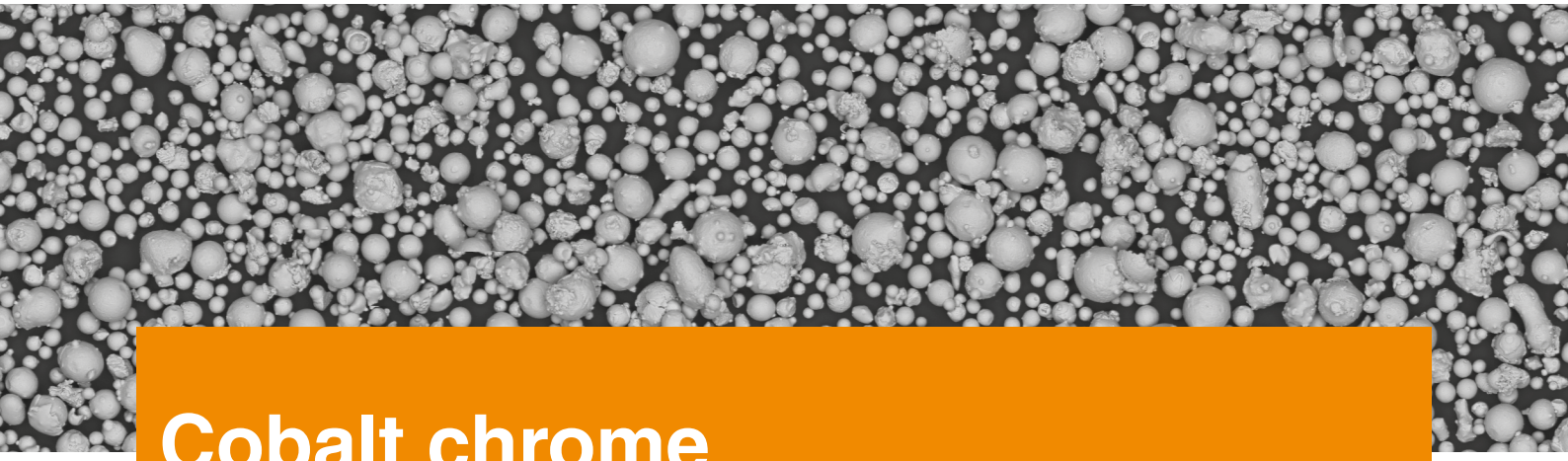
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Cobalt chrome

This material is compatible with LIBERTAS™ technology.

This data sheet indicates the material properties achievable with additively manufactured (AM) parts made from cobalt chrome (Co28Cr6Mo) powder. The data shown is only applicable to parts made on Renishaw's RenAM 500 series of Laser Powder Bed Fusion (LBPF) metal AM systems.

Cobalt chrome (Co28Cr6Mo) is a cobalt-based alloy containing chromium of mass fraction up to 30% and molybdenum up to 7%, along with other minor elements. The alloy has a high melting point and corrosion resistance, making it very stable at high temperatures.

Cobalt chrome (Co28Cr6Mo) is particularly suitable for applications requiring corrosion resistance, high-temperature stability, and wear resistance. Its excellent biocompatibility, strength, and wear resistance make it widely used in orthopaedic and dental applications.

Material properties

- High strength and hardness
- High corrosion resistance
- Excellent biocompatibility
- High temperature resistance

Applications

- Medical and dental
- Gas turbines
- Engine components

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1 Typical wrought material properties

The typical wrought material properties of cobalt chrome (Co28Cr6Mo) that can be used as reference data to support comparison and material qualification.

Material property	Wrought material value
Density	8.4 g/cm3
Thermal conductivity	13 W/mK
Melting temperature	1 260 °C to 1 360 °C
Coefficient of thermal expansion [1]	13×10^{-6} K^{-1}

NOTE: To learn more about the flag notes, refer to section 6 “Notes”.

2 Recommended composition of powder

The recommended powder size distribution is 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.

