VELO3D

Ti 6Al-4V

Material & Process Capability

Ti 6Al-4V ELI is an alpha-beta titanium alloy characterized by its strength-to-mass ratio and corrosion resistance. It is a lightweight yet strong alloy suitable for highly loaded structures, including aerospace jet engines, gas turbines, pressure vessels, and biomechanical components.

The VELO3D intelligent additive printing solution uniquely enables companies to build the parts they need without compromising design or quality—resulting in complex, higher performance parts than traditional casting techniques or other additive methods.

General Process

This data sheet specifies the expected mechanical properties and characteristics of this alloy when manufactured on a VELO3D Sapphire® System. All data is based on parts built with VELO3D standard 50 μm layer thickness parameters, using standard 15-53 μm Ti 6Al- 4V ELI grade 23 powder.

Accuracy, Small Parts	±0.050 (±0.002)	(in)
Accuracy, Large Parts	±0.2	percent
Minimum Wall Thickness; up to 500:1 aspect ratio	0.200 (0.008)	(in)
Typical Volume Rate[1]	45	cc per hr
Density	4.43 (0.16)	g/cc (lbs/in^3)
Relative Density	99.9+	percent
Surface Finish, Sa[2]	6 (240)	μm (μin)

Mechanical Properties at Room Temperature

	After Heat Treatment[5]		After Hot Isostatic Pressing[6]		
Property[3]	Mean -3σ/ Min	Average	Mean -3σ/ Min	Average	
Modulus of Elasticity[4]	95 (13.8)	115 (16.7)	107 (15.5)	112 (16.2)	GPa (MSI)
Ultimate Tensile Strength	970 (141)	994 (144)	988 (143)	1009 (146)	MPa (KSI)
Yield (0.2% Offset)	798 (116)	819 (119)	822 (119)	838 (122)	MPa (KSI)
Elongation At Break	17	21	13	17	percent

1. Geometry-dependent. 2. Depends on orientation and process selected. 3. Mechanical & test samples printed in vertical orientation. 4. For reference; estimated from ASTM E8 tensile testing. 5. Heat treatment anneal 2 hours at 800°C in argon atmosphere. 6. Hot isostatic pressing: 2 hours at 800°C and 200 MPa, processed at Quintus Technologies.

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Ti6Al4V Titanium Alloy

CAD TO METAL

Arcam AB®

www.arcam.com

Ti6Al4V Titanium Alloy

General characteristics

The high strength, low weight ratio and outstanding corrosion resistance inherent to titanium and its alloys has led to a wide and diversified range of successful applications which demand high levels of reliable performance in surgery and medicine as well as in aerospace, automotive, chemical plant, power generation, oil and gas extraction, sports, and other major industries.

In the majority of these and other engineering applications titanium has replaced heavier, less serviceable or less cost-effective materials. Designing with titanium taking all factors into account has resulted in reliable, economic and more durable systems and components, which in many situations have substantially exceeded performance and service life expectations.

Titanium is available in several different grades. Pure titanium is not as strong as the different titanium alloys are.

Special characteristics

Ti6Al4V is the most widely used titanium alloy. It features good machinability and excellent mechanical properties. The Ti6Al4V alloy offers the best all-round performance for a variety of weight reduction applications in aerospace, automotive and marine equipment.

Ti6Al4V also has numerous applications in the medical industry. Biocompatibility of Ti6Al4V is excellent, especially when direct contact with tissue or bone is required.

