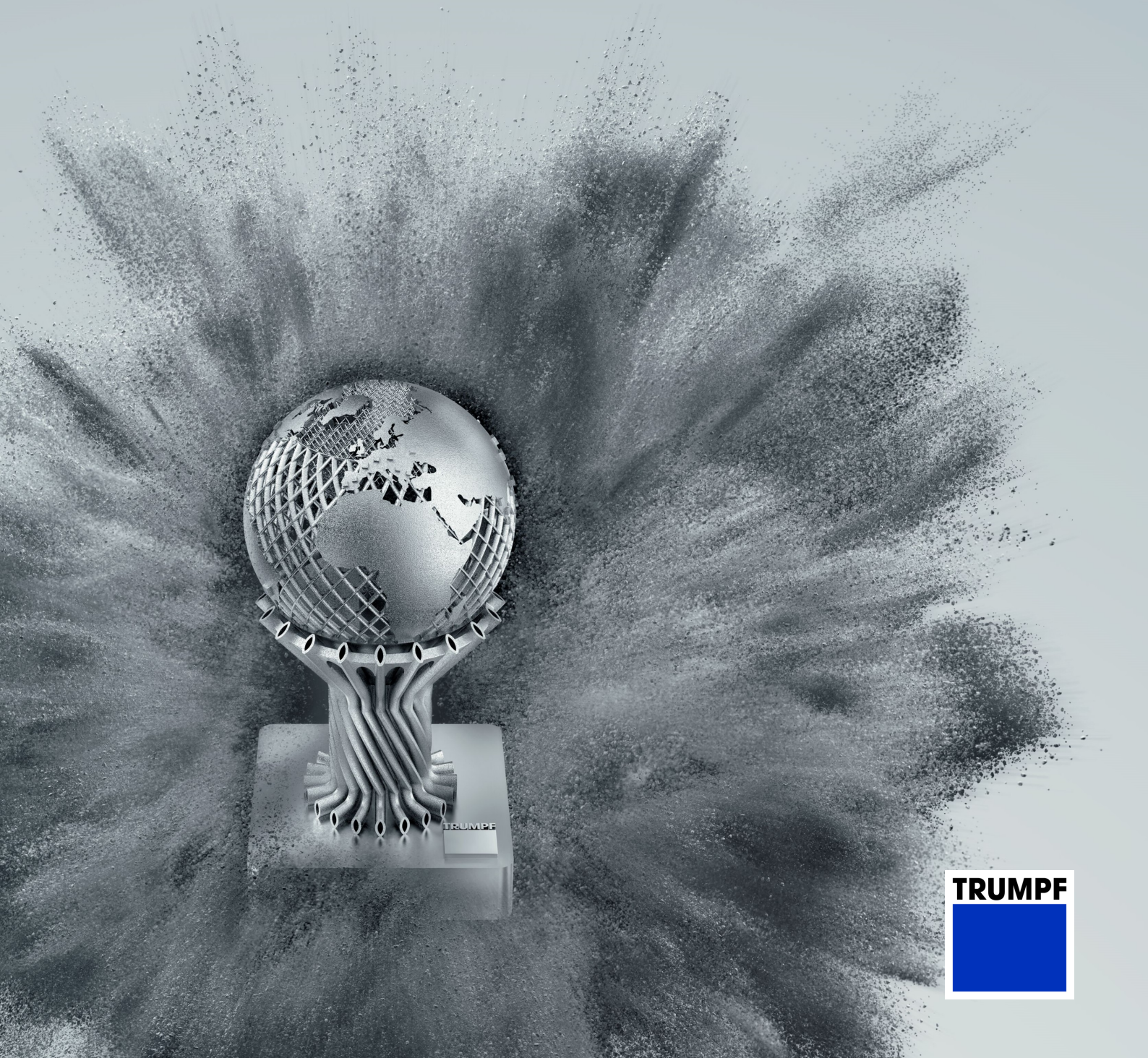
TruPrint 2000 Stainless Steel



TRUMPF

Contents

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TRUMPF Laser- und Systemtechnik SE
Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

