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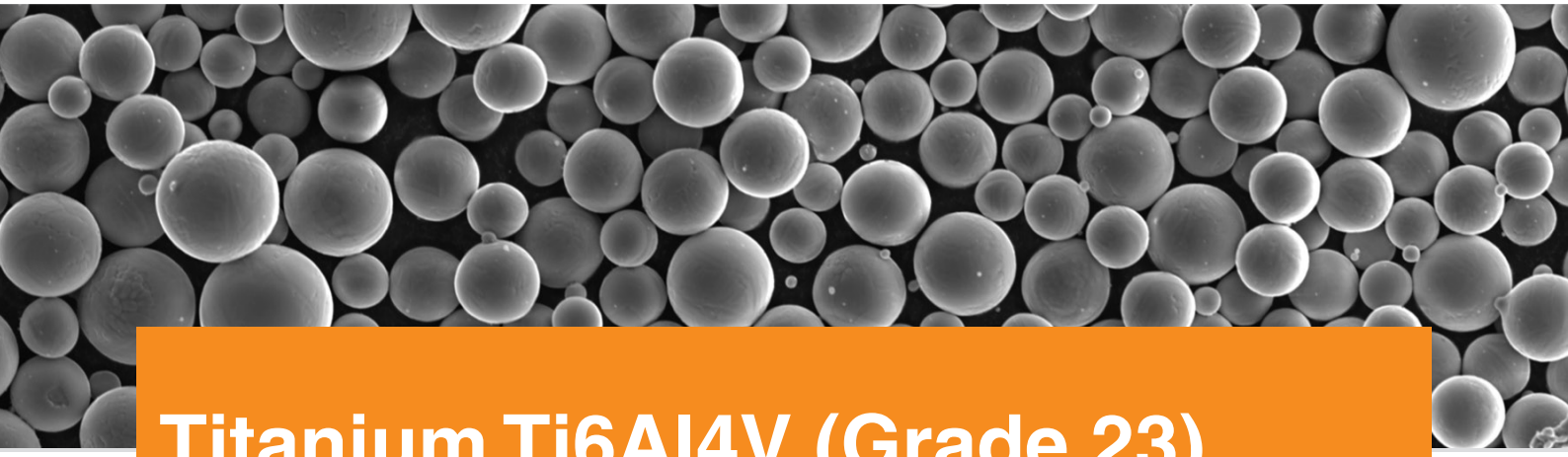

Titanium Ti6Al4V (Grade 23)

Parameter set options

Layer thickness	Optimised for	Page
60 µm	Single laser per part	3
60 µm	Multiple lasers per part	4

To download the latest material files, visit **www.renishaw.com/softwarelicensing.**

Material description

Ti6Al4V alloy comprises of titanium alloyed with aluminium and vanadium, along with other minor elements. Ti6Al4V grade 23 is otherwise referred to as Extra Low Interstitial (ELI) with regards to the interstitial impurities oxygen, carbon, and nitrogen. It is a higher purity version of Ti6Al4V grade 5, where the reduced interstitial elements in grade 23 lead to an increase in both ductility and fracture toughness.

Ti6Al4V has excellent specific strength (strength to weight ratio), which makes it an ideal choice where weight saving load structures are required. It has good corrosion resistance and biocompatibility, so can be used for a range of surgical and dental applications.

Material properties

- High specific strength
- High corrosion resistance
- Excellent biocompatibility
- Good osseointegration
- Low thermal expansion
- Low thermal conductivity

Applications

- Medical and dental
- Aerospace and defence
- Motorsport
- Jewellery and art
- Maritime applications
- High-end sports equipment

Generic material data

Typical wrought material properties

Material property	Wrought material value
Density	4.4 g/cm^3
Thermal conductivity	6 W/mK to 8 W/mK
Melting temperature	1 635 °C to 1 665 °C
Coefficient of thermal expansion [1]	8×10^{-6} K^{-1} to 9×10^{-6} K^{-1}

[1] In the range of 0 °C to 100 °C.