Applications

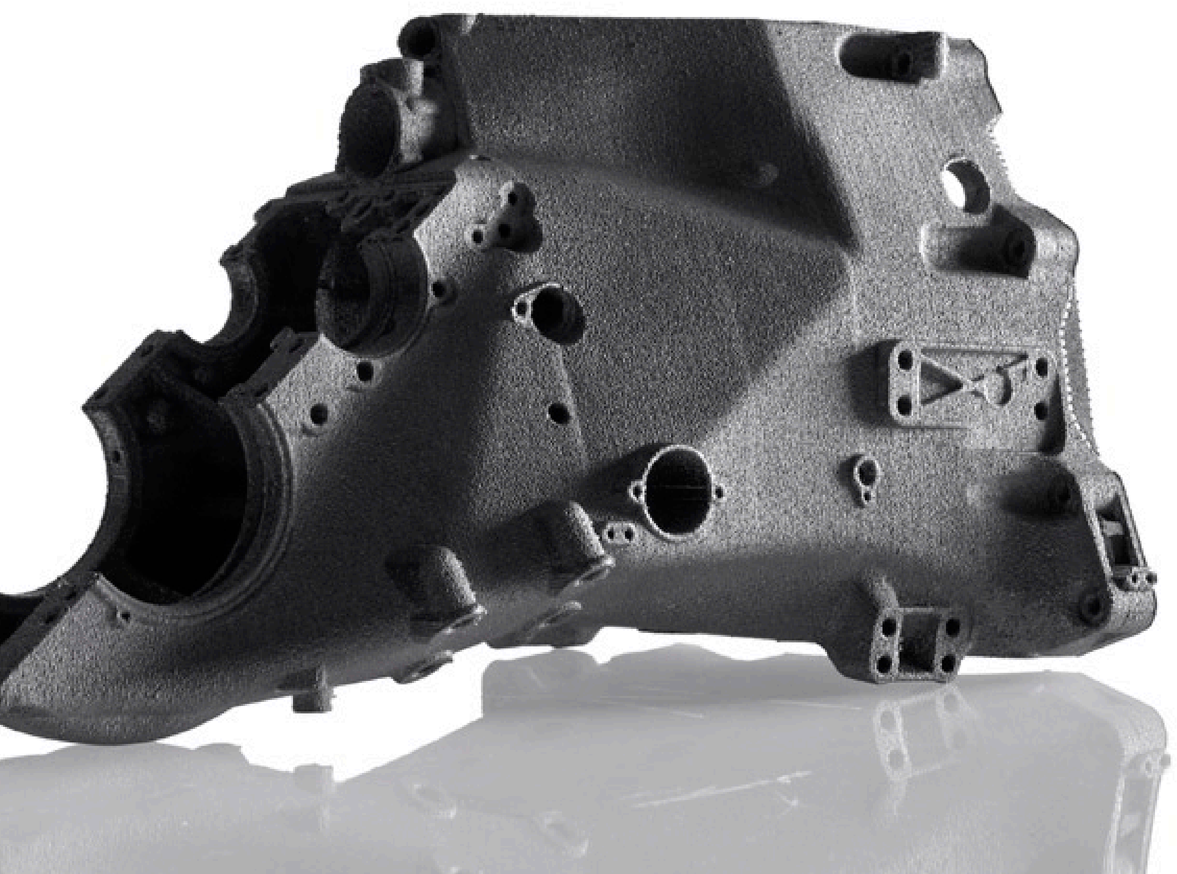
Ti6Al4V is typically used for:

- Direct Manufacturing of parts and prototypes for racing and aerospace industry
- Biomechanical applications, such as implants and prosthesis
- Marine applications
- Chemical industry
- Gas turbines

Powder specification

The Arcam Titanium Ti6Al4V (Grade 5) powder has a particle size between 45 and 100 microns. This limit on the minimum particle size ensures safe handling of the powder.

Please refer to the Arcam MSDS (Material Safety Data Sheet) for more information about the handling and safety of the Arcam Ti6Al4V alloy.



Race car gearbox manufactured with Arcam EBM in Ti6Al4V.

CHEMICAL SPECIFICATION

	Arcam Ti6Al4V, Typical	Ti6Al4V, Required*	Ti6Al4V, Required**
Aluminium, Al	6%	5,5–6,75%	5,5–6,75%
Vanadium, V	4%	3,5–4,5%	3,5–4,5%
Carbon, C	0,03%	< 0,1%	< 0,08%
Iron, Fe	0,1%	< 0,3%	< 0,3%
Oxygen, O	0,15%	< 0,2%	< 0,2%
Nitrogen, N	0,01%	< 0,05%	< 0,05%
Hydrogen, H	0,003%	< 0,015%	< 0,015%
Titanium, Ti	Balance	Balance	Balance

*ASTM F1108 (cast material) **ASTM F1472 (wrought material)

MECHANICAL PROPERTIES

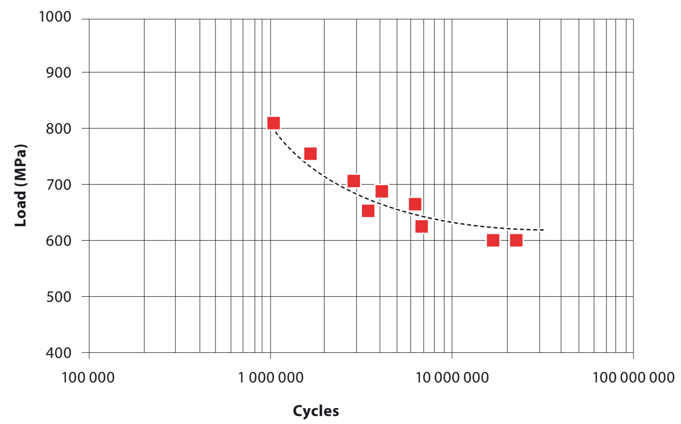
	Arcam Ti6Al4V, Typical	Ti6Al4V, Required**	Ti6Al4V, Required***
Yield Strength (Rp 0,2)	950 MPa	758 MPa	860 MPa
Ultimate Tensile Strength (Rm)	1020 MPa	860 MPa	930 MPa
Elongation	14%	>8%	>10%
Reduction of Area	40%	>14%	>25%
Fatigue strength* @ 600 MPa	>10,000,000 cycles		
Rockwell Hardness	33 HRC		
Modulus of Elasticity	120 GPa		

*After Hot Isostatic Pressing **ASTM F1108 (cast material) ***ASTM F1472 (wrought material)

The mechanical properties of materials produced in the EBM process are comparable to wrought annealed materials and are better than cast materials.