Element	Co	Cr	Mo	Mn	Si	Fe	Ni	N	W	Al	O	Ti	C	P	B	S
Mass (%)	Balance	27.00 to 30.00	5.00 to 7.00	≤ 1.00	≤ 1.00	≤ 0.75	≤ 0.50	≤ 0.25	≤ 0.20	≤ 0.10	≤ 0.10	≤ 0.10	≤ 0.05	≤ 0.02	≤ 0.01	≤ 0.01

3 Recommended RenAM 500 series machine settings

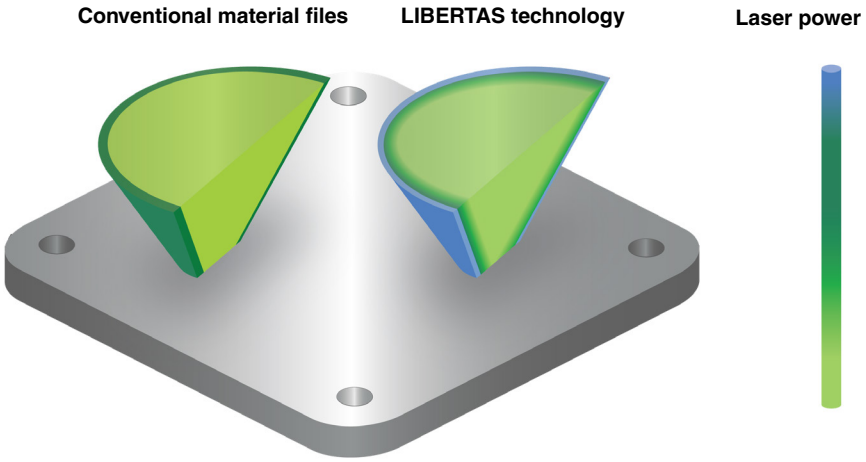
These system settings are intended for ASTM standard composition powder at the recommended powder size distribution. See section 2 “Recommended composition of powder” for details.

Gas flow	190 m^3/h
Sieve size	63 µm
Differential pressure setting for the SafeChange™ filter	95 mbar

4 LIBERTAS technology

LIBERTAS technology is a laser control method developed by Renishaw that gives you freedom to dynamically adjust laser parameters (such as power and exposure time) during a build to meet the requirements of your part geometry.

Unlike conventional material files that use fixed laser settings for each type of area in a part (e.g. downskin, borders and bulk), LIBERTAS allows selected laser parameters to continuously vary between these areas. This results in better distribution of laser energy, meaning improved heat management and reduced internal stress in your parts.



4.1 Support Reduction Package

Building on the foundation of LIBERTAS technology, Renishaw has developed the Support Reduction Package (SRP). SRP leverages LIBERTAS technology to modify energy distribution across each layer, reducing the need for supports.

Traditionally, support structures are required for overhanging surfaces with a critical angle of 45° or less from the horizontal. Using SRP can reduce this critical angle to just 10° in some cases. To show the material performance at these low angles, material property data for SRP material files is shown at build angles of 90°, 50°, 40°, 30°, 20° and 10°.