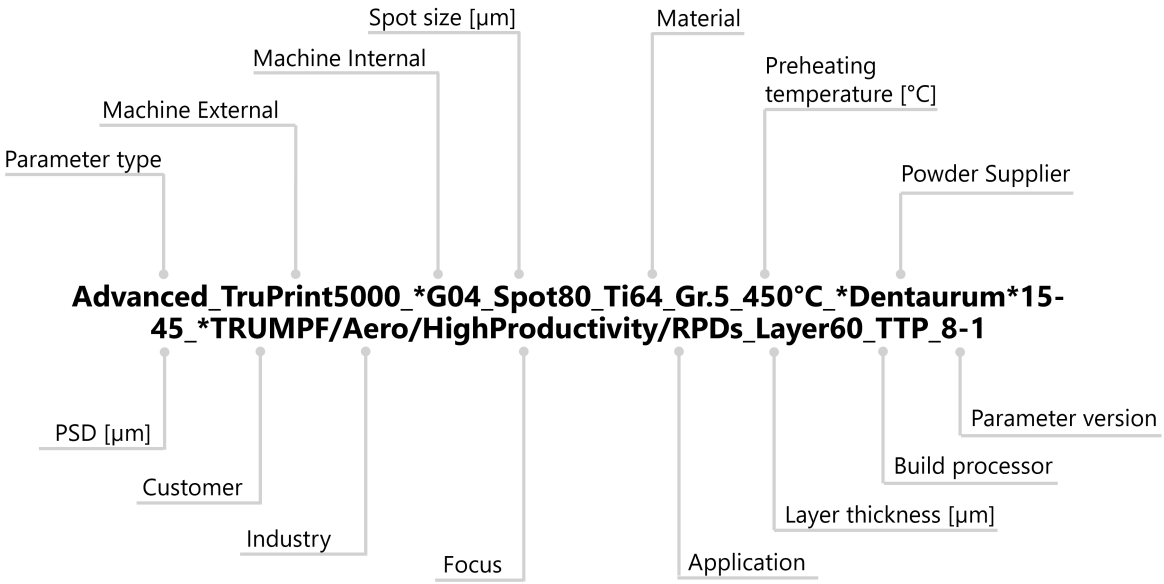
1. Introduction to parameters at TRUMPF AM

This document details the parameter set for processing Stainless Steel using the TruPrint 2000. The set encompasses all materials within this material group, various layer thicknesses, and types of data preparation software. TRUMPF recommends using TruTops Print for data preparation. Each set may include basic and advanced parameters. Basic parameters are intended as a starting point for development. They are suitable for test geometries, but are generally not recommended for direct part production. Advanced parameters are refined settings suitable for actual component production.

Additionally, the document provides detailed information about the powders used to develop these parameters. Other powders, similar to those mentioned, are also suitable for production on our systems.

We are happy to assist you further in parameter development and optimization to meet your part requirements. Please reach out to us for support.

How do parameter names work at TRUMPF Additive Manufacturing?



***optional possibilities to differ the parameter portfolio**

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

2. Available Parameters

Material	Machine	Parameter type[1]	Spot [µm]	Preheating temperature[2] [°C]	Layer thickness [mm]	Build processor[3]	Build rate[4] [cm³/h]
630	G05	Basic	55	200	0.02	TTP | Mat	11.5
316L	G05	Basic	55	23	0.02	TTP | Mat	11.5
316L	G05	Basic	55	23	0.04	TTP | Mat	28.5
316L	G05	Basic	80	23	0.03	TTP	21.6
316L	G05	Basic	80	23	0.06	TTP	54.0
Printdur HSA	G05	Basic	55	200	0.04	TTP	27.2

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

3. Powder Information

Please contact additive.manufacturing@de.trumpf.com for direct contact to powder manufacturers.

