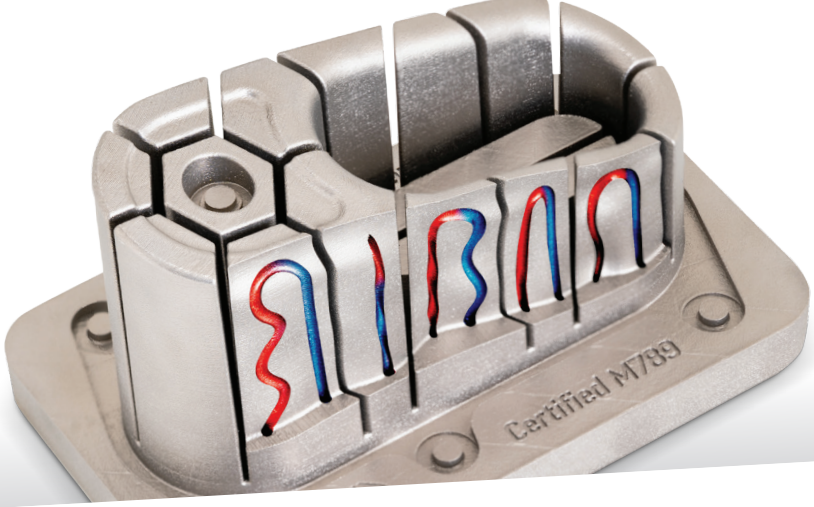


Certified M789 (A)

Thoroughly developed and validated print parameter sets for BÖHLER's AMPO M789 on DMP Flex and Factory 350 as well as ProX® DMP 320 metal 3D printers. M789 is a cobalt-free steel and produces mold inserts, tools and parts with high hardness and excellent corrosion resistance.

The print parameter database license available for Certified M789 (A) in 3DXpert® all-in-one metal AM software for DMP Flex and Factory 350 as well as ProX DMP 320 metal 3d printers has been extensively developed to deliver high repeatable part quality and consistent part properties, tested and optimized by 3D Systems and GF Machining Solutions together with voestalpine BÖHLER Edelstahl and industry partners. Based on producing a multitude of test samples, geometries and endurance jobs at multiple facilities, the properties listed below provide high confidence to the user in terms of job-to-job and machine-to-machine repeatability.

Material Description

M789 combines high hardness with excellent corrosion resistance. M789 displays a broad process window on 3D Systems DMP Flex and Factory 350 and ProX DMP 320 metal printers leading to high density parts across the build plate. No preheating of the powder is required.

In the as printed and solution annealed condition, M789 reaches a hardness of around 30 HRc which allows for easy machinability. During the ageing heat treatment, intermetallic precipitates containing Ni, Ti, Al and Si are formed within the martensitic microstructure. This increases the hardness further up to 52 HRc. Unlike typical maraging steel alloys, cobalt is not needed to facilitate the ageing process. With regards to corrosion resistance M789 is comparable to and sometimes even exceeding that of PH 13-8 Mo, 17-4PH and 1.2083.

In tool and mold making M789 is used for its very high strength paired with corrosion resistance to produce mold and tool inserts with complex surfaces, fine features and conformal cooling channels for improved mold productivity. In the transportation industry typical steel components such as axel components and drive train parts can be quickly produced and reproduced in Metal AM using M789 material. For the oil and gas industry, this material enables the direct production of complex drill heads.

Mechanical Properties

PROX DMP 320, DMP FLEX 350, DMP FACTORY 350[2]	TEST METHOD	METRIC	U.S.	METRIC	U.S.
		SA + A – LT30[4,5]		SA + A – LT60[4,6]	
Ultimate tensile strength (MPa | ksi)[1] Horizontal direction - XY Vertical direction - Z	ASTM E8[3]	 1880±25 1830±25	 270±4 265±4	 1880±25 1840±20	 270±4 265±3
Yield strength Rp0.2% (MPa | ksi)[1] Horizontal direction - XY Vertical direction - Z		 1730±40 1690±40	 250±6 245±6	 1740±35 1710±20	 250±5 245±3
Plastic elongation (%) [1] Horizontal direction - XY Vertical direction - Z		 12±4 9±3		 10±3 10±2	
Hardness, Rockwell C (HRC) [1]	ASTM E18	52±1		52±1	
Impact toughness[7] (J | ft.lb)	ASTM E23[8]	6±1.5	4±1	8±2	6±1.5