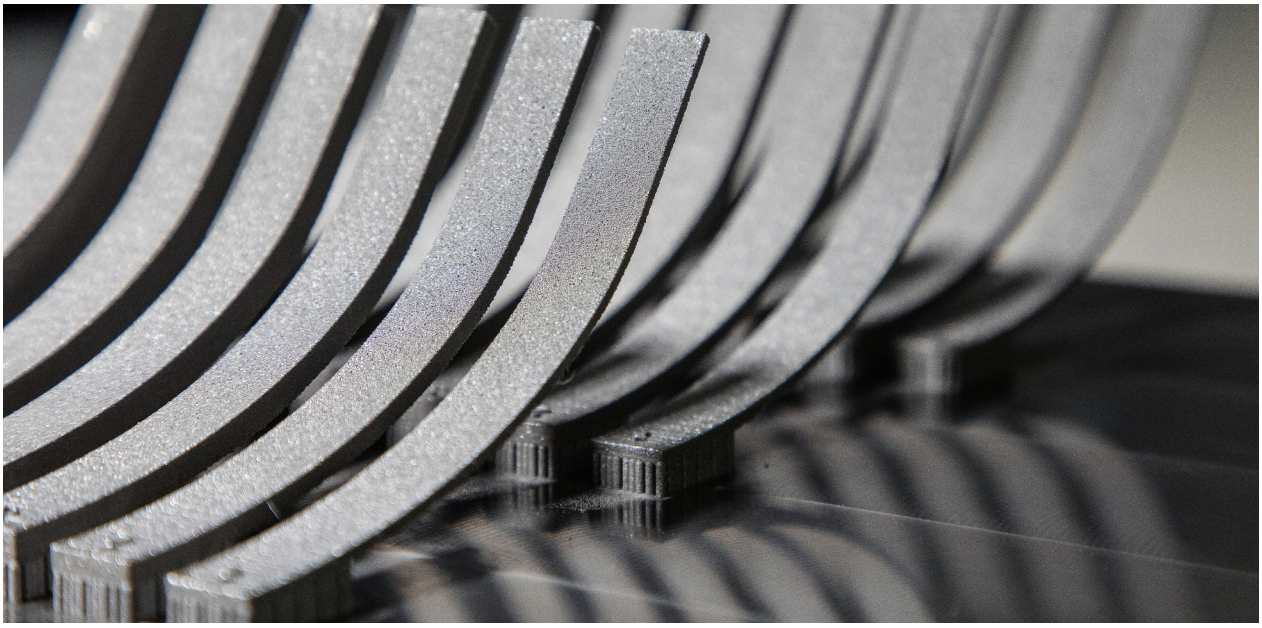


Figure 1 Complex curve SRP build used to test low-angle performance

5 Material file properties

Material files contain the validated laser parameters used by Renishaw AM systems to build a specific alloy at a defined layer thickness and laser mode. Each file defines how the machine applies laser energy to achieve the intended material performance, which is indicated in the material property data below.

To download the latest material files for the RenAM 500 series, visit **www.renishaw.com/softwaredownloads.**

5.1 40 µm – single laser per part – continuous wave

Material files: CoCr_500QS_B40_M_03_A (meander scan strategy)
CoCr_500QS_B40_S_03_A (stripe scan strategy)

LIBERTAS technology	Layer thickness	Optimised for	Laser mode	Build rate	
No	40 µm	Single laser per part	Continuous wave	One laser: 13.7 cm^3/h	Four lasers: 54.8 cm^3/h

Properties of additively manufactured components

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.

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. Stripe scan strategy was used for horizontal samples.

		Solution treated [2]
Bulk density [3]		≥ 99.8%
Ultimate tensile strength [4]	Horizontal (XY)	1 092 MPa ±15 MPa
	Vertical (Z)	1 068 MPa ±20 MPa
Yield strength [4]	Horizontal (XY)	573 MPa ±5 MPa
	Vertical (Z)	566 MPa ±12 MPa
Elongation after fracture [4]	Horizontal (XY)	34% ±2%
	Vertical (Z)	37% ±3%
Modulus of elasticity [4]	Horizontal (XY)	238 GPa ±12 GPa
	Vertical (Z)	236 GPa ±8 GPa
Hardness (Vickers) [5]	Horizontal (XY)	323 HV0.5 ±9 HV0.5
	Vertical (Z)	322 HV0.5 ±9 HV0.5
Surface roughness [6]	Vertical (Z) (Median Ra)	8 µm ±1 µm

NOTE: To learn more about the flag notes, refer to section 6 “Notes”.

5.1.1 LIBERTAS SRP – 40 µm – single laser per part – continuous wave

Material file: CoCr_500QS_E40_M_01_A (meander scan strategy)

LIBERTAS technology	Layer thickness	Optimised for	Laser mode	Build rate	
Yes	40 µm	Single laser per part	Continuous wave	One laser: 26.1 cm^3/h	Four lasers: 104.6 cm^3/h

Properties of additively manufactured components

This parameter set is optimised for support reduction. The material properties in the following table and graphs are indicative only. Further modification of the material file may be required to suit your application.

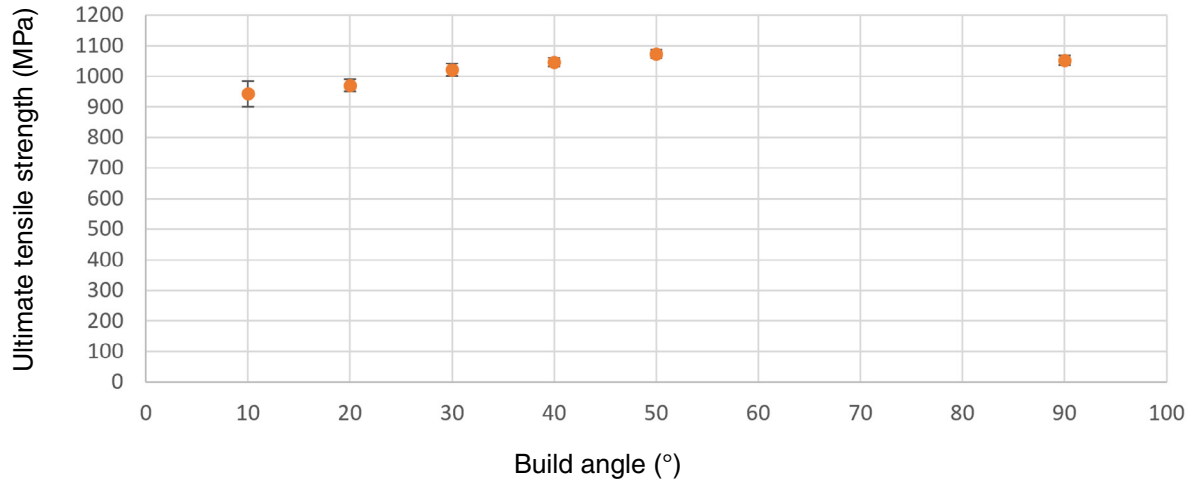
Mechanical test samples were created using two lasers, one laser per sample and with no downstream processing.