Material	Supplier	Powder name	PSD [µm]	Supplier ID
630	Oerlikon Metco	MetcoAdd 17-4PH-A	15-45	1093744.0
316L	ArcelorMittal	AdamIQ™ 316L	20-53	AdamIQ™ 316L
316L	GKN	ANCOR AM 316L	15-53	503608.0
316L	Indo-MIM	PLM-316AA	15-53	PLM-316AA
316L	Indo-MIM	PLM-316AB	15-45	PLM-316AB
316L	Oerlikon Metco	MetcoAdd 316L-A	15-45	1093739.0
Printdur HSA	DEW	Printur HSA	10-53	4799.97

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

4. Parameter details

4.1. Basic_TruPrint2000_Spot55_630_Layer20

Powder information		Material properties	
Material	630	**Build rate[4] [cm³/h]**	11.5
Supplier	Oerlikon Metco	**Relative density[5] [%]**	99.9
Powder name	MetcoAdd 17-4PH-A	**Average roughness[6] R_a [µm]**	—
Supplier ID	1093744.0	**Average roughness[6] R_z [µm]**	—

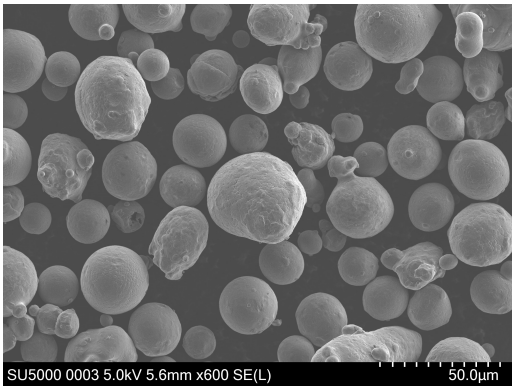

Figure 1: 630 powder by Oerlikon Metco. PSD: 15-45 µm. SEM magnification: 600x.

No Heat Treatment

All properties are reported using 3σ-intervals[8]. The values for 0° and 90° are derived from qualification reports, while the average values are calculated from additional measurements.

Mechanical properties[9] machined					
	0°	**90°**	**Average[12]**		
Yield strength [MPa]	—	—	566.2 – 934.0	**Samples**	25
Tensile strength [MPa]	—	—	264.7 – 1854.1	**Build jobs**	2
Elong. at break [%]	—	—	7.9 – 29.5	**Machines**	2

Learn more

Property profile of stainless steels in additive manufacturing, produced on the TruPrint 2000

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Johann-Maus-Straße 2, 71254 Ditzingen
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+49 (0) 7156 303-31620

4.2. Basic_TruPrint2000_Spot55_316L_Layer20

Powder information		Material properties	
Material	316L	**Build rate[4] [cm³/h]**	11.5
Supplier	Oerlikon Metco	**Relative density[5] [%]**	99.9
Powder name	MetcoAdd 316L-A	**Average roughness[6] R_a [µm]**	—
Supplier ID	1093739.0	**Average roughness[6] R_z [µm]**	—

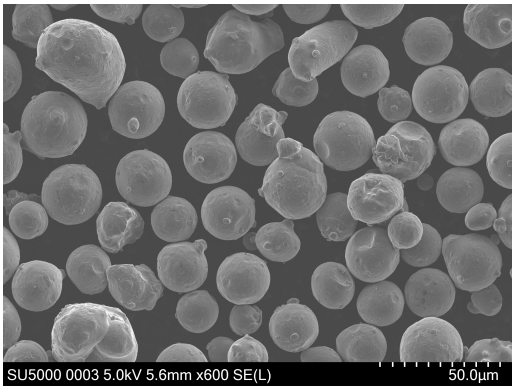

Figure 2: 316L powder by Oerlikon Metco. PSD: 15-45 µm. SEM magnification: 600x.

Other suitable 316L powders
For details see powder information page.

Supplier	Powder Name
ArcelorMittal	AdamIQ™ 316L
GKN	ANCOR AM 316L
Indo-MIM	PLM-316AA
Indo-MIM	PLM-316AB

SEM images of other suitable 316L powders

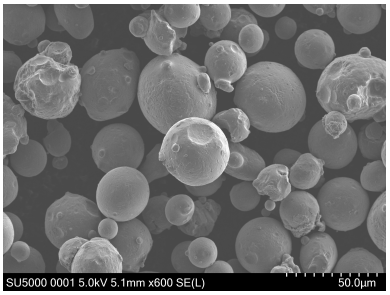

Figure 3: 316L powder by Indo-MIM. PSD: 15-45 µm. SEM magnification: 600x.

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

No Heat Treatment

All properties are reported using 3σ-intervals[8]. The values for 0° and 90° are derived from qualification reports, while the average values are calculated from additional measurements.

