SLM SOLUTIONS

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

MATERIAL DATA SHEET

MATERIAL DATA SHEET

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

MATERIAL

Titanium, atomic number 22 in the Periodic Table, is a transition metal with an outstanding strength-to-density ratio and a high corrosion resistance. While it is used in unalloyed condition, most industrial applications rely on titanium alloys. This particular Grade 23 ELI consists of additional aluminum and vanadium, which lead to formation of metastable α and β phases. It is very similar to Grade 5, but limits the maximum allowable content for some elements and, therefore, is ELI – extra low interstitial, meaning the amount of the interstitial elements oxygen and iron are reduced to improve both ductility and fracture toughness. Ti6Al4V Grade 23 ELI is commonly used in medical implants due to its biocompatibility, but also in aerospace and automotive applications and others.

CHEMICAL COMPOSITION

ASTM B348[1]											
	Ti	**Al**	**V**	**Fe**	**O**	**C**	**N**	**H**	**Y**	**Total each**	**Total others**
Min.	Bal.	5.50	3.50								
Max.		6.50	4.50	0.25	0.13	0.08	0.03	0.0125	-	0.10	0.40

ASTM F136[1]											
	Ti	**Al**	**V**	**Fe**	**O**	**C**	**N**	**H**	**Y**	**Total each**	**Total others**
Min.	Bal.	5.50	3.50								
Max.		6.50	4.50	0.25	0.13	0.08	0.05	0.012	-	-	-

ASTM F3001[1]											
	Ti	**Al**	**V**	**Fe**	**O**	**C**	**N**	**H**	**Y**	**Total each**	**Total others**
Min.	Bal.	5.50	3.50								
Max.		6.50	4.50	0.25	0.13	0.08	0.05	0.012	0.005	0.10	0.40

POWDER PROPERTIES

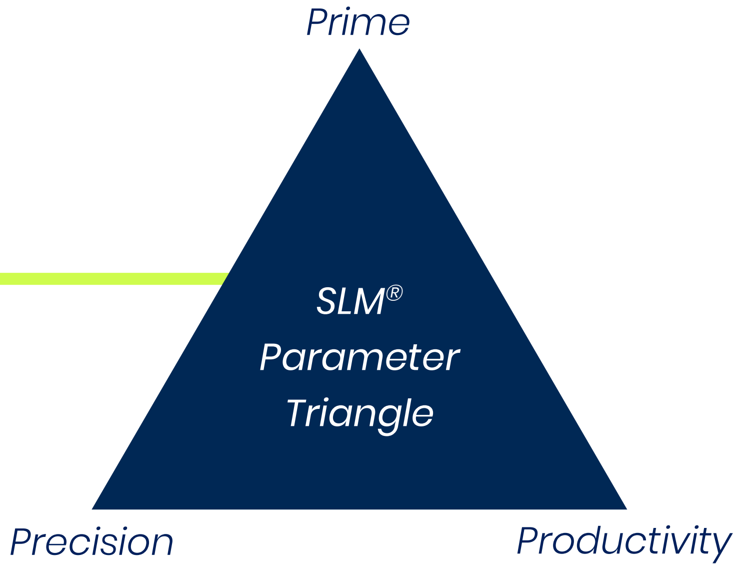
Particle Size[1]	20 - 63 µm
Mass Density[2]	≈ 4.43 g/cm³
Particle Shape[3]	Spherical

SLM® PARAMETERS

It only takes 3 tools to make you successful with metal additive manufacturing:

1. The **SLM® machine** fitting your needs,
2. The **metal powder** that defines the later purpose and functionality of a part,
3. Precisely engineered **SLM® parameters** as the missing link.

Our open parameters are the result of our vast experience in multi-laser technology and a diligent development and qualification procedure. They are key to produce fully functional parts with properties you can expect and rely on – whether you are new to AM or a large-scale production operator. We offer them in three categories to you: from high-resolution complex details (**Precision**) up to the highest build rates (**Productivity**) or right in between (**Prime**).