	Annealed [7]
Bulk density [8]	≥ 99.8%
Modulus of elasticity [4]	Refer to section 5.1 “40 µm – single laser per part – continuous wave”.

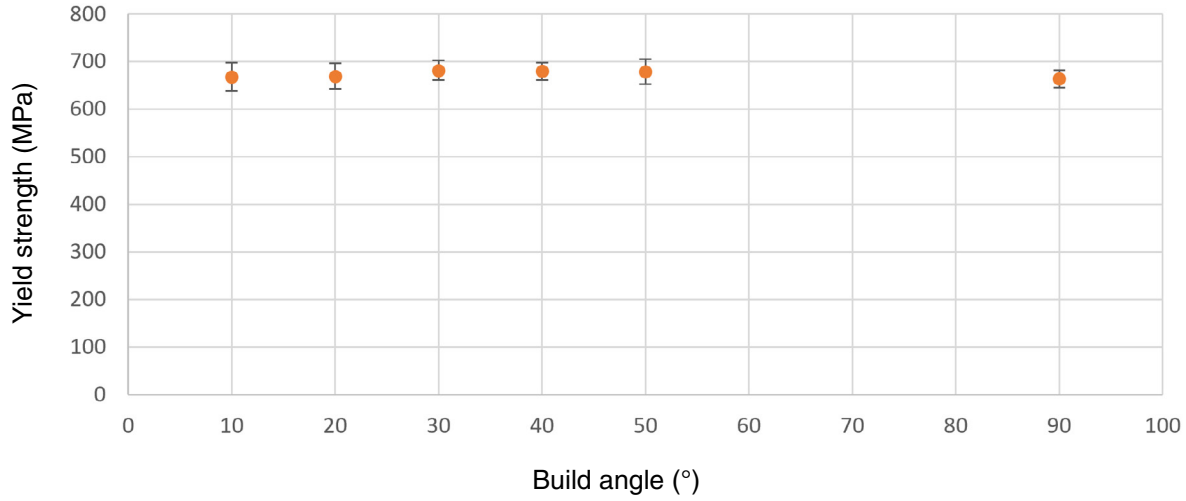
NOTE: To learn more about the flag notes, refer to section 6 “Notes”.

Material properties are presented as mean values achieved at each build angle. Error bars indicate standard deviation.

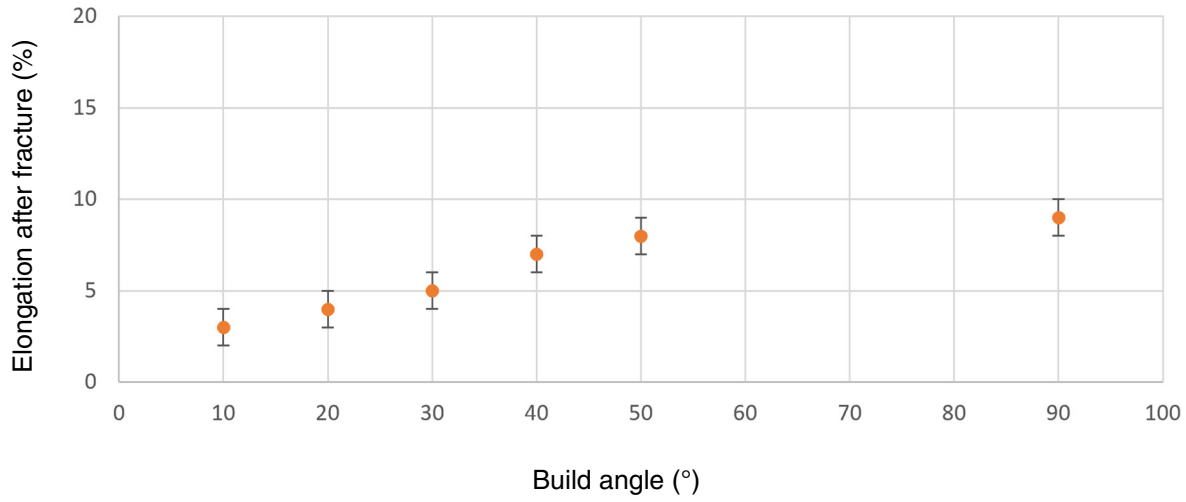
Ultimate tensile strength by build angle [9]