Physical properties	
Electrical conductivity [%IACS]	2.0 – 2.0
Thermal conductivity[14] [W/mK]	7.9

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

4.3. Basic_TruPrint2000_Spot55_316L_Layer40

Powder information		Material properties	
Material	316L	**Build rate[4] [cm³/h]**	28.5
Supplier	Oerlikon Metco	**Relative density[5] [%]**	99.9
Powder name	MetcoAdd 316L-A	**Average roughness[6] R_a [µm]**	—
Supplier ID	1093739.0	**Average roughness[6] R_z [µm]**	—

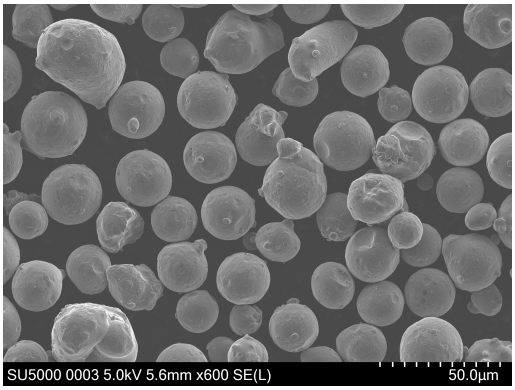

Figure 4: 316L powder by Oerlikon Metco. PSD: 15-45 µm. SEM magnification: 600x.

Other suitable 316L powders
For details see powder information page.

Supplier	Powder Name
ArcelorMittal	AdamIQ™ 316L
GKN	ANCOR AM 316L
Indo-MIM	PLM-316AA
Indo-MIM	PLM-316AB

SEM images of other suitable 316L powders

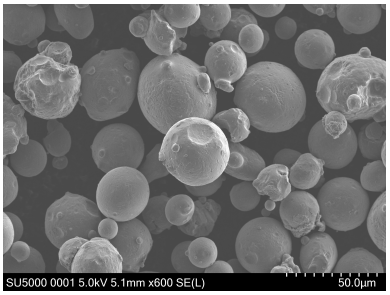

Figure 5: 316L powder by Indo-MIM. PSD: 15-45 µm. SEM magnification: 600x.

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

No Heat Treatment

All properties are reported using 3σ-intervals[8]. The values for 0° and 90° are derived from qualification reports, while the average values are calculated from additional measurements.

Mechanical properties[9] machined					
	0°	90°	Average[12]		
Yield strength [MPa]	—	474.0 – 534.0	486.0 – 521.4	**Samples**	15
Tensile strength [MPa]	—	628.0 – 652.0	627.3 – 652.5	**Build jobs**	1
Elong. at break [%]	—	37.0 – 43.0	38.2 – 42.4	**Machines**	1

Hardness[13]	
Vickers [HV]	233.0 – 251.0

Physical properties	
Electrical conductivity [%IACS]	2.0 – 2.0
Thermal conductivity[14] [W/mK]	7.9

