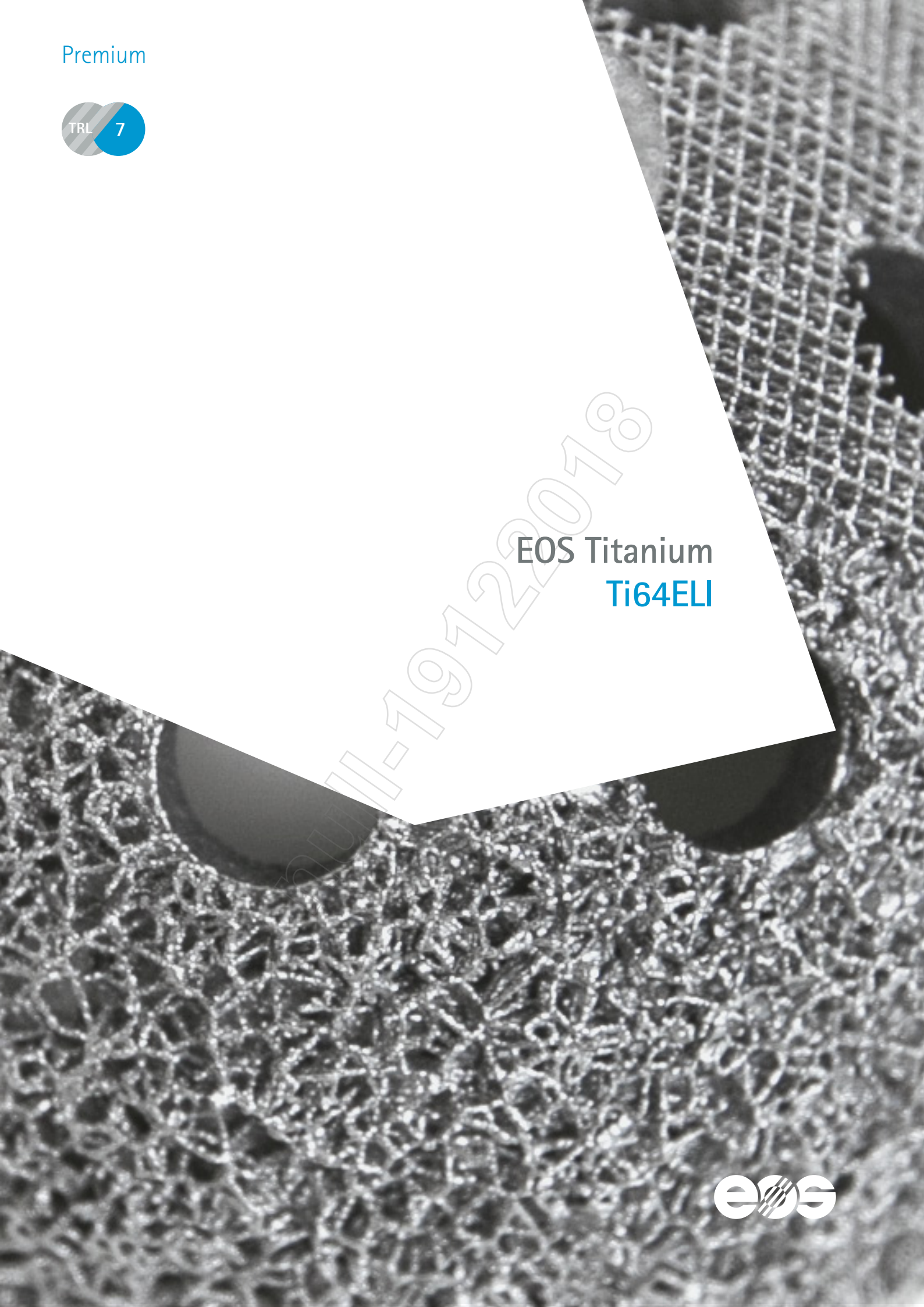
Premium

TRL 7

EOS Titanium
Ti64ELI



EOS Titanium **Ti64ELI**

EOS Titanium Ti64ELI (Extra Low Interstitial) 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 standard 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.

EOS Titanium Grade 23 is specially developed to have high fatigue strength without hot isostatic pressing (HIP).

Parts built with EOS Titanium Ti64ELI powders can be machined, shot-peened and polished in as manufactured and heat treated states. Due to layerwise building method, the parts have a certain anisotropy. Heat treatment is recommended to reduce internal stresses and increase ductility.

