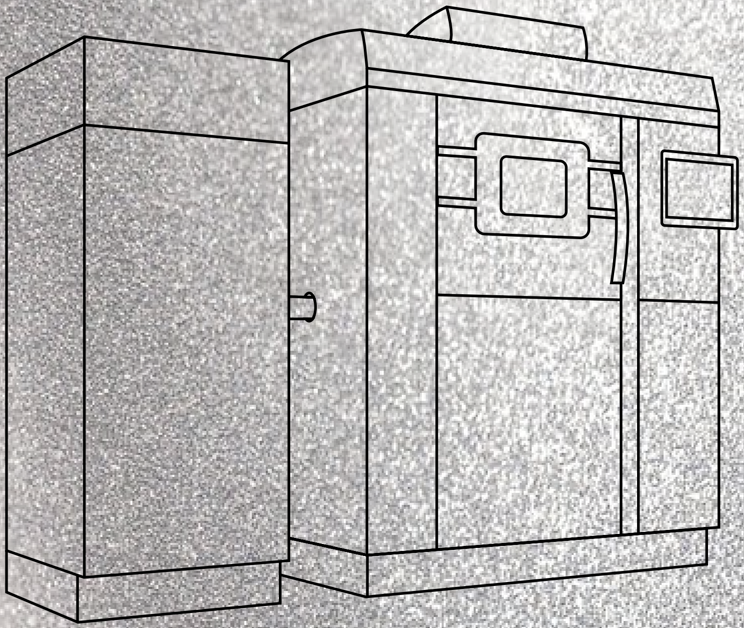
Coefficient of Thermal Expansion ASTM E228

Temperature	25 – 100 °C	25 – 200 °C	25 – 300 °C
CTE	9.0 $*10^{-6}$/K	9.4 $*10^{-6}$/K	9.7 $*10^{-6}$/K

Cytotoxicity

The cytotoxicity of EOS Titanium Ti64 Grade 23 plate samples was evaluated using an in vitro method according to ISO 10993-1: 2009, ISO 10993-5: 2009 and ISO 10993-12: 2012. In this study under the given conditions no leachable substances were released in cytotoxic concentrations from the test item as confirmed by two different endpoints (XTT, BCA). It is the responsibility of the producer of a part to validate biocompatibility as well as its suitability for a particular purpose. EOS has not FDA cleared this product for medical device manufacturers to use this material in FDA sensitive applications.

TRL 3
Core



EOS Titanium Ti64 Grade 23
for EOS M 290 | 80 µm

Process Information
Physical Part Properties

V3.0, preCR09, 2020-05

EOS Titanium Ti64 Grade 23 for EOS M 290 | 80 µm

Process Information

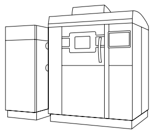
This process product is optimized for faster production of parts with properties according to ASTM F136. For most demanding applications, Hot Isostatic Pressing (HIP) is recommended to optimize high cycle fatigue properties

Main Characteristics:

- Parameter set for fast and cost efficient production of Ti64ELI parts in small series or serial production
- 15 - 30 % faster than EOS Ti64 Speed (60 µm) parameter set
- 50 % faster than EOS Ti64 Grade 23 HiPer (40 µm) parameter set
- Industries that require hot isostatic pressing (HIP) as standard post-treatment, the parameter set enables faster production.

