ArcelorMittal Powders

AdamIQ™ SAM 1

COBALT-FREE SUSTAINABLE REPLACEMENT OF M300

Made from 100% recycled steel and renewable energy. Spherical, with high flowability and low level of impurities.

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This innovative, lean, Cobalt-free maraging steel alloy is engineered to deliver a balanced combination of high strength, toughness, and corrosion resistance through an optimized composition.

Ideal for applications that demand both strength and durability, it avoids the environmental and material challenges associated with traditional high-alloy maraging steels. The alloy forms a martensitic microstructure that achieves excellent mechanical properties as-built, making it particularly suitable for high-performance tooling, conformal-cooled moulds, and demanding engineering applications, including rubber-tire mould production. Tailored heat treatment can be applied to adjust peak Hardness.

With a chromium content of 8%, this steel mimics the corrosion resistance of stainless steels like 17-4PH, allowing it to perform effectively in mildly corrosive environments such as those found in the food, pulp and paper, and oil & gas industries.

AdamIQ™ SAM 1 is a robust feedstock for any laser powder bed fusion machine (L-PBF). This new composition maintains printability comparable to 18Ni300 while offering superior ease of printing over H13.

Inert gas atomized Lean maraging steel powder with an essentially martensitic microstructure. AdamIQ™ SAM 1 is ideally suited for use in laser powder bed fusion processes, where its printability, corrosion resistance, and mechanical performance make it a versatile option for industries requiring both strength and reliability in mildly corrosive environments, high-performance tooling, conformal-cooled molds, and engineering applications that demand both resilience and corrosion resistance.

Main characteristics	**Markets**
Cobalt-free	Corrosion environments
High printability	Moulding
Corrosion resistance	Aerospace
Polishability	Oil and gas
Hardness of M300	Thin gauge rolling

Powder properties

Chemical composition in weight (%) [1]

Iron	Balance
Nickel	6.00 – 7.50
Chromium	5.00 – 8.50
Silicon	0.50 – 1.50
Titanium	0.50 – 1.50
Copper[4]	0.50 – 1.00
Carbon	< 0.04

Physical test data

Nominal particle range	20-53 µm
Apparent density[2]	4.2 g /cm³
Hall Flow[3]	<20 s / 50 g
Skeletal Density[5]	7.7 g /cm³
Thermal expansion coefficient	12.4 10^{-6} K^{-1}
Thermal conductivity	15 W/mK at 25 °C 19 W/mK at 550 °C 24 W/mK at 650 °C

Also available in particle sizes:
• Less than 20 microns for Binder Jetting (BJT), Metal Injection Molding (MIM) or specific processes targeting very thin walls.
• 53-105 microns typically for Electron Beam Melting (EBM, E-PBF) and Laser Metal Deposition (LMD).
• Specific sizing can be considered under conditions.

1. Patent Pending
2. Apparent density according to ASTM B212
3. Hall Flow according to ASTM B213
4. Optionally containing
5. Skeletal density according to ASTM B923

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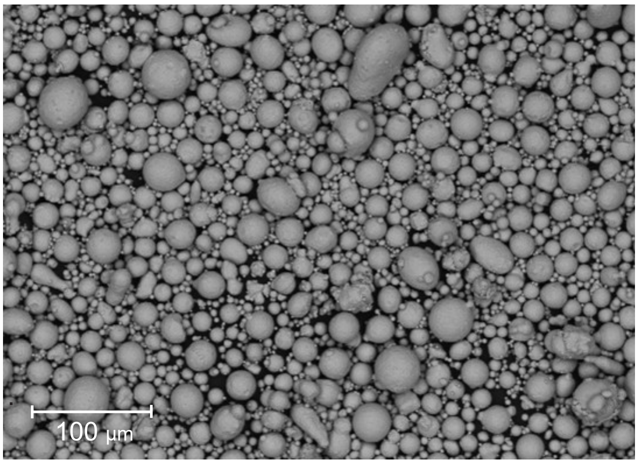
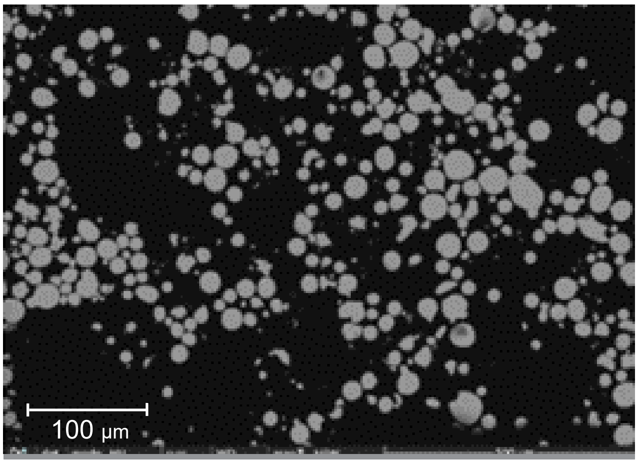
Powder morphology