Arcam Ti6Al4V High Cycle Fatigue Test

HCF S/N diagram in MPa units



POST PROCESSING

Heat treatment

Hot Isostatic Pressing (HIP) is recommended for fatigue-loaded components. The following HIP parameters are recommended:

- 920° C
- 100 MPa
- 120 minutes

Machining

Ti6Al4V parts manufactured in the EBM process feature good machinability and can be machined as stock parts.

The following factors contribute to efficient machining of Ti6Al4V parts:

- Low cutting speeds
- High feed rate
- Generous quantities of cutting fluid
- Sharp tools
- Rigid setup

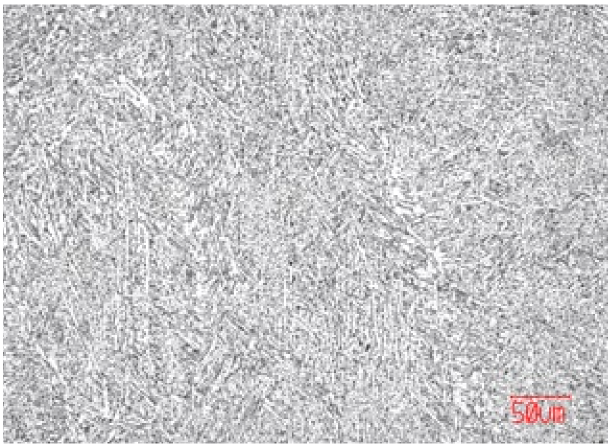
Welding

Ti6Al4V may be welded by a wide variety of conventional fusion and solid-state processes, although its chemical reactivity typically requires special measures and procedures.

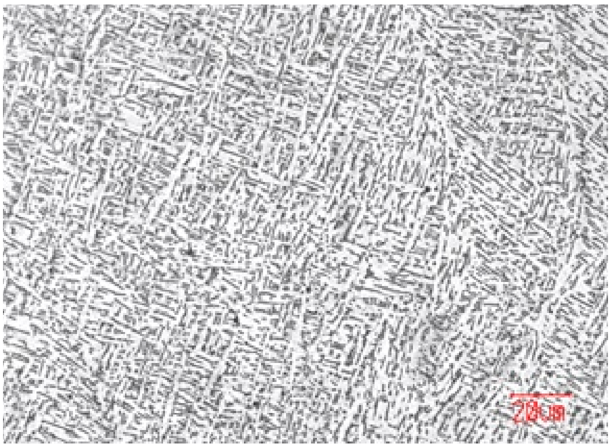
Microstructure

Ti6Al4V parts manufactured in the EBM process have a microstructure better than cast Ti6Al4V containing a lamellar α-phase with larger β-grains, and with a higher density and significantly finer grain, thanks to the rapid cooling of the melt pool.

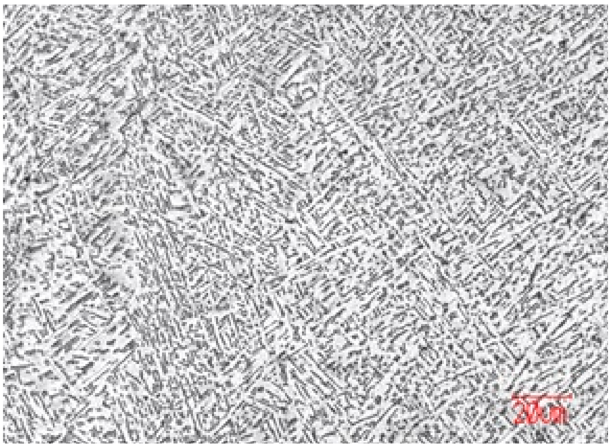
The build chamber is kept at an elevated temperature throughout the entire build, and the material thus comes out of the EBM process in a naturally aged condition.