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

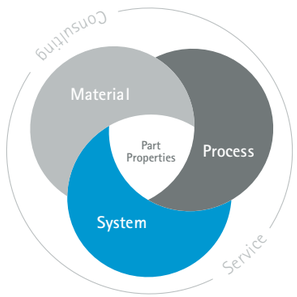
Typical applications for EOS Titanium Ti64ELI:

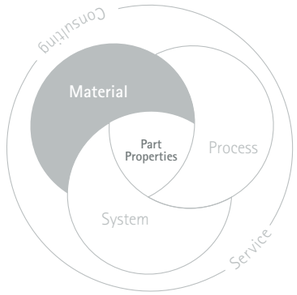
- Medical components
- Implants
- Other industrial applications where low weight in combination with high strength are required

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 Datasheet is produced according to the Quality Management System and standards.





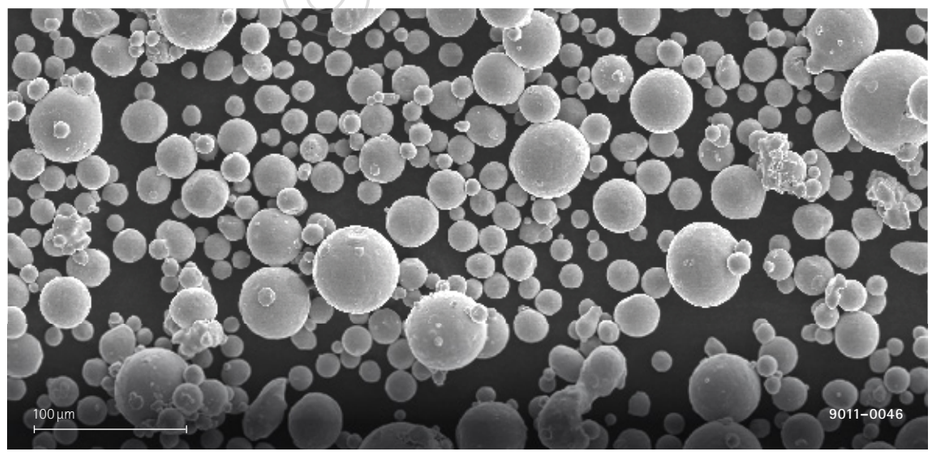
EOS Titanium Ti64ELI Grade 23 Technical Data
Powder Properties

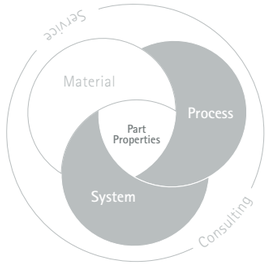
EOS Titanium Ti64ELI powder is classified as Grade 23 titanium alloy according to ASTM B348. The chemical composition is in compliance with standards ASTM F136, ASTM F3001, and ASTM F3302.

Powder chemical composition (wt.-%)	**EOS Titanium Ti64ELI**	
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	**EOS Titanium Ti64 Grade 23** 9011-0046
Generic particle size distribution	20 – 80 µm

SEM picture of EOS Titanium Ti64 Grade 23 powder.





EOS Titanium Ti64ELI Grade 23 Technical Data
Process and Heat Treatment Information

EOS M System setup	M 290
EOS ParameterSet	M 290 Ti64 Grade23 040 V1
EOSPAR name	Ti64_Grade23_040_HiPerM291_100
Software/System Requirements	EOSPRINT 2.5 or newer HCS 2.8 or newer
Volume rate	6.2 mm^3/s 22 cm^3/h
Compatible powder	9011-0046
Recoater Blade	EOS HSS Blade
Nozzle	EOS Grid Nozzle
Inert Gas	Argon
Sieve	90 µm

Additional information	
Min. wall thickness	Approx. 0.4 mm

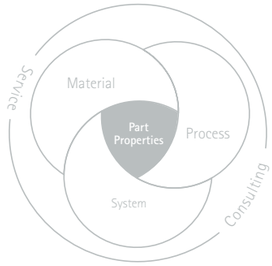
Heat treatment of EOS Titanium Ti64ELI

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.

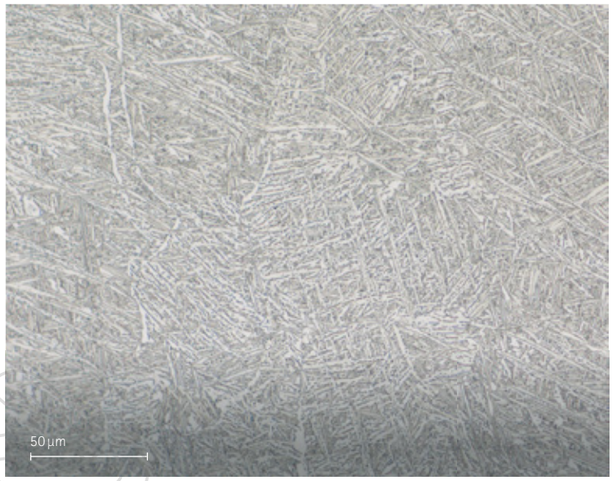
→ **Heat treatment description:** 120 min (± 30 min) at 800 °C (± 10 °C) measured from the part in vacuum (1.3×10^{-3}-1.3×10^{-5} mbar) followed by cooling under vacuum or argon quenching. Material mechanical properties are relatively insensitive to changes in heating and cooling rates, but longer treatment 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.