Printed Part Properties

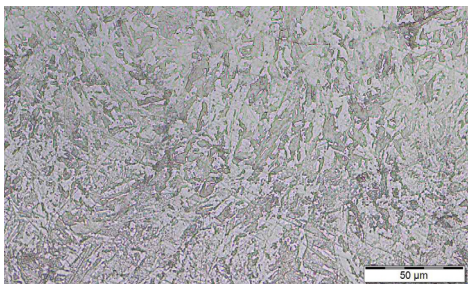
DENSITY[9]	TEST METHOD	METRIC	U.S.
Absolute theoretical[10] (g/cm³ | lb/in³)	Value from literature	7.715	0.2787
Relative density (%), layer thickness 30 µm [2, 11]	Optical method (pixel count)	≥ 99.8 Typical 99.9	
Relative density (%), layer thickness 60 µm [2, 11]		≥ 99.8 Typical 99.9	

[1] Values based on average and 90% tolerance interval with 90% confidence. Tested on a minimum of 6 samples
[2] Parts manufactured with standard parameters on DMP Flex and Factory 350, Config B using the 15-45 µm BÖHLER M789 AMPO powder
[3] Tested according to ASTM E8 using round tensile test specimen type 4 with stress control (10 MPa/s) during the elastic and strain control (20%/min) during plastic regime
[4] Solution annealing (SA) performed at 1000°C for 1 hour with subsequent rapid cooling (>75°C/min) to room temperature (<32°C), followed by ageing (A) at 500°C for 3 hours and air cooling
[5] Layer thickness 30 µm (LT30)
[6] Layer thickness 60 µm (LT60)
[7] Values based on average and 2 times standard deviation. Tested on 6 samples.
[8] Tested according to ASTM E23 using V-notch Charpy (Simple-Beam) impact test specimens, printed in the Z-direction
[9] May deviate depending on specific part geometry
[10] Values based on literature
[11] Minimum values based on 95% tolerance interval with 95% confidence. Tested on a minimum of 15 samples using specific 3DS test coupons.

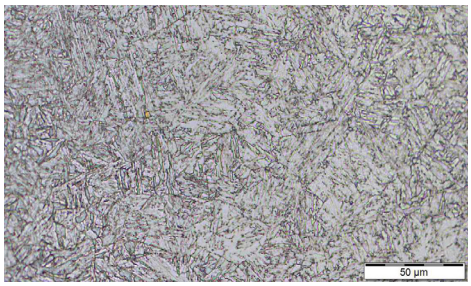
SURFACE ROUGHNESS R_a [2, 9, 11, 12, 13]	TEST METHOD	METRIC	U.S.
Vertical side surface (µm | µin) Layer thickness 30 µm	ISO 25178	Typically, around 8	Typically, around 315
Vertical side surface (µm | µin) Layer thickness 60 µm	ISO 25178	Typically, around 10	Typically, around 390

Chemical Composition

ELEMENT	TYPICAL % OF WEIGHT
C	<0.02
Si	0.5
Cr	12.2
Ni	10.0
Co	/
Mo	1.0
Al	0.6
Ti	1.0
Fe	Balance



Microstructure as build



Microstructure after solution annealing and aging

To confirm that Certified M789 (A) material is the best suited for your specific application, please contact the 3D Systems Application Innovation Group (AIG):
https://www.3dsystems.com/consulting/application-innovation-group

Once confirmed, Certified M789 (A) powder powder can be purchased directly from voestalpine BÖHLER Edelstahl GmbH:
https://www.bohler-edelstahl.com/en/products/m789-ampo/
where it is available under the name BÖHLER M789 AMPO 15-45 µm

BÖHLER AMPO Additive Manufacturing Powder

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[12] Surface treatment performed with zirconia blasting medium at 2 bar
[13] Vertical side surface measurement along the building direction