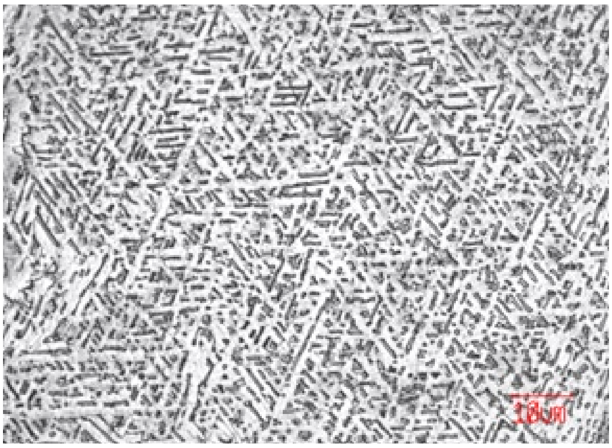
Micrograph of Arcam Ti6Al4V material, 200x.



Micrograph of Arcam Ti6Al4V material, 500x.



Micrograph of Arcam Ti6Al4V material, 500x.



Micrograph of Arcam Ti6Al4V material, 1000x.

CAD TO METAL

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Ti grade 2

SPECIFICATIONS

EU	T 40
WN	3.7035
USA	R50400

MATERIAL DESCRIPTION

- Titanium of commercially pure and biocompatible grade. It combines moderate mechanical properties with very good corrosion resistance especially in the marine environment.

COMPOSITION

weight %

Ti	Balance
Fe	<0,3
O	<0,3
C	<0,08

APPLICATIONS

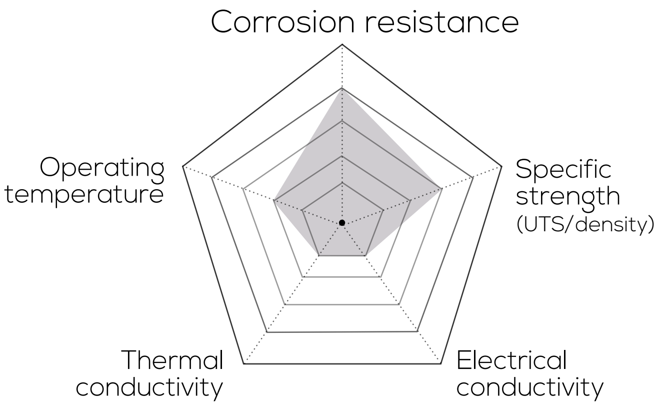
MATERIAL SHEET

Typical mechanical properties

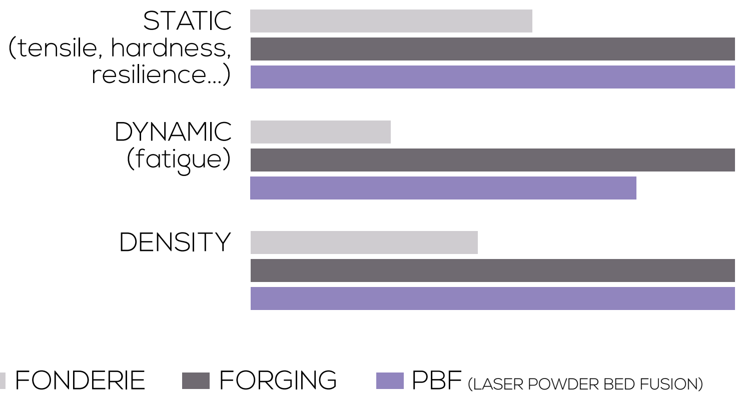
The data provided in this document represent typical but not guaranteed values.

	Stress-relieved
Ultimate Tensile Strength UTS, MPa	750
Yield Strength YS, MPa	650
Elongation at break E 5D, %	24

Physical properties



Qualitative comparison according to processes



Technical data

PARTICULES SIZE :
Available in different granulometries.

SUPPLIERS :
AddUp will provide support with your choice of powder supplier.

Ti grade 2

MATERIAL SHEET

Applications, in detail

CHEMICAL INDUSTRY
Piping and tap

The corrosion resistance of Ti grade 2, especially when exposed to seawater or chlorine medium, make it useful for piping and taps in chemical industries and industries exposed to marine environments

MEDICAL
Artificial heart

Titanium is a biocompatible and light-weight material. Coupled with metal additive manufacturing processes, it is a perfect candidate for complex medical implants that require moderate strength.

Material data sheet - FlexLine

EOS Titanium Ti64 Flexline

EOS Titanium Ti64 is a titanium alloy powder intended for processing on EOS DMLS systems. This document provides information and data for parts built using EOS Titanium Ti64 powder (EOS art.-no. 9011-0039) on the following specifications:

- EOS DMLS system M100
  - HSS-Blade (300006274)
  - Type 2-dosage unit (300012325)
  - 63µm mesh for powder sieving recommended
  - Argon atmosphere
- EOSPRINT 1.5 or newer / EOSSYSTEM 1.7.12 or newer
- EOS Parameter set Ti64_Flexline_M100 1.0

Description

Parts built in EOS Titanium Ti64 Flexline have a chemical composition corresponding to ASTM F2924. Ti64 is well-known light alloy, characterized by having excellent mechanical properties and corrosion resistance combined with low specific weight and biocompatibility. This material is ideal for many high-performance applications. Parts built with EOS Titanium Ti64 powder can be machined, shot-peened and polished in as-built and heat treated states. Due to the layerwise building method the parts have a certain anisotropy.