MATERIAL QUALIFICATION

As one of the inventors of the selective laser melting process, we impose the most comprehensive test procedures on ourselves: hundreds of samples, multiple systems, various powder batches, numerous heat-treatments, machined vs. near-net-shape tensile specimens, several surface roughness conditions and angles, fatigue behavior, corrosion investigation, creep testing... Did we miss anything? Get in touch with us!

MATERIAL DATA SHEET

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

SLM SOLUTIONS

PRECISION SLM® 280

Parameter Set	Ti6Al4V_SLM280_PREC_MBP3_V1.0 (30 µm)
Machine Compatibility	SLM® 280 2.0, SLM® 280 Production Series (400 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	37.6 cm³/h (Twin)
Minimum Relative Density[5,7]	99.9 %

Mechanical Properties[6]

M: Mean | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

Non-heat-treated

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1240	1200	1085	880	8	5
Vertical	1310	1250	1205	1040	9	5
Near-Net-Shape	M		M		M	
Vertical	1290		1095		7	

Heat-treated (ANN2 AMS-H-81200)[8]

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1080	1030	1000	950	16	13
Vertical	1075	1030	1025	970	16	12

Hardness[9]

M: Mean | SD: Standard Deviation

	Vickers hardness HV10	
	M	SD
As built	365	5
Heat-treated[8]	315	15

Surface Roughness[10]

M: Mean | SD: Standard Deviation

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	SD	M	SD
As built	14	5	91	28
Corundum + Glass bead	8	4	45	22

MATERIAL DATA SHEET

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

SLM SOLUTIONS

PRECISION SLM® 500

Parameter Set	Ti6Al4V_SLM500_PREC_MBP3_V1.0 (30 µm)
Machine Compatibility	SLM® 500 1.3 (400 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	75.2 cm³/h (Quad)
Minimum Relative Density[5,7]	99.9 %

Mechanical Properties[6]

M: Mean | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

Non-heat-treated

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1290	1250	1130	1030	9	6
Vertical	1305	1240	1200	1100	9	6
Near-Net-Shape	M		M		M	
Vertical	1285		1065		5	

Heat-treated (ANN2 AMS-H-81200)[8]

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1070	1020	995	910	16	13
Vertical	1085	1045	1035	995	16	14

Hardness[9]

M: Mean | SD: Standard Deviation

	Vickers hardness HV10	
	M	SD
As built	375	10
Heat-treated[8]	305	10

Surface Roughness[10]

M: Mean | SD: Standard Deviation

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	SD	M	SD
As built	9	3	61	18
Corundum + Glass bead	5	1	27	6

MATERIAL DATA SHEET

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

SLM SOLUTIONS

PRIME SLM® 280

Parameter Set	Ti6Al4V_SLM280_PRIM_MBP3_V1.0 (60 µm)
Machine Compatibility	SLM® 280 2.0, SLM® 280 Production Series (400 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	64.8 cm³/h (Twin)
Minimum Relative Density[5,7]	99.9 %

Mechanical Properties[6]

M: Mean | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

Non-heat-treated

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1270	1250	1145	1070	7	5
Vertical	1280	1200	1180	1000	9	4
Near-Net-Shape	M		M		M	
Vertical	1230		1060		6	

Heat-treated (ANN2 AMS-H-81200)[8]

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1085	1080	995	970	16	12
Vertical	1045	990	925	800	12	7

Hardness[9]

M: Mean | SD: Standard Deviation

	Vickers hardness HV10	
	M	SD
As built	365	10
Heat-treated[8]	345	10

Surface Roughness[10]

M: Mean | SD: Standard Deviation

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	SD	M	SD
As built	15	5	87	25
Corundum + Glass bead	5	1	23	4

MATERIAL DATA SHEET

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

SLM SOLUTIONS

PRIME SLM® 500

Parameter Set	Ti6Al4V_SLM500_PRIM_MBP3_V1.0 (60 µm)
Machine Compatibility	SLM® 500 1.3 (400 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	129.6 cm^3/h (Quad)
Minimum Relative Density[5,7]	99.9 %