EOS Titanium Ti64ELI Grade 23 Technical Data
Physical and Chemical Properties of Parts

The chemical composition of parts is in compliance with standards ASTM F136, ASTMF3001, and ASTM F3302. Composition complies with EOS Titanium Ti64ELI powder.



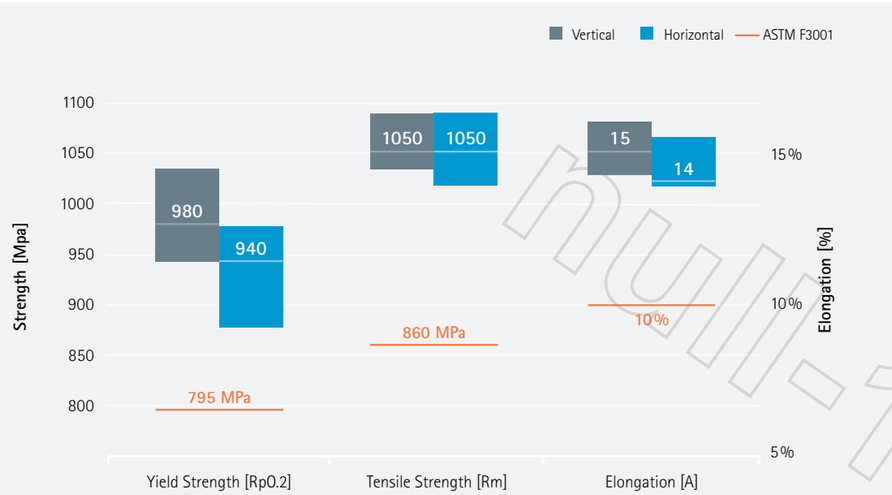
Heat treated microstructure. Etched according to ASTM E407 modified recipe #190.

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

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 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.

EOS Titanium Ti64ELI Grade 23 Technical Data

Mechanical Properties of Parts 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

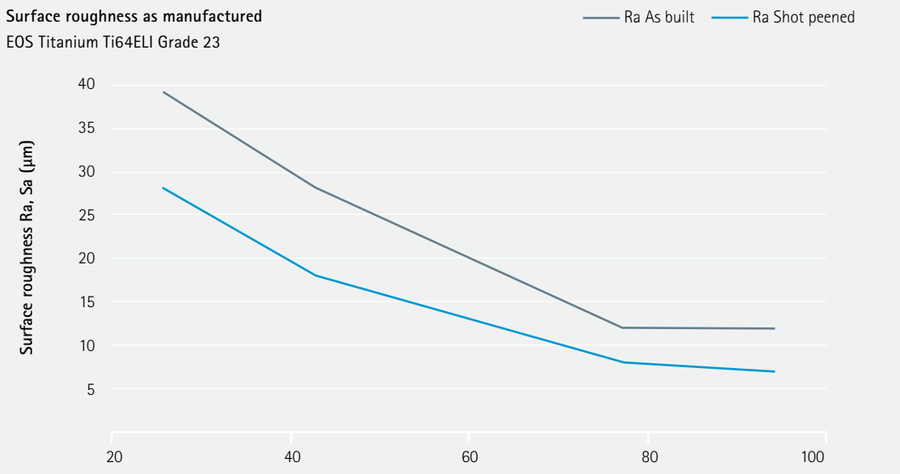
Estimation of fatigue strength at 1 x 10^7 cycles in heat treated status

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].

	EOS Titanium Ti64 Grade 23 (9011-0046) + EOS ParameterSet M 290 Ti64 Grade23 040 V1	EOS Titanium Ti64 (9011-0040) + EOS ParameterSet Ti64 60µm Speed
Fatigue strength, MPa	589 MPa	480 MPa

EOS Titanium Ti64ELI Grade 23 Technical Data

Part Properties



The surface quality was characterized by optical measurement method from down-facing surfaces according to internal procedure.

Coefficient of thermal expansion ASTM E228

	25 – 100 °C	25 – 200 °C	25 – 300 °C
CTE	11.1 *10^{-6}/K	11.6 *10^{-6}/K	11.9 *10^{-6}/K

Cytotoxicity

The cytotoxicity of EOS Titanium Ti64 Grade 23 (9011-0046) 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.

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