Quality Assurance

The quality of the EOS Titanium Ti64 powder lots is ensured by the Quality Assurance procedures. The procedures include sampling (ASTM B215), PSD analysis (ISO 13320), chemical analyses (ASTM E2371, ASTM E1409, ASTM E1941, ASTM E1447), and mechanical testing (ISO 6892-1).

The results of the quality assurance tests are given in the lot specific Mill Test Certificates (MTC) according to EN 10204 type 3.1.

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Heat treatment

Heat treatment procedure:

Solution treatment: Hold at 800°C ± 10 °C for 2 hours in Argon atmosphere, cooling in room temperature under protective atmosphere to reduce oxidation.

Technical Data

Powder properties

The chemical composition of powder is in compliance with standard ASTM F2924.

Material composition [wt.%]

Element	Min	Max
Al	5.50	6.75
V	3.50	4.50
O	-	0.20
N	-	0.05
C	-	0.08
H	-	0.015
Fe	-	0.30
Y	-	0.005
Other elements, each	-	0.10
Other elements, total	-	0.40
Ti	bal.	

Particle size

d50 [1]	39 ±3 µm

[1] Particle size distribution analysis according to ISO 13320.

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Material data sheet - FlexLine

General process data

Layer thickness	20 µm
Volume rate [2]	1.68 mm^3/s (6.05 cm^3/h)

[2] The volume rate is a measure of build speed during laser exposure of the skin area. The total build speed depends on this volume rate and many other factors such as exposure parameters of contours, supports, up and downskin, recoating time, Home-In or LPM settings.

Physical properties of parts

Part density [3]	4,4 g/cm3
Surface roughness after shot peening [4]	Approx. R_a 4 µm
Part accuracy after shot peening	± 50 µm
Minimum wall thickness	0,3 mm
Average defect amount [5]	0,02 %

[3] Weighing in air and water according to ISO 3369.

[4] The values are measured at the vertical surfaces of test parts. Due to the layerwise building the roughness strongly depends on the orientation of the surface, for example sloping and curved surfaces exhibit a stair-step effect.

[5] Measured percentage area of defects in sample crosscut.

Tensile data at room temperature [6,7]

	Heat treated [8]	
	Horizontal	**Vertical**
Ultimate tensile strength, Rm	1077 MPa	1065 MPa
Yield strength, Rp0.2	964 MPa	956 MPa
Elongation at break, A	13,0 %	13,3 %

[6] The numbers are average values for horizontal and vertical orientation samples.

[7] Tensile testing according to ISO6892 (ANNEX D) Method A14, proportional test pieces, diameter of the neck area 4mm, original gauge length 16mm (4D).

[8] Heat treatment procedure: 2 hours hold at 800 °C in protective Argon atmosphere.

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Abstract

Abbreviations

min. minimum

max. maximum

wt. weight

The quoted values refer to the use of this material with above specified EOS DMLS system, EOSYSTEM software version, parameter set and operation in compliance with parameter sheet and operating instructions. All measured values are average numbers. Part properties are measured with specified measurement methods using defined test geometries and procedures and. Further details of the test procedures used by EOS are available on request. Any deviation from these standard settings may affect the measured properties.

The data correspond to EOS knowledge and experience at the time of publication and they are subject to change without notice as part of EOS' continuous development and improvement processes.

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Material data sheet

EOS Titanium Ti64

EOS Titanium Ti64 is a titanium alloy powder which has been optimized especially for processing on EOSINT M systems.

This document provides information and data for parts built using EOS Titanium Ti64 powder (EOS art.-no. 9011-0014) on the following system specifications:

- EOSINT M 280 with PSW 3.6 and Original EOS Parameter Set Ti64_Speed 1.0
- EOS M 290 400W with EOSPRINT 1.0 and Original EOS Parameter Set Ti64_Performance 1.0 und Ti64_Speed 1.0

Description

Parts built in EOS Titanium Ti64 have a chemical composition corresponding to ISO 5832-3, ASTM F1472 and ASTM B348.

This well-known light alloy is characterized by having excellent mechanical properties and corrosion resistance combined with low specific weight and biocompatibility.

This material is ideal for many high-performance engineering applications, for example in aerospace and motor racing, and also for the production of biomedical implants (note: subject to fulfilment of statutory validation requirements where appropriate).