Mechanical Properties[6]

M: Mean | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

Non-heat-treated

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1300	1285	1150	1030	6	4
Vertical	1285	1250	1180	1140	8	5

Heat-treated (ANN2 AMS-H-81200)[8]

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1105	1095	1020	980	14	12
Vertical	1105	1090	1045	1020	15	12

Hardness[9]

M: Mean | SD: Standard Deviation

	Vickers hardness HV10	
	M	SD
As built	370	15
Heat-treated[8]	340	5

Surface Roughness[10]

M: Mean | SD: Standard Deviation

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	SD	M	SD
As built	9	1	60	8
Corundum + Glass bead	7	2	35	10

MATERIAL DATA SHEET

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

SLM SOLUTIONS

PRIME NXG XII 600

Parameter Set	Ti6Al4V_NXG600_PRIM_MBP3_V1 (60 µm)
Machine Compatibility	NXG XII 600
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	421.2 cm³/h (12 Lasers)
Minimum Relative Density[5,7]	99.9 %

Mechanical Properties[6]

M: Mean | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

Non-heat-treated

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	**M**	**MIN**	**M**	**MIN**	**M**	**MIN**
Horizontal	1245	1200	1090	1045	8	7
Vertical	1230	1200	1110	1070	7	3
Near-Net-Shape	**M**	**MIN**	**M**	**MIN**	**M**	**MIN**
Vertical	1185	1170	1055	1000	7	4

Heat-treated (ANN2 AMS-H-81200)[8]

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	**M**	**MIN**	**M**	**MIN**	**M**	**MIN**
Vertical	1025	1015	955	935	15	11

Hardness[9]

M: Mean | SD: Standard Deviation

	Vickers hardness HV10	
	M	**SD**
As built	360	5

Surface Roughness[10]

M: Mean | SD: Standard Deviation

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	**SD**	**M**	**SD**
As built	8	1	50	6

MATERIAL DATA SHEET

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

SLM SOLUTIONS

PRODUCTIVITY SLM® 280

Parameter Set	Ti6Al4V_SLM280_PROD_MBP3_V1.0 (60 µm)
Machine Compatibility	SLM® 280 2.0, SLM® 280 Production Series (700 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	81.0 cm³/h (Twin)
Minimum Relative Density[5,7]	99.9 %

Mechanical Properties[6]

M: Mean | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

Non-heat-treated

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1260	1230	1150	1090	8	5
Vertical	1245		1155		8	
Near-Net-Shape	M		M		M	
Vertical	1205		1045		4	

Heat-treated (ANN2 AMS-H-81200)[8]

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1095	1060	1000	940	15	12
Vertical	1100	1085	1035	1020	15	9

Hardness[9]

M: Mean | SD: Standard Deviation

	Vickers hardness HV10	
	M	SD
As built	360	5
Heat-treated[8]	325	10

Surface Roughness[10]

M: Mean | SD: Standard Deviation

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	SD	M	SD
As built	12	3	73	15
Corundum + Glass bead	5	1	23	4

MATERIAL DATA SHEET

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

SLM SOLUTIONS

PRODUCTIVITY SLM® 500

Parameter Set	Ti6Al4V_SLM500_PROD_MBP3_V1.0 (60 µm)
Machine Compatibility	SLM® 500 1.3 (700 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	162.0 cm³/h (Quad)
Minimum Relative Density[5,7]	99.8 %

Mechanical Properties[6]

M: Mean | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

Non-heat-treated

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1245	1230	1100	975	8	4
Vertical	1240	1200	1140	1100	9	7
Near-Net-Shape	M		M		M	
Vertical	1170		1010		5	

Heat-treated (ANN2 AMS-H-81200)[8]

	Tensile strength R_m [MPa]		Yield strength $R_{p0.2}$ [MPa]		Elongation at break A [%]	
Machined	M	MIN	M	MIN	M	MIN
Horizontal	1080	1065	985	920	14	10
Vertical	1080	1070	1010	985	14	10