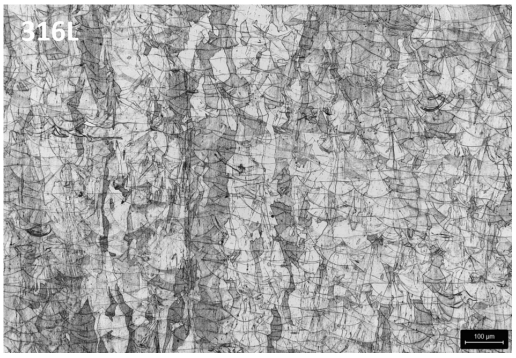

Figure 6: Microstructure of 316L: no heat treatment

Additional Information

Material		316L	AISI 630	Printdur HSA
Relative Density [%]		> 99.7 %	> 99.7 %	> 99.7 %
Safety (REACH, UN)		Co free	Co free	Ni / Co free
Heat Treatment		No	**H900**	No
Tensile Test	$Rp_{0,2}$ [MPa]	504 ± 10 MPa	1147 ± 55 MPa	861 ± 13 MPa
	R_m [MPa]	640 ± 4 MPa	1419 ± 14 MPa	1116 ± 6 MPa
	A [%]	40 ± 1 %	9 ± 2 %	30 ± 5 %
Impact Test [J]		148 ± 7 J	9 ± 1 J	23 ± 4 J
Application Temperature [°C]		Up to 550 °C	Up to 315 °C	Up to 200 – 300 °C
XRD		95% Austenite*	97% Ferritic 3% Austenitie	98 % Austenite*
Corrosion	Surface Corrosion ASTM G5 I_5 Potential Curve (H_2SO_4)	✓	✓	✓
	Pitting Corrosion ASTM G 48 E ($FeCl_3$, 35 °C)	48.9 mm/a	27,6 mm/a	5.9 mm/a
	Pitting Equivalent Number (PREN	24	16	34

Figure 7: Comparison of stainless steels.

TRUMPF Laser- und Systemtechnik SE
Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

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Property profile of stainless steels in additive manufacturing, produced on the TruPrint 2000

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

4.4. Basic_TruPrint2000_Spot80_316L_Layer30

Powder information		Material properties	
Material	316L	**Build rate[4] [cm³/h]**	21.6
Supplier	Oerlikon Metco	**Relative density[5] [%]**	99.9
Powder name	MetcoAdd 316L-A	**Average roughness[6] R_a [µm]**	—
Supplier ID	1093739.0	**Average roughness[6] R_z [µm]**	—

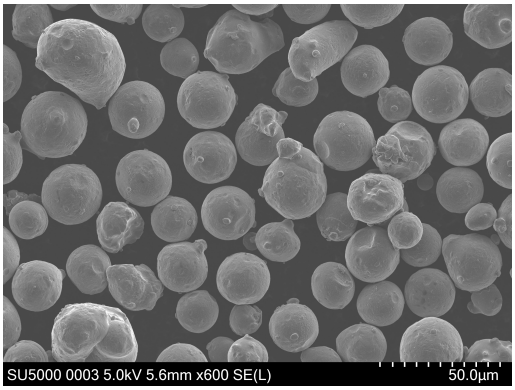

Figure 8: 316L powder by Oerlikon Metco. PSD: 15-45 µm. SEM magnification: 600x.

Other suitable 316L powders
For details see powder information page.

Supplier	Powder Name
ArcelorMittal	AdamIQ™ 316L
GKN	ANCOR AM 316L
Indo-MIM	PLM-316AA
Indo-MIM	PLM-316AB

SEM images of other suitable 316L powders

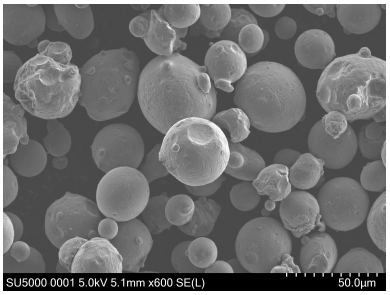

Figure 9: 316L powder by Indo-MIM. PSD: 15-45 µm. SEM magnification: 600x.

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

No Heat Treatment

All properties are reported using 3σ-intervals[8]. The values for 0° and 90° are derived from qualification reports, while the average values are calculated from additional measurements.

Physical properties	
Electrical conductivity [%IACS]	2.0 – 2.0
Thermal conductivity[14] [W/mK]	7.9

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

4.5. Basic_TruPrint2000_Spot80_316L_Layer60

Powder information		Material properties	
Material	316L	**Build rate[4] [cm³/h]**	54.0
Supplier	Oerlikon Metco	**Relative density[5] [%]**	99.9
Powder name	MetcoAdd 316L-A	**Average roughness[6] R_a [µm]**	—
Supplier ID	1093739.0	**Average roughness[6] R_z [µm]**	—

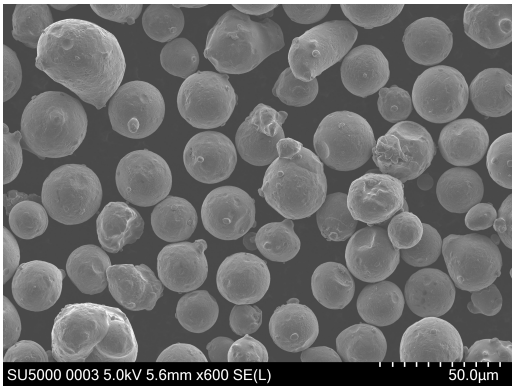

Figure 10: 316L powder by Oerlikon Metco. PSD: 15-45 µm. SEM magnification: 600x.