SEM image AdamIQ™ SAM 1 20-53 µm



LOM image AdamIQ™ SAM 1 20-53 µm

Mechanical properties As-Built

	Yield Strength $R_{p0.2}$ [Mpa]	Tensile Strength R_m [Mpa]	Elongation A [%]	Impact Energy at 20 °C [J]	Impact Energy at -60 °C [J]
Vertical	961	1,069	25	153	38 (365)
Horizontal	–	–	–	–	–

Microstructure in LPBF As-Built

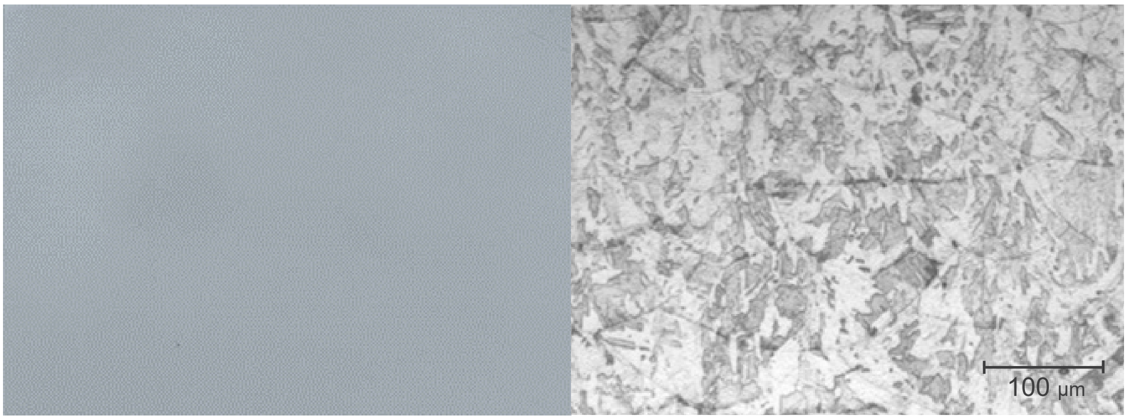


Fig. 1 Micrograph of polished and etched areas.

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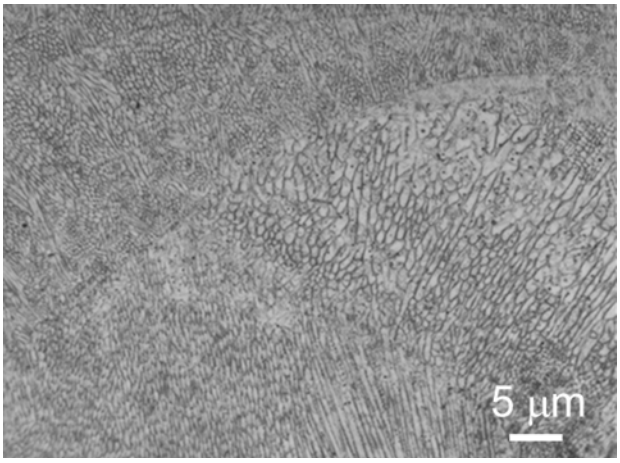
Designing Steel Alloys for Additive Manufacturing