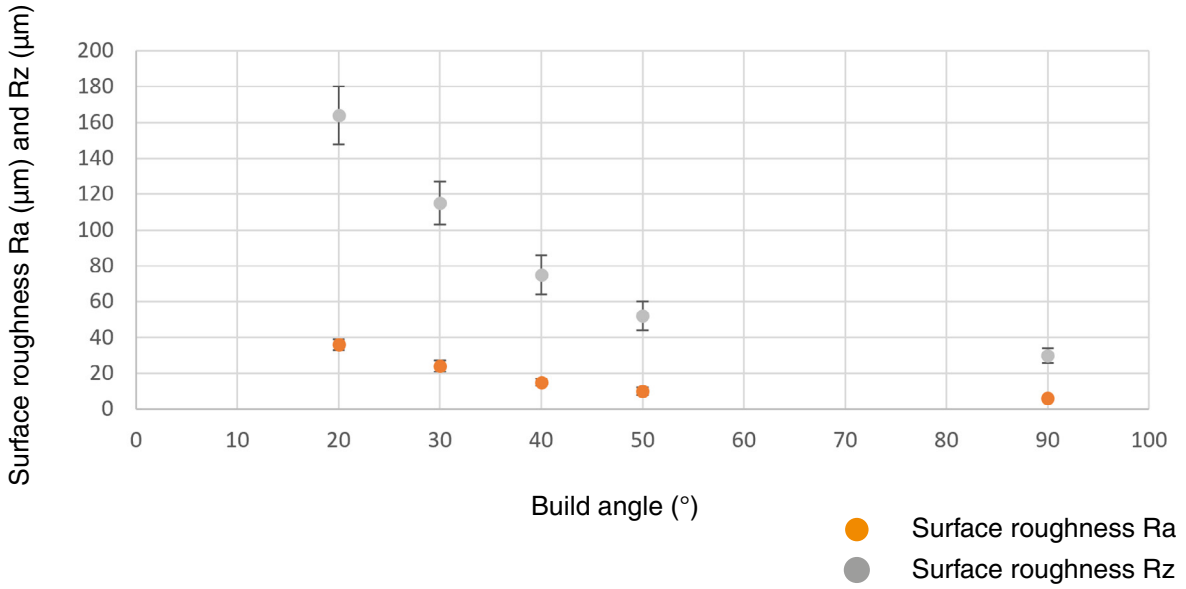
Yield strength by build angle [9]



Elongation after fracture by build angle [9]



Surface roughness (Ra and Rz) by build angle [10]



5.2 60 µm – single laser per part – continuous wave

Material files: CoCr_500QS_B60_M_02_A (meander scan strategy)
CoCr_500QS_B60_S_02_A (stripe scan strategy)

LIBERTAS technology	Layer thickness	Optimised for	Laser mode	Build rate	
No	60 µm	Single laser per part	Continuous wave	One laser: 26.1 cm^3/h	Four lasers: 104.4 cm^3/h

Properties of additively manufactured components

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.

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

		As built	Annealed [7]
Bulk density [3]		≥ 99.8%	–
Ultimate tensile strength [4]	Vertical (Z)	1 193 MPa ±9 MPa	1 104 MPa ±28 MPa
Yield strength [4]	Vertical (Z)	689 MPa ±5 MPa	560 MPa ±11 MPa
Elongation after fracture [4]	Vertical (Z)	25% ±1%	39% ±5%
Modulus of elasticity [4]	Vertical (Z)	224 GPa ±14 GPa	237 GPa ±13 GPa
Hardness (Vickers) [5]	Vertical (Z)	365 HV0.5 ±17 HV0.5	–
Surface roughness [6]	Vertical (Z) (Median Ra)	8 µm ±1 µm	8 µm ±1 µm

NOTE: To learn more about the flag notes, refer to section 6 “Notes”.

6 Notes

[1] In the range of 20 °C to 100 °C.