Due to the layerwise building method, the parts have a certain anisotropy, which can be reduced or removed by appropriate heat treatment - see Technical Data for examples.

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Material data sheet

Technical data

General process and geometric data

Typical achievable part accuracy [1], [8]	± 50 µm
Min. wall thickness [2], [8]	approx. 0.3 – 0.4 mm approx. 0.012 – 0.016 inch
Surface roughness, as built [3], [8]	
Ti64 Performance (30 µm)	R_a 9 - 12 µm, R_z 40 - 80 µm R_a 0.36 – 0.47 x 10^{-3} inch, R_z 1.6 – 3.2 x 10^{-3} inch
Ti64 Speed (60 µm)	R_a 6 - 10 µm, R_z 35 - 40 µm R_a 0.23 – 0.39 x 10^{-3} inch, R_z 1.37 –1.57 x 10^{-3} inch
Volume rate [4]	
Ti64 Performance (30 µm)	5 mm^3/s (18 cm^3/h) 0.82 in^3/h
Ti64 Speed (60 µm)	9 mm^3/s (32.4 cm^3/h) 1.98 in^3/h

[1] Based on users' experience of dimensional accuracy for typical geometries. Part accuracy is subject to appropriate data preparation and post-processing, in accordance with EOS training.

[2] Mechanical stability is dependent on geometry (wall height etc.) and application

[3] Due to the layerwise building, the surface structure depends strongly on the orientation of the surface, for example sloping and curved surfaces exhibit a stair-step effect. The values also depend on the measurement method used. The values quoted here given an indication of what can be expected for horizontal (up-facing) or vertical surfaces.

[4] Volume rate is a measure of build speed during laser exposure. The total build speed depends on the average volume rate, the recoating time (related to the number of layers) and other factors such as DMLS-Start settings.

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Material data sheet

Physical and chemical properties of parts

Material composition	Ti (balance) Al (5.5 – 6.75 wt.-%) V (3.5 – 4.5 wt.-%) O (< 2000 ppm) N (< 500 ppm) C (< 800 ppm) H (< 150 ppm) Fe (< 3000 ppm)
Relative density	approx. 100 %
Density	4.41 g/cm³ 0.159 lb/in³

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Material data sheet

Mechanical properties of parts [8]

	As built	Heat treated [6]
Tensile strength [5]		
- in horizontal direction (XY)	typ. 1290 ± 50 MPa typ. 187 ± 7 ksi	min. 930 MPa (134.8 ksi) typ. 1100 ± 40 MPa (160 ± 6 ksi)
- in vertical direction (Z)	typ. 1240 ± 50 MPa typ. 187 ± 7 ksi	min. 930 MPa (134.8 ksi) typ. 1100 ± 40 MPa (160 ± 6 ksi)
Yield strength ($R_{p0.2}$) [5]		
- in horizontal direction (XY)	typ. 1140 ± 50 MPa typ. 165 ± 7 ksi	min. 860 MPa (124.7 ksi) typ. 1000 ± 50 MPa (145 ± 7 ksi)
- in vertical direction (Z)	typ. 1120 ± 80 MPa typ. 162 ± 12 ksi	min. 860 MPa (124.7 ksi) typ. 1000 ± 60 MPa (145 ± 9 ksi)
Elongation at break [5]		
- in horizontal direction (XY)	typ. (7 ± 3) %	min. 10 % typ. (13.5 ± 2 %)
- in vertical direction (Z)	typ. (10 ± 3) %	min. 10 % typ. (14.5 ± 2 %)
Modulus of elasticity [5]		
- in horizontal direction (XY)	typ. 110 ± 15 GPa typ. 16 ± 2 Msi	typ. 110 ± 15 GPa typ. 16 ± 2 Msi
- in vertical direction (Z)	typ. 110 ± 15 GPa typ. 16 ± 2 Msi	typ. 110 ± 15 GPa typ. 16 ± 2 Msi
Hardness [7]	typ. 320 ± 12 HV5	

[5] Tensile testing according to ISO 6892-1:2009 (B) Annex D, proportional test pieces, diameter of the neck area 5 mm (0.2 inch), original gauge length 25 mm (1 inch).

[6] Specimens were treated at 800 °C (1470 °F) for 4 hours in argon inert atmosphere. Mechanical properties are expressed as minimum values to indicate that mechanical properties exceed the minimum requirements of material specification standards. ASTM F1472-08. By fulfilling these minimum values, also the specifications of standards ASTM B348-09 and ISO 5832-3:2000 are meet.

[7] Vickers hardness measurement (HV) according to EN ISO 6507-1 on polished surface. Note that measured hardness can vary significantly depending on how the specimen has been prepared.