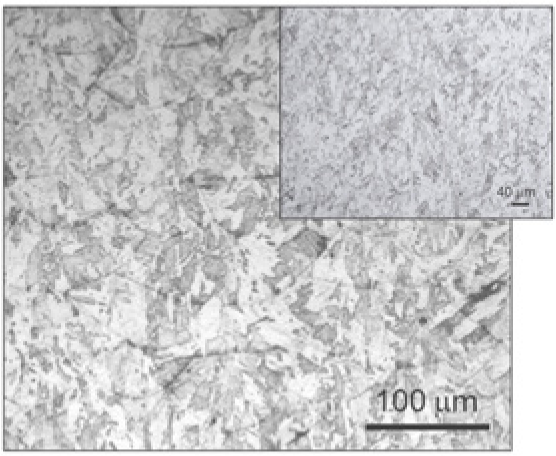
In designing cobalt-free maraging steel alloys for additive manufacturing, a primary objective was to create a sustainable and cost-effective alternative to 18Ni300, which is often over-engineered for applications where it replaces H13.

While 18Ni300 provides high strength and toughness, its cobalt content introduces environmental and supply chain concerns. A key design target was to develop a cobalt-free alloy that offers comparable strength and enhanced corrosion resistance while being suitable for use in the as-built condition.

This approach minimizes the need for extensive post-processing, improving efficiency in additive manufacturing. Additionally, the alloy retains the potential for age-hardening, allowing for fine-tuning of hardness and other mechanical properties to achieve an optimal balance for specific applications.

By achieving these targets in alloys like AdamIQ™ SAM 1, it is aimed to deliver durable, high-performance materials optimized for demanding environments, all while reducing dependency on critical raw materials.





Optical micrographs of as-built LPBF printed AdamIQ™ SAM 1 powder etched with Nital (left) and Viella (right).

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Mechanical properties As-Built

The chart shows the hardness of different materials in both their as-built and peak-aged conditions using the Laser Powder Bed Fusion (L-PBF) process. SAM 1 demonstrates versatility, achieving competitive hardness levels comparable to industry-standard alloys like 18Ni300 and H13.

• SAM 1 (Wrought Peak Hardness): SAM 1 reaches a peak hardness of 54 HRC (578 HV) in its wrought form, closely matching the peak hardness of LPBF-printed H13 (54 HRC) and approaching the level of 18Ni300 (56 HRC).

• AdamIQ™ SAM 1 in L-PBF As-Built Condition: AdamIQ™ SAM 1 achieves 38 HRC (336 HV) in the as-built LPBF condition, which is equivalent to as-built 18Ni300 and H13, demonstrating that AdamIQ™ SAM 1 can offer comparable initial hardness without additional post-processing.

• AdamIQ™ SAM 1 in L-PBF Peak Condition: With heat treatment, LPBF-printed SAM 1 reaches 56 HRC (615 HV), matching the peak hardness of LPBF-printed 18Ni300 and exceeding the peak hardness of H13 in both wrought and LPBF forms.

