Ti6Al4V Grade 23 ELI

ASTM B348 / ASTM F136 / ASTM F3001

MATERIAL DATA SHEET

Nikon SLM SOLUTIONS

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MATERIAL

Titanium and its alloys typically have a high strength-to-density ratio and a high corrosion resistance. This material, Grade 23 ELI, is alloyed aluminum and vanadium, which leads to formation of metastable α and β phases. It is very similar to Grade 5, but has extra low interstitial (ELI) elements, 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]

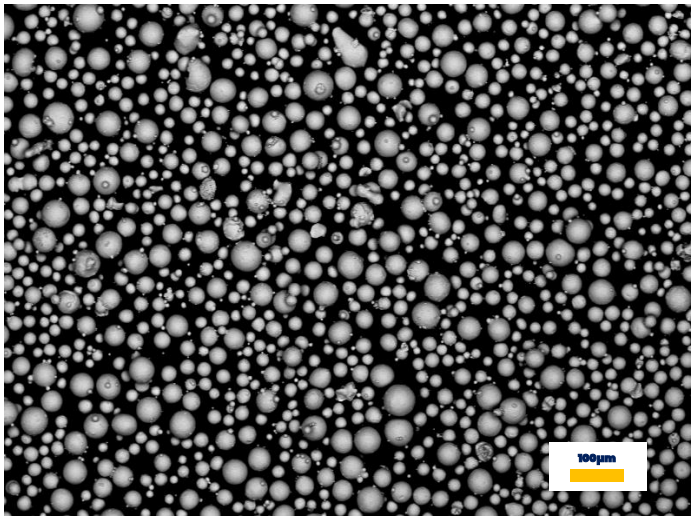
	Ti	Al	V	Fe	O	C	N	H	Y	Total each	Total others
Min.	Bal.	5.50	3.50								
Max.		6.50	4.50	0.25	0.13	0.08	0.05	0.012	-	-	-

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, typical batch morphology displayed below



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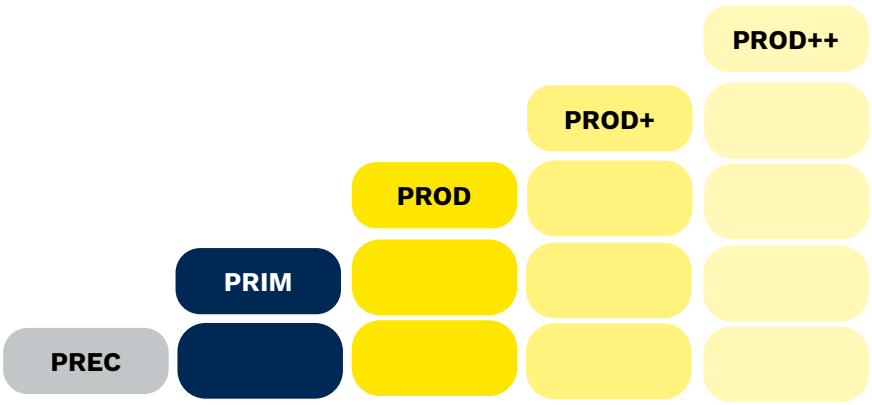
NIKON SLM® PARAMETERS

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

1. The **NIKON SLM® machine** fitting your needs,
2. The **metal powder** that defines the later purpose and functionality of a part,
3. Precisely engineered **NIKON 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 to you in the following categories: **Precision (PREC)** for high-resolution complex details, **Prime (PRIM)** for balanced properties with improved productivity and **Productivity (PROD)** for the highest build rates. Pushing boundaries is in our work culture, we can also offer a new dimension of productivity on selected materials with **Productivity+ (PROD+)** and **Productivity++ (PROD++)** parameters.



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!

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SLM®280 PRECISION

Parameter Set	Ti6Al4V_SLM280_PREC_MBP3_V1 (30 µm)
Machine Compatibility	SLM®280 2.0, SLM®280 Production System (400W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	37.6 cm^3/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 (ANN)[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 | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

	Vickers hardness HV10	
	M	**MIN**
As built	365	280
Heat-treated[8]	315	

SURFACE ROUGHNESS[10]

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

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	**MAX**	**M**	**MAX**
As built	14		91	
Corundum + Glass bead	8		45	

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SLM®280 PRIME

Parameter Set	Ti6Al4V_SLM280_PRIM_MBP3_V1 (60 µm)
Machine Compatibility	SLM®280 2.0, SLM®280 Production System (400 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	64.8 cm^3/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 (ANN)[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 | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

	Vickers hardness HV10	
	M	**MIN**
As built	365	
Heat-treated[8]	345	

SURFACE ROUGHNESS[10]

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

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	**MAX**	**M**	**MAX**
As built	15		87	
Corundum + Glass bead	5		23	

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SLM®280 PRODUCTIVITY

Parameter Set	Ti6Al4V_SLM280_PROD_MBP3_V1 (60 µm)
Machine Compatibility	SLM®280 2.0, SLM®280 Production System (700 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	81.0 cm^3/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 (ANN)[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 | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

	Vickers hardness HV10	
	M	**MIN**
As built	360	
Heat-treated[8]	325	

SURFACE ROUGHNESS[10]