[8] Hint: these properties were determined for Ti64_Performance 1.0 on an EOSINT M 280-400W and EOSINT M 290-400W. Test parts from Ti64_Speed 1.0 were determined on machine types EOSINT M 280-400W and correspond with data from an EOS M 290-400W.

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Material data sheet

Thermal properties of parts

Maximum long-term operating temperature	approx. 350 °C approx. 660 °F

Abbreviations

typ.	typical
min.	minimum
wt.	weight
approx.	approximately

Notes

The data are valid for the combinations of powder material, machine and parameter sets referred to on page 1, when used in accordance with the relevant Operating Instructions (including Installation Requirements and Maintenance) and Parameter Sheet. Part properties are measured using defined test procedures. Further details of the test procedures used by EOS are available on request.

The data correspond to our knowledge and experience at the time of publication. They do not on their own provide a sufficient basis for designing parts. Neither do they provide any agreement or guarantee about the specific properties of a part or the suitability of a part for a specific application. The producer or the purchaser of a part is responsible for checking the properties and the suitability of a part for a particular application. This also applies regarding any rights of protection as well as laws and regulations. The data are subject to change without notice as part of EOS' continuous development and improvement processes.

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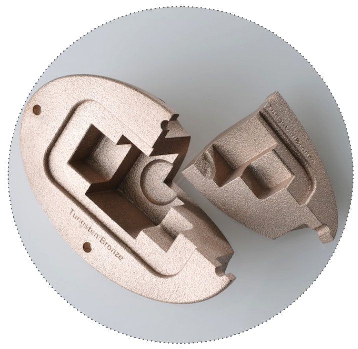
Tungsten-Bronze

ExOne's Tungsten-Bronze is a versatile high-density shielding material with an excellent tensile strength. Tekna's plasma spheroidized Tungsten Powder is printed using ExOne's M-Flex® printer.

Printed part

Applications

ExOne® Tungsten-Bronze has the versatility to be manufactured on various scales for different industries such as a lead replacement material, radiation shielding components and thin wall collimators.

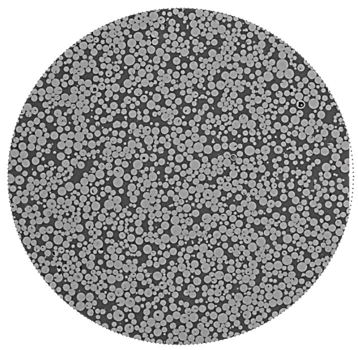


Printed part

Typical Material Properties

Material Properties	Test Method	Tungsten-Bronze
Tensile Strength		
Ultimate Strength		X & Y: 427 MPa Z: 496 MPa
Yield Strength (0.2% offset)	ASTM E8	X & Y: 420 MPa Z: 441 MPa
Elongation		X & Y: 0% Z: 1%
Hardness	ASTM E18	85 HRB
Relative Density		97%
Density		14.0 g/cc

Material Composition	
Tungsten	50-55%
Bronze	bal



Microstructure image

X1 Metal 316i™

60% 316 Steel Infiltrated with 40% Bronze

ExOne's 3D printed X1 Metal 316i™ is a matrix material composed of 60% 316 steel infiltrated with 40% bronze. The lower yield strength of the material enables it to be easily machined and polished. This material also exhibits enhanced corrosion resistance properties.

Applications

This material system has low magnetic properties which makes it particularly useful for applications in the food and medical industries. The copper alloy acts as a natural antibacterial agent making it easy to decontaminate printed parts. Since the matrix material is easy to polish, additional applications exist in bath and kitchen hardware prototypes and low volume production.

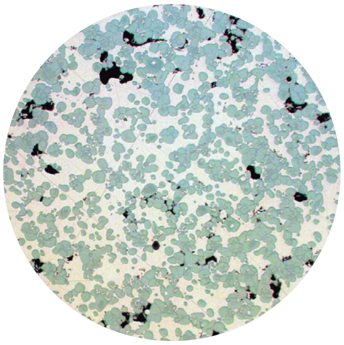
Printed part

Composition

Stainless Steel: Alloy 316
Bronze: 90% Cu / 10% Sn

Printing

Using binder jetting technology, ExOne's state-of-the-art 3D printing machines produce parts directly from 3D CAD models by precisely controlling the jetting of binder onto a powder bed, and then subsequently spreading new layers of powder. This process is repeated until the part is completed. This 3D printing process offers increased design flexibility, reduced manufacturing cost and shortened lead times.



X1 Metal 316i™

Post Processing

After printing is complete, the parts are cured in an oven, which enables the parts to be handled. After curing, the parts are sintered and infiltrated with bronze above 1100°C. Cool down can be varied to control the machinability and hardness of the material.