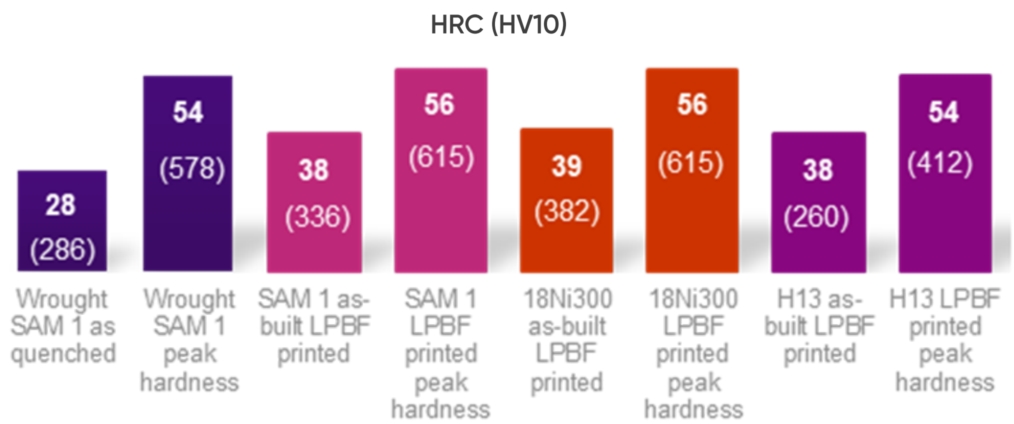

Fig. 2 Peak Hardness values comparison between SAM 1 (both the Wrought and the LPBF-printed experimental data), 18Ni300 and 17-4PH in the as-built and aged conditions. L-PBF 18Ni300 and 17-4PH values are extracted from data reported in different MDS available in the web.

Fig. 3 indicates that for applications requiring high hardness, it is best to age the material at 460–500°C, where it reaches peak hardness around 55 HRC. Aging at higher temperatures will reduce the hardness, which may be useful if other mechanical properties need to be balanced, but it will decrease wear resistance. This information is essential for tailoring the material's properties depending on the intended application.

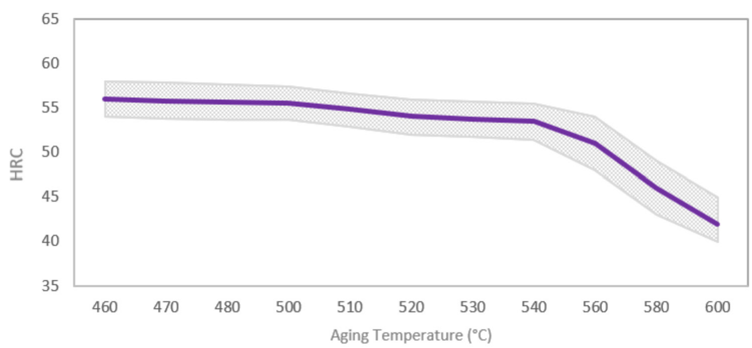

Fig. 3 illustrates the effect of aging time and temperature on the hardness (HRC) of the LPBF-printed AdamIQ™ SAM 1 alloy. Hardness measurements were taken over a period of 2 hours for different aging temperatures.

Fig. 4 chart shows how the hardness (HRC) of a material changes over time at different aging temperatures. Each line represents a different aging temperature, indicated by the color-coded legend on the right. The x-axis shows time (in hours), and the y-axis shows hardness (HRC).

• Lower Aging Temperatures (480°C - 520°C): These temperatures achieve and sustain the highest hardness (around 55 HRC), making them ideal for applications requiring maximum hardness.

• Higher Aging Temperatures (540°C and above): These temperatures lead to an initial hardness increase but are followed by a decline due to over-aging. The higher the temperature, the more quickly hardness decreases over time.

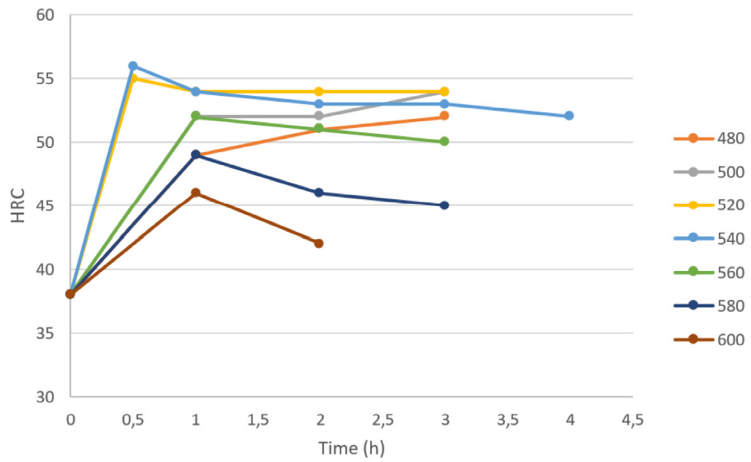

Fig. 4 Mean Hardness (HRC) Over Aging Time at Various Temperatures for LPBF-Printed AdamIQ™ SAM 1 Composition

All this data helps identify the ideal aging parameters for achieving peak hardness in AdamIQ™ SAM 1 , particularly for applications where maximum hardness is critical or a compromised is required.