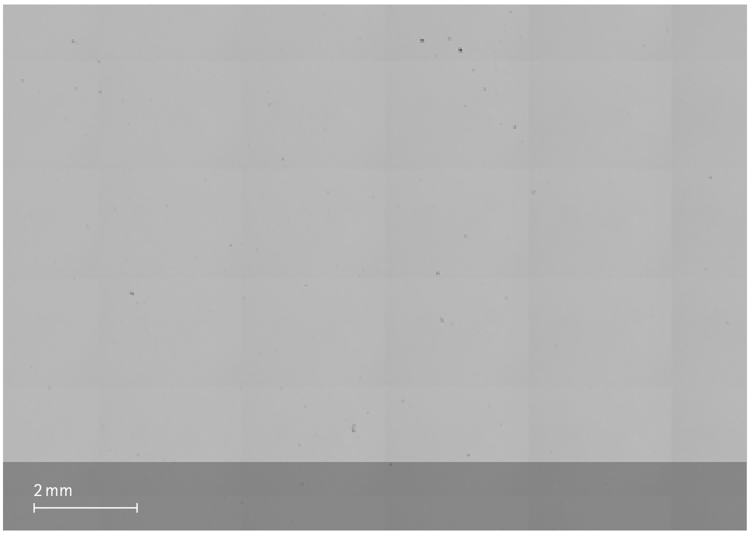
System set-up	EOS M 290
EOS ParameterSet	M 290 Ti64 Grade 23 080 V1
EOSPAR name	Ti64Grade23_080_CoreM291_100
Software requirements	EOSPRINT 2.5 or newer EOSYSTEM 2.8 or newer
Powder part no.	9011-0046
Recoater blade	EOS HSS blade
Nozzle	EOS grid nozzle
Inert gas	Argon
Sieve	90 µm

Additional information	
Layer thickness	80 µm
Volume rate	12.0 mm^3/s



Chemical and Physical Properties of Parts

The chemical composition of parts is in compliance with standards ASTM F136, ASTM F3001, and ASTM F3302. Composition complies with EOS Titanium Ti64 Grade 23 powder.



Defects	Result
Average defect percentage	<0.1 %*
Surface roughness Ra	**Result**
Vertical	9 µm

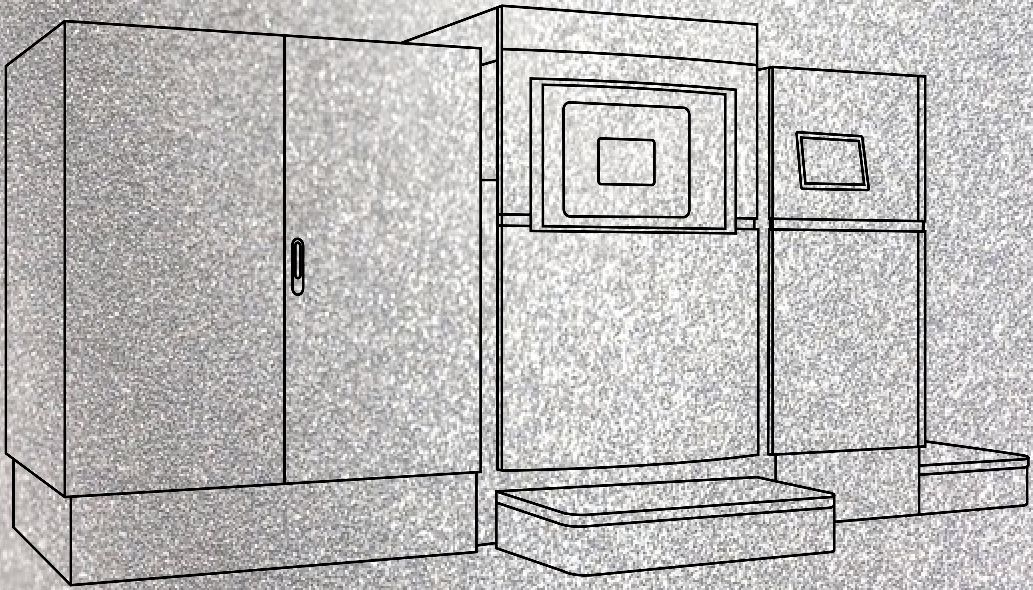
** Defect% varies with platform position.*

Typical properties

	Yield strength $R_{p0.2}$ [MPa]	Tensile strength R_m [MPa]	Elongation at break A [%]	Reduction of area Z [%]	Fatigue strength N = 9
Heat treated horizontal	1,000	1,100	15	> 25	-
Heat treated vertical	1,020	1,110	15**	> 25**	
HIP horizontal	900	1,010	16	> 25	675 MPa
HIP vertical	920	1,020	16	> 25	