Other suitable 316L powders
For details see powder information page.

Supplier	Powder Name
ArcelorMittal	AdamIQ™ 316L
GKN	ANCOR AM 316L
Indo-MIM	PLM-316AA
Indo-MIM	PLM-316AB

SEM images of other suitable 316L powders

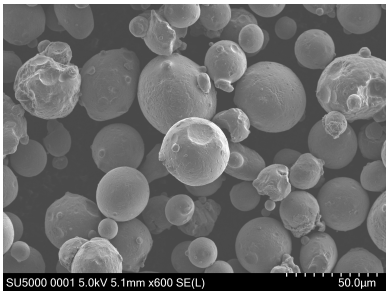

Figure 11: 316L powder by Indo-MIM. PSD: 15-45 µm. SEM magnification: 600x.

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

No Heat Treatment

All properties are reported using 3σ-intervals[8]. The values for 0° and 90° are derived from qualification reports, while the average values are calculated from additional measurements.

Physical properties	
Electrical conductivity [%IACS]	2.0 – 2.0
Thermal conductivity[14] [W/mK]	7.9

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

4.6. Basic_TruPrint2000_Spot55_Printdur_HSA_Layer40

Powder information		Material properties	
Material	Printdur HSA	**Build rate[4] [cm³/h]**	27.2
Supplier	DEW	**Relative density[5] [%]**	99.9
Powder name	Printdur HSA	**Average roughness[6] R_a [µm]**	—
Supplier ID	4799.97	**Average roughness[6] R_z [µm]**	—

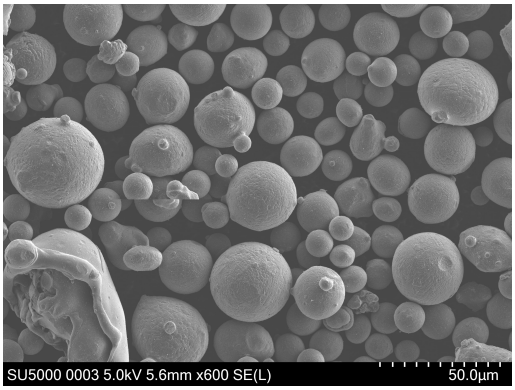

Figure 12: Printdur HSA powder by DEW. PSD: 10-53 µm. SEM magnification: 600x.

No Heat Treatment

All properties are reported using 3σ-intervals[8]. The values for 0° and 90° are derived from qualification reports, while the average values are calculated from additional measurements.

Mechanical properties[9] machined					
	0°	**90°**	**Average[12]**		
Yield strength [MPa]	905.0 – 971.0	823.0 – 901.0	781.2 – 961.8	**Samples**	17
Tensile strength [MPa]	1148.0 – 1220.0	1098.0 – 1134.0	1047.4 – 1202.2	**Build jobs**	1
Elong. at break [%]	16.4 – 31.4	22.1 – 37.1	14.8 – 44.2	**Machines**	1

Hardness[13]	
Vickers [HV]	359.0 – 389.0

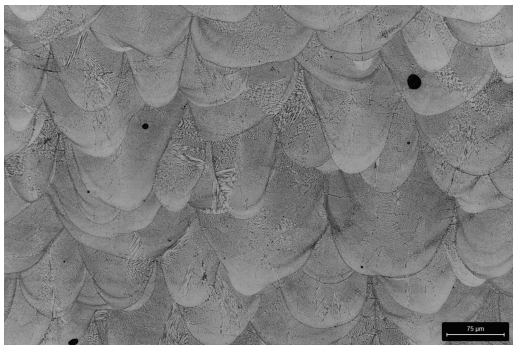

Figure 13: Microstructure of Printdur HSA: no heat treatment

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Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620