Additionally, microhardness tests were conducted on as-built and heat treated specimens (540°C – 2h and 600°C – 1h) over a cross-sectional area of 1.5 x 1.5 mm², with over 600 indentations at 100 g load. The resulting hardness map of an LPBF-printed cube shows values between 29 to 41 HRC, with 36 HRC as the most common, consistent with macrohardness results.

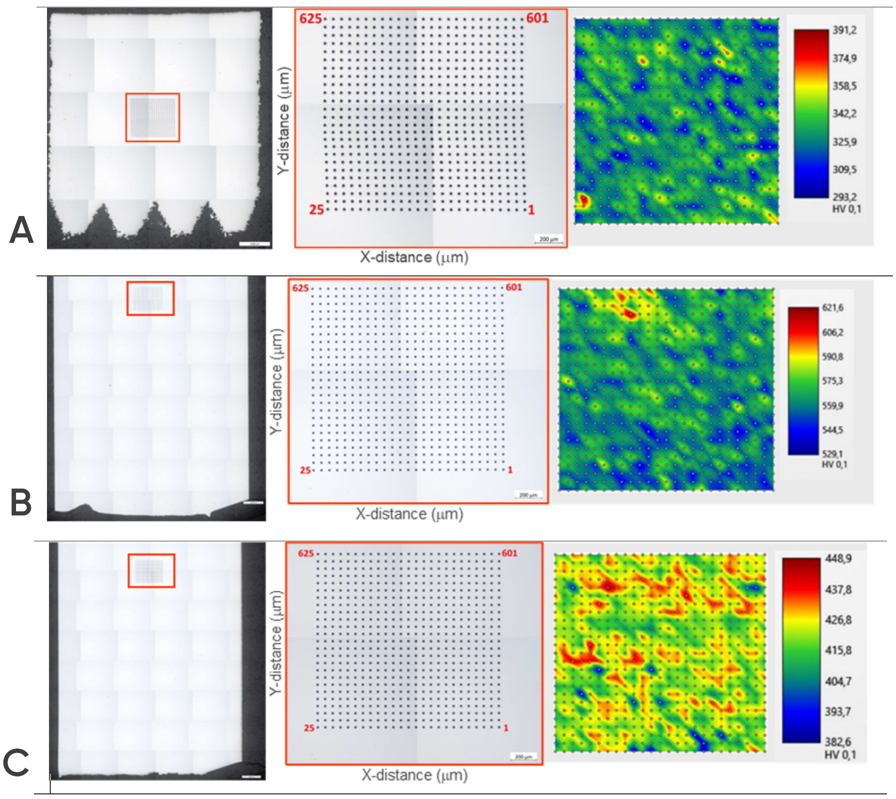

Fig 5. Hardness mapping o f an area of 1.5 x 1.5 mm²

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Impact Toughness

The table below compares the impact toughness (measured as Specific Absorbed Energy and Absorbed Energy) and hardness (HRC) of two materials, 18Ni300 (data from commercial MDS), SAM1 and AdamIQ™ SAM 1, in different conditions, including wrought, LPBF (Laser Powder Bed Fusion) as-built, and aged states.

Material	Condition	Specimen Orientation	Specific Absorbed Energy (J/cm2) at RT	Specific Absorbed Energy (J/cm2) at RT	HRC
18Ni300	Wrought As Quenched	N/A	167 ± 7	134 ± 4	39
18Ni300	LPBF As Built	LPBF As Built	-	55 ± 13	33
18Ni300	LPBF + Aging	Vertical	-	9 ± 1	53
SAM 1	Wrought As Quenched	N/A	272 ± 10	217 ± 8	28
SAM 1	Wrought + Aging	N/A	16 ± 8	13 ± 6	36
AdamIQ™ SAM1	LPBF As Built	Vertical	191 ± 6	153 ± 5	38
AdamIQ™ SAM1	LPBF + Aging (540 °C - 2h)	Vertical	6 ± 3	5 ± 2	53
AdamIQ™ SAM1	LPBF + Aging (600 °C - 1h)	Vertical	21 ± 6	17 ± 5	46

SAM 1's Flexibility: SAM 1 can achieve a range of mechanical properties depending on the aging treatment, making it adaptable for applications needing either higher toughness or higher hardness.