High cycle fatigue strength was estimated statistically according to ISO 12107.
Testing was done according to ASTM E466 with run-out limit 10^7 cycles.
*** Mean values above the standard limit, some outliers below the limit.*

TRL 3
Core



EOS Titanium Ti64 Grade 23
for EOS M 400-4 | 80 µm

Process Information
Physical Part Properties

V3.0, preCR09, 2020-05

EOS Titanium Ti64 Grade 23 for EOS M 400-4 | 80 µm
Process Information

This process product is optimized for faster production of parts with properties according to ASTM F136. For most demanding applications, Hot Isostatic Pressing (HIP) is recommended to optimize high cycle fatigue properties

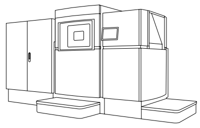
Main Characteristics:

- → Parameter set for fast and cost efficient production of Ti64ELI parts in small series or serial production
- → 15 - 30 % faster than EOS Ti64 Speed (60 µm) parameter set
- → Industries that require hot isostatic pressing (HIP) as standard post-treatment, the parameter set enables faster production.

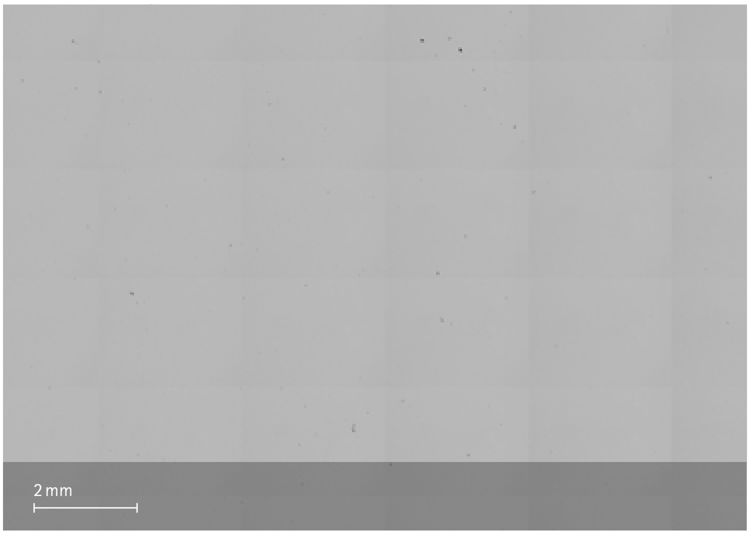
System set-up	EOS M 400-4
EOS ParameterSet	M 400-4 Ti64 Grade 23 080 V1
EOSPAR name	Ti64Grade23_080_CoreM404_100
Software requirements	EOSPRINT 2.5 or newer EOSYSTEM 2.8 or newer
Powder part no.	9011-0046
Recoater blade	EOS HSS blade
Inert gas	Argon
Sieve	90 µm

Additional information	
Layer thickness	80 µm
Volume rate	4 x 12.0 mm^3/s

Chemical and Physical Properties of Parts



The chemical composition of parts is in compliance with standards ASTM F136, ASTM F3001, and ASTM F3302. Composition complies with EOS Titanium Ti64 Grade 23 powder.



Defects	Result
Average defect percentage	<0.1 %*

Surface roughness Ra	Result
Vertical	9 µm

** Defect% varies with platform position.*

Typical properties

	Yield strength $R_{p0.2}$ [MPa]	Tensile strength R_m [MPa]	Elongation at break A [%]	Reduction of area Z [%]	Fatigue strength N = 9
Heat treated horizontal	990	1,090	15	> 25	-
Heat treated vertical	1,010	1,090	14**	> 25**	
HIP horizontal	890	1,000	16	> 25	563 MPa
HIP vertical	910	1,010	16	> 25	

High cycle fatigue strength was estimated statistically according to ISO 12107.
Testing was done according to ASTM E466 with run-out limit 10^7 cycles.
*** Mean values above the standard limit, some outliers below the limit.*