Maraging Steel MS1

MATERIAL DATA SHEET

Maraging Steel MS1 is characterized by having very good mechanical properties, and being easily heat-treatable using a simple thermal age-hardening process to obtain excellent hardness and strength. Parts built from Maraging Steel MS1 are easily machinable after the building process and can be easily post-hardened to more then 50 HRC by age-hardening at 490 °C (914 °F) for 6 hours. In both as-built and age-hardened states the parts can be machined, spark-eroded, welded, micro shot-peened, polished and coated if required. Due to the layer-wise building method, the parts have a certain anisotropy, which can be reduced or removed by appropriate heat treatment.

General process data

Typical achievable part accuracy [1] *- small parts (< 80 x 80 mm)*	approx. ± 20 µm approx. ± 0.8 x 10^{-3} inch
- large parts	approx. ± 50 µm approx. ± 0.002 inch
Age hardening shrinkage [2]	approx. 0.08 %
Minimum wall thickness [1] [3]	approx. 0.3 mm approx. 0.012 inch
Surface roughness *(approx.)* [4] *- as manufactured*	
MS1 Surface (20 µm)	Ra 4 µm; Rz 20 µm Ra 0.16 x 10^{-3} inch Rz 0.78 x 10^{-3} inch
MS1 Performance (40 µm)	Ra 5 µm; Rz 28 µm Ra 0.19 x 10^{-3} inch Rz 1.10 x 10^{-3} inch
MS1 Speed (50 µm)	Ra 9 µm; Rz 50 µm Ra 0.47 x 10^{-3} inch Rz 2.36 x 10^{-3} inch
- after shot-peening	Ra 4 - 6.5 µm; Rz 20 - 50 µm Ra 0.16 – 0.26 x 10^{-3} inch Rz 0.78 – 1.97 x 10^{-3} inch
- after polishing	Rz up to < 0.5 µm Rz up to < 0.02 x 10^{-3} inch *(can be very finely polished)*

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Maraging Steel MS1

MATERIAL DATA SHEET

General process data - continued

Volume rate [5]	
- Parameter set MS1_Surface 1.0 / default job MS1_020_default.job (20 µm layer thickness)	1.6 mm³/s (5.8 cm³/h) 0.35 in³/h
- Parameter set MS1_Performance 2.0 / default job MS1_040_default.job (40 µm layer thickness)	3 mm³/s (10.8 cm³/h) 0.66 in³/h
- Parameter set MS1_Performance 1.0 / for M 280 / 400 W (40 µm layer thickness)	4.2 mm³/s (15.1 cm³/h) 0.92 in³/h
- Parameter set MS1_Speed 1.0 / for M 280 / 400 W (50 µm layer thickness)	5.5 mm³/s (19.8 cm³/h) 1.21 in³/h

Physical & chemical properties of parts

Material composition	Fe (balance)	Ti (0.6 - 0.8 wt-%)	C (≤ 0.03 wt-%)
	Ni (17 - 19 wt-%)	Al (0.05 - 0.15 wt-%)	Mn (≤ 0.1 wt-%)
	Co (8.5 - 9.5 wt-%)	Cr (≤ 0.5 wt-%)	Si (≤ 0.1 wt-%)
	Mo (4.5 - 5.2 wt-%)	Cu (≤ 0.5 wt-%)	P, S (each ≤ 0.01 wt-%)
Relative density	approx. 100 %		
Density	8.0 - 8.1g/cm³ 0.289 - 0.293 lb/in³		

Mechanical properties of parts at 20° C (68° F) - as built

	Horizontal Axis (XY)	Vertical Axis (Z)
Tensile strength [6]	typ. 1100 ± 100 MPa typ. 160 ± 15 ksi	typ. 1100 ± 100 MPa typ. 160 ± 15 ksi
Yield strength (Rp 0.2 %) [6]	typ. 1050 ± 100 MPa typ. 152 ± 15 ksi	typ. 1000 ± 100 MPa typ. 145 ± 15 ksi
Elongation at break [6]	typ. (10 ± 4) %	typ. (10 ± 4) %
Modulus of elasticity [6]	typ. 160 ± 25 GPa typ. 23 ± 4 Msi	typ. 150 ± 20 GPa typ. 22 ± 3 Msi
Hardness [7]	typ. 33 - 37 HRC	
Ductility (Notched Charpy impact test)	typ. 45 ± 10 J	

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Mechanical properties of parts at 20° C (68° F) - after age hardening [2]

	Minimum	*All axis*
Tensile strength [6]	min. 1930 MPa min. 280 ksi	typ. 2050 ± 100 MPa typ. 297 ± 15 ksi
Yield strength (Rp 0.2 %) [6]	min. 1862 MPa min. 270 ksi	typ. 1990 ± 100 MPa typ. 289 ± 15 ksi
Elongation at break [6]	min. 2 %	typ. (4 ± 2) %
Modulus of elasticity [6]	N/A	typ. 180 ± 20 GPa typ. 26 ± 3 Msi
Hardness [7]	typ. 50 - 56 HRC	
Ductility (Notched Charpy impact test)	typ. 11 ± 4 J	

Thermal properties of parts - as built

Thermal conductivity	typ. 15 ± 0.8 W/m°C typ. 104 ± 6 Btu in/(h ft² °F)
Specific head capacity	typ. 450 ± 20 J/kg °C typ. 0.108 ± 0.005 Btu/(lb °F)

Thermal properties of parts - after age hardening [2]

Thermal conductivity	typ. 20 ± 1W/m°C typ. 139 ± 7 Btu in/(h ft² °F)
Specific head capacity	typ. 450 ± 20 J/kg °C typ. 0.108 ± 0.005 Btu/(lb °F)
Maximum operating temperature	approx. 400 °C approx. 750 °F

[1] Based on users' experience of dimensional accuracy for typical geometries, as built. Part accuracy is subject to appropriate data preparation and post-processing.

[2] Aging temperature 490 °C (914 °F), 6 hours, air cooling.

[3] Mechanical stability is dependent on geometry (wall height etc.) and application.

[4] Due to the layer-wise building, the surface structure depends strongly on the orientation of the surface, for example sloping and curved surfaces exhibit a stair-step effect. The values also depend on the measurement method used. The values quoted here given an indication of what can be expected for horizontal (up-facing) or vertical surfaces.

[5] Volume rate is a measure of build speed during laser exposure of hatched areas. The total build speed depends on the average volume rate, the re-coating time (related to the number of layers) and other geometry- and machine setting-related factors.

[6] Tensile testing according to ISO 6892-1:2009 (B) Annex D, proportional test pieces, diameter of the neck area 5mm (0.2 inch), original gauge length 25mm (1 inch).

[7] Rockwell C (HRC) hardness measurement according to EN ISO 6508-1 on polished surface. Note that measured hardness can vary significantly depending on how the specimen has been prepared.