Trade-Offs in Aging: Both materials exhibit a trade-off between toughness and hardness when aged. While aging increases hardness, it significantly reduces impact toughness.

Advantages in As-Built State: AdamIQ™ SAM 1 shows better as-built performance in the LPBF condition than 18Ni300, providing a good balance of hardness and toughness without additional heat treatment.

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Corrosion resistance

Fig. 6 and Table 2 illustrate the corrosion performance of different materials—Marval 18, 18Ni300, SAM1, and 17-4PH—in terms of open circuit potential (OCP) over time and potentiodynamic polarization measurements.

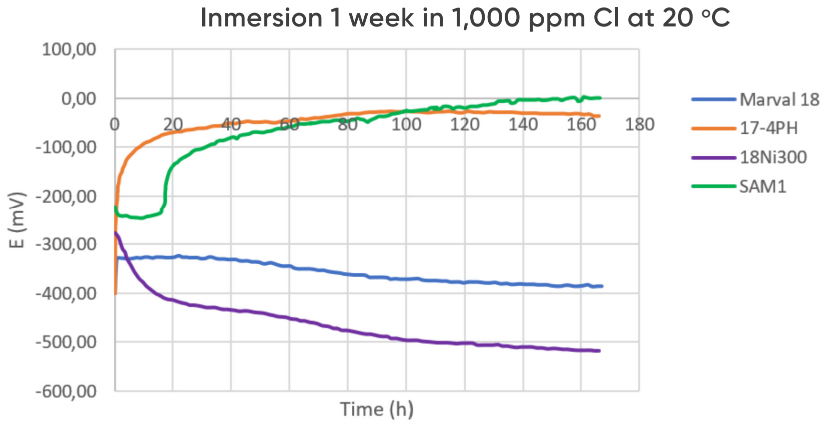

Fig. 6 Open circuit potential evolution over 1 week immersion in 1000 ppm Cl- at 20 °C .

Table 2 Potentiodynamic polarization measurements (ASTM G3) carried out on as built polished samples at RT in a 3.5 wt. % NaCl solution. Corrosion current density and corrosion potential values were extrapolated by Tafel method.

Grade	Corrosion Potential E_{corr} (V)	Corrosion Current Density I_{corr} (µA/cm²)
Wrought 17-4PH	0.049	0.023
LPBF 17-4PH	-0.052	0.241
LPBF 18Ni300	-0.39	1.16
LPBF AdamIQ™SAM 1	-0.113	0.310

• 17-4PH (both wrought and printed) shows excellent corrosion resistance, with a high, stable OCP and very low corrosion current density, as expected for stainless steel.
• SAM 1 and AdamIQ™ SAM1, demonstrates impressive corrosion resistance, nearing that of 17-4PH, even with lower chromium content. Its OCP rises close to that of 17-4PH over time, with a moderate corrosion current density, highlighting its strong performance as a cobalt-free alloy.
• LPBF 18Ni300 exhibits the lowest corrosion resistance, with a low OCP and high corrosion current density, making it less suitable for corrosive environments.
• Marval 18 (wrought) provides moderate resistance, stable but inferior to 17-4PH and SAM1.

AdamIQ™ SAM 1 As-Built offers a viable, sustainable alternative without cobalt, with corrosion resistance comparable to stainless steel, ideal for applications in both additive manufacturing and environments demanding durability

Contact us to know how we can assist your production.

Visit **powders.arcelormittal.com** or
e-mail us at **contact.powders@arcelormittal.com**
to talk to our experts.

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