Hardness[9]

M: Mean | SD: Standard Deviation

	Vickers hardness HV10	
	M	SD
As built	340	20
Heat-treated[8]	335	2

Surface Roughness[10]

M: Mean | SD: Standard Deviation

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	SD	M	SD
As built	9	1	60	7
Corundum + Glass bead	6	2	33	8

MATERIAL DATA SHEET

Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

DISCLAIMER

The properties and mechanical characteristics apply to powder that is tested and sold by SLM Solutions, and that has been processed on SLM Solutions machines using the original SLM Solutions parameters in compliance with the applicable operating instructions (including installation conditions and maintenance). The part properties are determined based on specified procedures. More details about the procedures used by SLM Solutions are available upon request.

The specifications correspond to the most recent knowledge and experience available to us at the time of publication and do not form a sufficient basis for component design on their own. Certain properties of products or parts or the suitability of products or parts for specific applications are not guaranteed. The manufacturer of the products or parts is responsible for the qualified verification of the properties and their suitability for specific applications. The manufacturer of the products or parts is responsible for protecting any third-party proprietary rights as well as existing laws and regulations.

MDS_Ti6Al4V_2023-11.1_EN

CONTACT

Headquarters

Nikon SLM Solutions AG
Estlandring 4
23560 Lübeck
Germany

Phone: +49 451 4060-3000

www.slm-solutions.com

NOTES

[1] With respect to powder material. Compositions stated as mass or weight percent.

[2] Material density varies within the range of possible chemical composition variations.

[3] According to DIN EN ISO 3252:2001.

[4] Theoretical system build rate = layer thickness x scan speed x hatch distance x number of lasers. The value represents a com-parable indicator but remains a theoretical value after all. It does expressively not reflect true build rates, which are influenced by part geometry, ratio between hatch and contour areas, area of exposure, recoating times, and more.

[5] Optical density determination at test specimens by light microscopy according to internal specification. Relative density may vary depending on part geometry, orientation, volume, and other process factors. Population coverage: 99 %, confidence level: 99 %.

[6] Tensile testing was performed in accordance to DIN EN ISO 6892-1:2017 B and conducted at room temperature. Samples are either machined before testing or tested in near-net-shape without any surface finishing (geometry according to DIN 50125:2016-D6x30). Samples labelled “Horizontal” correspond to a polar angle of θ = 90°; samples labelled “vertical” correspond to a polar angle of θ = 0° (DIN EN ISO/ASTM 52921). Values include overlap samples, i.e. multiple lasers work simultaneously on one specimen. All data is derived from standardized SLM Solutions qualification jobs. Samples are built out of both virgin powder as well as used powder. Population coverage: 95 %, confidence level: 95 %.

[7] Minimum values are set by using tolerance interval method, which is a statistical approach based on the input of population coverage (PC) and confidence level (CL). Tolerance intervals ensure that a certain percentage of samples within a batch will be above the minimum value with a certain probability, e.g. the probability that 95 % of all samples will be above the stated minimum value (within a defined batch and tested according to mentioned specifications) is 95 %.

[8] Heat treatment according to AMS-H-81200. Annealing in vacuum at 800 °C +/- 14 °C for 2 h, cooling in air or furnace cooling.

[9] Hardness testing according to DIN EN ISO 6507-1:2018. Measurement direction “2” according to VDI 3405 2.1. Values include overlap samples, i.e. multiple lasers work simultaneously on one specimen. All data is derived from standardized SLM Solutions qualification jobs. Samples are built out of both virgin powder as well as used powder.

[10] Roughness measurement on vertical walls according to DIN EN ISO 4288:1998; λc = 2.5 mm. Glass bead blasting is an additional post-processing step after corundum blasting. Values include overlap samples, i.e. multiple lasers work simultaneously on one specimen. All data is derived from standardized SLM Solutions qualification jobs. Samples are built out of both virgin powder as well as used powder.