[2] Solution treatment method used for testing: Under vacuum, heat at 8 °C/min to 640 °C ±10 °C, then hold temperature for 15 min. Heat at 8 °C/min to 1 000 °C ±10 °C, then hold temperature for 5 min. Heat at 8 °C/min to 1 050 °C ±10 °C, then hold temperature for 2 hours. Gas quench with argon at 1 bar to room temperature.

[3] Measured optically on 10 mm × 10 mm × 10 mm samples at 75× magnification.

[4] Tested at ambient temperature to ASTM E8. Machined prior to testing. Values based on 32 samples. Yield strength values report the 0.2% yield strength.

[5] Tested to ASTM E384-11 after polishing.

[6] Tested on as-built vertical surfaces using laser interferometry. Tested to JIS B 0601 2001 (ISO 4287:1997).

[7] Annealing method used for testing: Under vacuum, heat at 8 °C/min to 1150 °C ±10 °C, then hold temperature for 6 hours. Furnace cool to room temperature.

[8] Measured optically on a 40 mm × 10 mm × 3 mm Z-plane overhang sample at 75× magnification.

[9] Tested at ambient temperature to ASTM E8. Samples bead-blasted prior to testing with no machined surfaces. Values based on 8 dog-bone samples per build angle (4 tilted into and 4 away from the wiper) using minimal supports.

[10] Tested on bead-blasted downskin surfaces using laser interferometry. Tested to JIS B 0601-2001 (ISO 4287:1997). Values based on 8 dog-bone samples per build angle (4 tilted into and 4 away from the wiper) using minimal supports.

7 Disclaimer

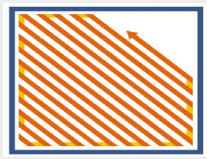
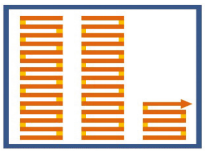
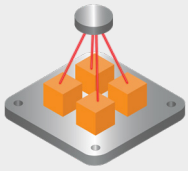
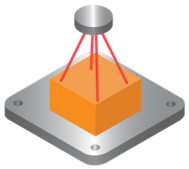
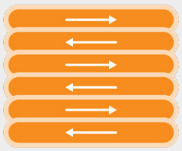
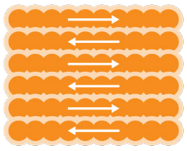
The mechanical property data featured in this document was obtained from tests performed in Renishaw's laboratories and only indicate the mechanical properties that can be achieved. The data is not intended as a guaranteed minimum specification.

8 Training and support

For training, application guidance, and technical support related to LIBERTAS and associated material parameter development, contact Renishaw directly. Renishaw can provide support to assist with material selection, parameter usage, and the effective application of LIBERTAS-enabled workflows within your manufacturing environment.

Phone number:	+44 (0) 1453 524 524 Hours of work: Monday to Friday 08:00 to 1700 hr (UTC and DST)
Email:	**am_applications@renishaw.com**
Service address:	Renishaw plc New Mills Wotton-under-Edge Gloucestershire GL12 8JR United Kingdom

9 Glossary of terms

Term	Definition
Scan strategy	Determines the path the laser will take to melt the cross-sectional area of the parts featured in each layer of the build process.
Meander 	A scan strategy that takes the form of a straight-line vector path that bounces back and forth from each side of the part border. Meander strategy is quick and ideal for parts with a small XY cross section.
Stripe 	A scan strategy where the area within the part border is split into strips and a meander technique is used within each strip. Stripe is ideal for parts with a large XY cross section.
Single laser per part 	Material files optimised for “single laser per part” are ideal for building many smaller parts simultaneously on a single build plate. They are best used by making sure each part is processed by only one dedicated laser throughout the entire build process.
Multiple laser per part 	Material files optimised for “Multiple lasers per part” are ideal for builds that feature only one or two large parts on the build plate. The scan paths of each laser have increased overlap with one another to ensure homogeneous melting of parts made with multiple lasers at once.
Continuous wave (CW) 	A laser strategy where a continuous laser beam delivers uninterrupted energy as it scans across the powder bed. It forms overlapping melt tracks to create a solid structure. This approach produces a stable and relatively broad melt pool, making it suitable operating at higher power and speeds. It is typically used for bulk regions where fast build rates and efficient material deposition are required.
Modulated wave (MW) 	A laser strategy where the laser is modulated, switching on and off to deliver energy as a series of discrete exposures. The laser modulation enables greater control over melt behaviour. This approach is well suited to detailed features where precision and controlled heat input are important.

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