Additional Information

Material		316L	AISI 630	Printdur HSA
Relative Density [%]		> 99.7 %	> 99.7 %	> 99.7 %
Safety (REACH, UN)		Co free	Co free	Ni / Co free
Heat Treatment		No	**H900**	No
Tensile Test	$Rp_{0,2}$ [MPa]	504 ± 10 MPa	1147 ± 55 MPa	861 ± 13 MPa
	R_m [MPa]	640 ± 4 MPa	1419 ± 14 MPa	1116 ± 6 MPa
	A [%]	40 ± 1 %	9 ± 2 %	30 ± 5 %
Impact Test [J]		148 ± 7 J	9 ± 1 J	23 ± 4 J
Application Temperature [°C]		Up to 550 °C	Up to 315 °C	Up to 200 – 300 °C
XRD		95% Austenite*	97% Ferritic 3% Austenitie	98 % Austenite*
Corrosion	Surface Corrosion ASTM G5 I_δ Potential Curve (H_2SO_4)	✓	✓	✓
	Pitting Corrosion ASTM G 48 E ($FeCl_3$, 35 °C)	48.9 mm/a	27,6 mm/a	5.9 mm/a
	Pitting Equivalent Number (PREN	24	16	34

Figure 14: Comparison of stainless steels.

Learn more

Property profile of stainless steels in additive manufacturing, produced on the TruPrint 2000

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+49 (0) 7156 303-31620

[1] Basic parameters: starting point for development, generally not recommended for direct part production. Advanced parameters: refined settings, suitable for actual component production.
[2] Describes the preheating temperature of the build plate. A generic value of 23°C is stated, if no active preheating was used. The actual value depends on the climatic conditions of the surrounding.
[3] TTP: TruTops Print, Mat: Materialise, Cam: Cambridge, Oqt: Oqton
[4] Calculated melting rate with maximum amount of lasers; effective melting rate may differ depending on the application.
[5] ASTM E 1245:2003. Measurement of the relative density was performed for specimens with cubic geometries. Values can differ for other geometries and sizes.
[6] Arcording to DIN EN ISO 21920-2-01:2022 with used measurement length of 4,8 mm
[7] The process description is read as follows: Example: 650°C/10min,850°C/10min,1010°C/30min,Air; 590°C/2h,Air; 590°C/2h,Air: 1. Heat treatment cycle: (1. temperature/1. holding time at temperature, 2. temperature/2. holding time, quenching medium); 2. heat treatment cycle (temperature/holding time, quenching medium); 3. heat treatment cycle (temperature/holding time, quenching medium). We recommend that titanium is heat treated under vacuum.
[8] Values are stated as intervals from 3σ to the left of the mean to 3σ to the right of the mean. This ensures that, statistically, 99.73% of the process output meets customer requirements. For sufficiently many data points, a full process capability analysis was performed and intervals are stated such that a CPK of 1.33 was achieved.
[9] DIN EN ISO 6892-1:2017, DIN 50125:2016
[10] DIN EN ISO 22674
[11] ASTM E8
[12] The average values could include a combination of different build jobs on the same machine type, different powder manufacturers and different inspection orientations.
[13] DIN EN ISO 6506-1:2015
[14] Calculated from electrical conductivity using Wiedemann Franz Law: $\kappa/\sigma = LT$, with thermal conductivity κ [W/mK], electrical conductivity σ [S/m], Lorenz number $L = 2.44 \cdot 10^{-8}$ WΩ/K², temperature T [K].

Further test procedure details are available on request.

The component properties obtained were exclusively derived from the combination of suitable powder, the TRUMPF TruPrint and the parameter sets, while observing the current operator's manual.

The data in this technical data sheet and other information are up to date. They alone do not provide a sufficient basis for designing components. The suitability of a component for a particular application cannot be guaranteed by this information. The details in this data sheet are intended exclusively for information purposes and do not constitute an agreement on certain qualities. The TRUMPF warranty only covers agreements specified in the delivery contracts.

The manufacturer of a component is responsible for determining the properties and suitability for any use of the component. They are also responsible for respecting any potential property rights and current legislation and regulations.

As a result of continuous improvement processes in place at TRUMPF, the information in this data sheet is subject to change without prior notice. Errors are excepted.

TRUMPF Laser- und Systemtechnik SE
Johann-Maus-Straße 2, 71254 Ditzingen
additive.manufacturing@de.trumpf.com
+49 (0) 7156 303-31620