Recommended composition of powder

Element	Mass (%)
Titanium	Balance
Aluminium	5.50 to 6.50
Vanadium	3.50 to 4.50
Iron	≤ 0.25
Oxygen	≤ 0.13
Carbon	≤ 0.08
Nitrogen	≤ 0.03
Hydrogen	≤ 0.01
Yttrium	≤ 0.01
Residual elements	≤ 0.10 each, ≤ 0.40 total

Recommended powder size distribution: 15 µm to 45 µm.

The values shown in this table are for ASTM standard composition powder. Renishaw powders are supplied to a tighter specification to minimise batch-to-batch variations. Results quoted in this data sheet are from samples produced using Renishaw's tighter-specification powder. To purchase powder from Renishaw, visit the online store at **www.renishaw.com/shop**.

Please contact Renishaw for further information about specifications or if you require support in qualifying non-Renishaw powders.

Parameter set summary

Layer thickness	Optimised for	Laser mode	Gas flow rate	Build rate	
60 µm	Single laser per part	Continuous wave	190 m^3/h	One laser: 30.8 cm^3/h	Four lasers: 123 cm^3/h

Material files: Ti6Al4V_500QS_B60_M_##_# (meander scan strategy)
Ti6Al4V_500QS_B60_S_##_# (stripe scan strategy)

Properties of additively manufactured components

NOTE: This parameter set is optimised for bulk density. The material properties in this table are indicative only. Further modification of the material file may be required to suit your application.

	Annealed [1]	
	Mean	Standard deviation
Bulk density [2]	≥ 99.8%	-
Ultimate tensile strength [3]		
Horizontal direction (XY)	1 078 MPa	8 MPa
Vertical direction (Z)	1 065 MPa	5 MPa
Yield strength [3]		
Horizontal direction (XY)	985 MPa	24 MPa
Vertical direction (Z)	956 MPa	9 MPa
Elongation after fracture [3]		
Horizontal direction (XY)	17%	1%
Vertical direction (Z)	18%	1%
Modulus of elasticity [3]		
Vertical direction (Z)	115 GPa	3 GPa
Hardness (Vickers) [4]		
Horizontal direction (XY)	348 HV0.5	6 HV0.5
Vertical direction (Z)	345 HV0.5	6 HV0.5
Surface roughness (Ra) [5]		
Vertical direction (Z)	11 Ra	1 Ra

Mechanical test samples were created using four lasers, one laser per sample and with no downstream processing. Meander scan strategy was used for vertical samples and stripe scan strategy for horizontal samples. The mechanical property data were obtained from tests performed in Renishaw's laboratories and they indicate the mechanical properties that can be achieved. The data is not intended as a guaranteed minimum specification.

1 Annealing method used for testing: Under vacuum, heat at 13 °C/min to 800 °C ±10 °C, then hold temperature for 4 hours. Furnace cool to room temperature.

2 Measured optically on a 10 mm × 10 mm × 10 mm sample at 75× magnification.

3 Tested at ambient temperature to ASTM E8 by Nadcap and UKAS accredited independent laboratory. Machined prior to testing. Values based on 16 samples for vertical, 12 for horizontal.

4 Tested to ASTM E384-11 after polishing.

5 Tested on as-built vertical surfaces using laser interferometry. Tested to JIS B 0601-2001 (ISO 97).

Parameter set summary

Layer thickness	Optimised for	Laser mode	Gas flow rate	Build rate
60 µm	Multiple laser per part	Continuous wave	190 m^3/h	Four lasers: 123 cm^3/h

Material files: Ti6Al4V_500QS_C60_S_##_# (stripe scan strategy)

Properties of additively manufactured components

NOTE: This parameter set is optimised for bulk density. The material properties in this table are indicative only. Further modification of the material file may be required to suit your application.

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Part no.: H-5800-6797-02-A
Issued: 03.2023