X1 Metal 316i™

60% 316 Steel Infiltrated with 40% Bronze

Typical Material Properties

Material Properties	Test Method	X1 Metal 316i™
Tensile Strength		
Ultimate Strength	ASTM E8	84 ksi (580 MPa)
Yield Strength (0.2% offset)		41 ksi (283 MPa)
Elastic Modulus		19.5 Mpsi (135 GPa)
Elongation		14.5%
Hardness	ASTM E18	60 HRB
Fractional Density	MPIF 42	95%+ approximate
Density		0.284 lbs/in^3 (7.86 gm/cm^3)
Machinability		Conventionally machinable
Weldability		Use silicone bronze rod & TIG weld
Thermal Conductivity (Room Temp.)		11 BTU/hr ft^2 °F (19 W/m °K)
Specific Heat (at 600 °C)	ASTM E1269-11	0.131 BTU/lb °F (548 J/kg °K)
Thermal Expansion Coefficient at 600 °C	ASTM E831-14	10.37 x 10^{-6}/ °F (18.6 x 10^{-6}/ °K)

Note: Typical expected properties.

Surface Finish

After sintering: ≈ 600 µin R_a (15 µm R_a)

Bead blasting: ≈ 300 µin R_a (7.5 µm R_a)

Barrel finishing: ≈ 50 µin R_a (1.25 µm R_a)

After Sintering

Bead Blasting

Barrel Finishing

For information about ExOne systems, materials and applications, contact an ExOne Production Service Center or visit www.ExOne.com

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rev. 06/17/21

X1 Metal 420i™

60% 420 Steel Infiltrated with 40% Bronze

X1 Metal 420i™ is a matrix material composed of 60% 420 steel infiltrated with 40% bronze. This material offers good mechanical properties, is available in both an annealed and non-annealed condition, is able to be machined, welded and polished, and offers excellent wear resistance.

Applications

This material system is ideally suited for parts exposed to highly abrasive environments such as pump components, and parts for down-hole drilling and mining equipment. Additional applications include industrial components, molds, tooling, art objects and decorative hardware.

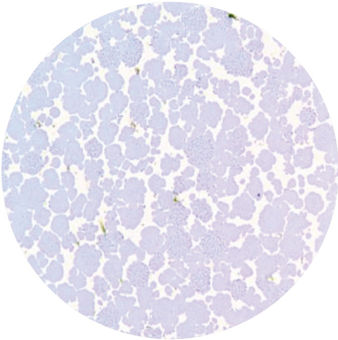
Printed part

Composition

Stainless Steel: Alloy 420
Bronze: 90% Cu / 10% Sn

Printing

Using binder jetting technology, ExOne's state-of-the-art 3D printing machines produce parts directly from CAD models by precisely controlling the jetting of binder onto a powder bed, and then subsequently spreading new layers of powder. This process is repeated until the part is completed. This 3D printing process offers increased design flexibility, reduced manufacturing cost and shortened lead times.



X1 Metal 420i™

Post Processing

After printing is complete, the parts are cured in an oven, which enables the parts to be handled. After curing, the parts are sintered and infiltrated with bronze above 1100°C. Cool down can be varied to control the machinability and hardness of the material.

X1 Metal 420i™

60% 420 Steel Infiltrated with 40% Bronze

Typical Material Properties

Material Properties	Test Method	X1 Metal 420i™
Tensile Strength		
Ultimate Strength	ASTM E8	99 ksi (682 MPa)
Yield Strength (0.2% offset)		66 ksi (455 MPa)
Elastic Modulus		21.4 Mpsi (147 GPa)
Elongation		2.3%
Hardness	ASTM E18	97 HRb
Fractional Density	MPIF 42	95%+
Density		0.284 lbs/in³ (7.86 g/cm³)
Machinability		Refer to ExOne for recommendations
Weldability		Use silicone bronze rod & TIG weld
Thermal Conductivity	ASTM E1530	13 BTU/hr ft °F (22.6 W/m°K)
Specific Heat	ASTM E1263	0.114 BTU/lb °F (478 J/kg°K)
Thermal Expansion Coefficient	ASTM E228	7.4×10^{-6}/°F (13.4×10^{-6}/°K)

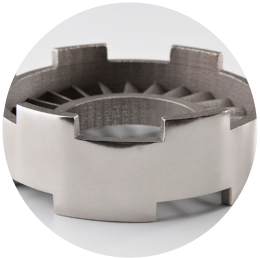
Surface Finish

After sintering: ≈ 600 µin R_a (15 µm R_a)

Bead blasting: ≈ 300 µin R_a (7.5 µm R_a)

Barrel finishing: ≈ 50 µin R_a (1.25 µm R_a)

Printed part, raw finish



Printed part, polished

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