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

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	**MAX**	**M**	**MAX**
As built	12		73	
Corundum + Glass bead	5		23	

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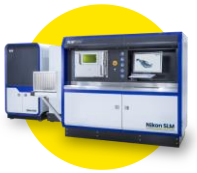

SLM®500 PRECISION

Parameter Set	Ti6Al4V_SLM500_PREC_MBP3_V1 (30 µm)
Machine Compatibility	SLM®500 (400 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	75.2 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	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 (ANN)[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 | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

	Vickers hardness HV10	
	M	**MIN**
As built	375	
Heat-treated[8]	305	

SURFACE ROUGHNESS[10]

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

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	**MAX**	**M**	**MAX**
As built	9		61	
Corundum + Glass bead	5		27	

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Ti6Al4V Grade 23 ELI

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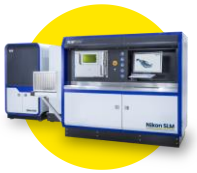

SLM®500 PRIME

Parameter Set	Ti6Al4V_SLM500_PRIM_MBP3_V1 (60 µm)
Machine Compatibility	SLM®500 (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 (ANN)[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 | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

	Vickers hardness HV10	
	M	MIN
As built	370	
Heat-treated[8]	340	

SURFACE ROUGHNESS[10]

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

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	MAX	M	MAX
As built	9		60	
Corundum + Glass bead	7		35	

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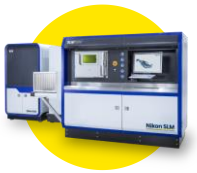

SLM®500 PRODUCTIVITY

Parameter Set	Ti6Al4V_SLM500_PROD_MBP3_V1 (60 µm)
Machine Compatibility	SLM®500 (700 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	162.0 cm^3/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 (ANN)[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 | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

	Vickers hardness HV10	
	M	**MIN**
As built	340	
Heat-treated[8]	335	

SURFACE ROUGHNESS[10]

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

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	**MAX**	**M**	**MAX**
As built	9		60	
Corundum + Glass bead	6		33	

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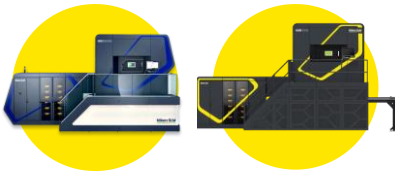

NXG PRIME

Parameter Set	Ti6Al4V_NXG600_PRIM_MBP3_V1 (60 µm)
Machine Compatibility	NXG XII 600, NXG 600E (1000 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	421.2 cm^3/h
Minimum Relative Density[5,7]	99.9 %

MECHANICAL PROPERTIES

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	6
Vertical	1215	1165	1095	1040	7	3
Near-Net-Shape	**M**	**MIN**	**M**	**MIN**	**M**	**MIN**
Vertical	1185	1170	1055	1000	7	4

Heat-treated (ANN)[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 | MIN: Minimum (95 % population coverage / 95 % confidence level)[7]

	Vickers hardness HV10	
	M	**MIN**
As built	357	346
Heat-treated[8]	316	308

SURFACE ROUGHNESS[10]

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

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	**MAX**	**M**	**MAX**
As built	8	11	51	66

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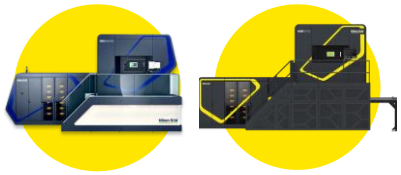

NXG PRODUCTIVITY

Parameter Set	Ti6Al4V_NXG600_PROD_MBP3_V1 (90 µm)
Machine Compatibility	NXG XII 600, NXG 600E (1000 W)
Validated Data Preparation	Materialise SLM Build Processor
Theoretical System Build Rate[4]	1020 cm^3/h
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**
Vertical	1160	1120	1030	980	4	1
Near-Net-Shape	**M**	**MIN**	**M**	**MIN**	**M**	**MIN**
Vertical	1110	1085	925	880	4	1

HARDNESS[9]

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

	Vickers hardness HV10	
	M	**MIN**
As built	355	340
Heat treated	310	300

SURFACE ROUGHNESS[10]

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

	Roughness average Ra [µm]		Mean roughness depth Rz [µm]	
	M	**MAX**	**M**	**MAX**
As built	8	11	51	70

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DISCLAIMER

The properties and mechanical characteristics apply to powder that is tested and sold by Nikon SLM Solutions, and that has been processed on Nikon SLM Solutions machines using the original Nikon 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 Nikon 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_2024-06.1_EN

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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 3252:2023.

[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 6892-1:2020 (method A / method 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 50125:2022-08 D6x30 and DIN 50125:2022-08 C6x30). Samples labelled “Horizontal” correspond to a polar angle of $\theta = 90°$; samples labelled “vertical” correspond to a polar angle of $\theta = 0°$ (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 or maximum 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 or below the maximum value with a certain probability, e.g. the probability that 95% of all samples will be above the minimum value or below the maximum value (within a defined batch and tested according to mentioned specifications) is 95%.

[8] Heat treatment: 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 6507-1:2024. 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 21920-3:2022; $\lambda c = 2.5$ 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.