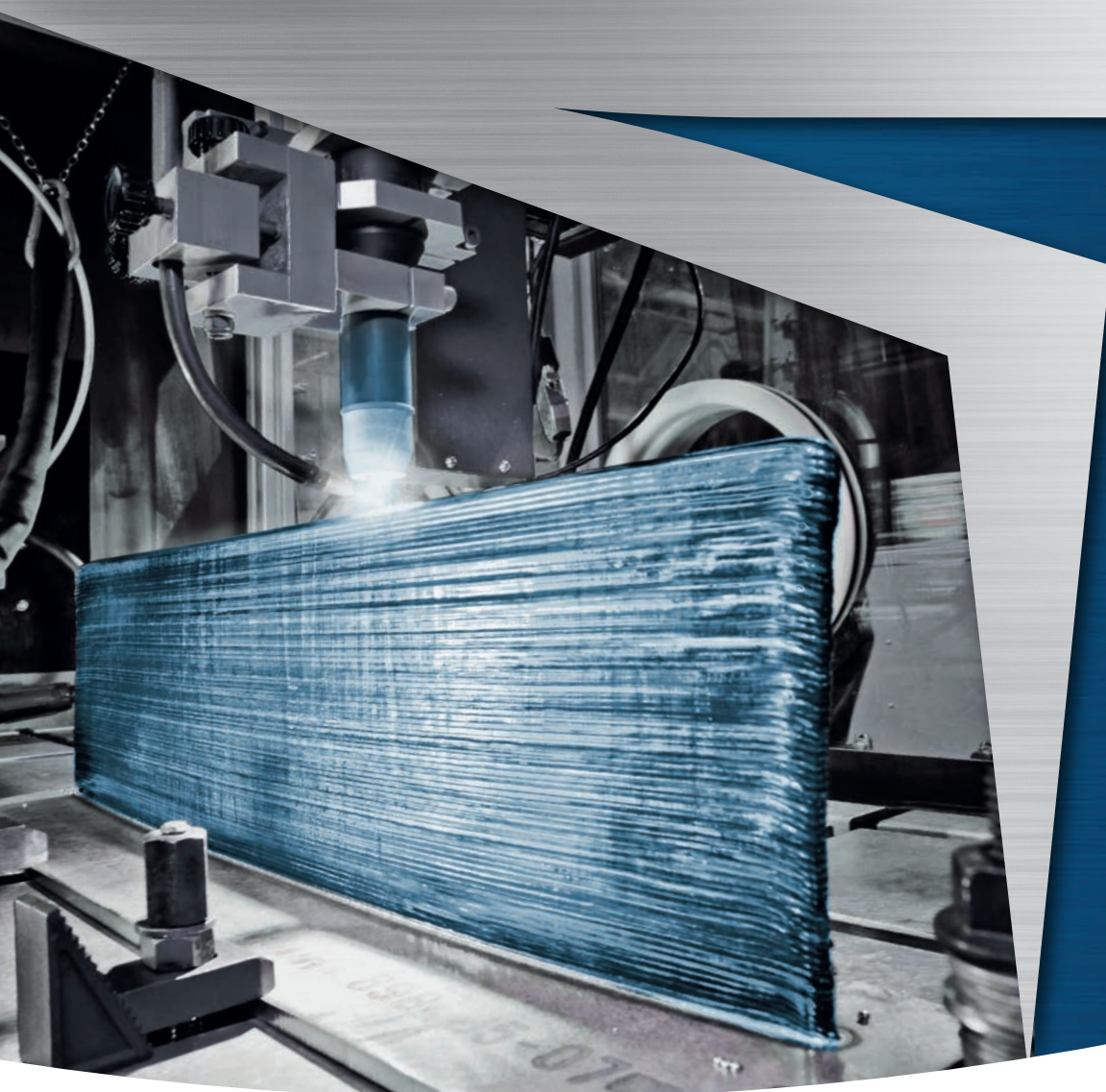


Lasting Connections

# THE FUTURE OF PRODUCTIVITY: WIRE ARC ADDITIVE MANUFACTURING





## THE FUTURE OF PRODUCTIVITY: WIRE ARC ADDITIVE MANUFACTURING

### 3D PRINTING WITH THE BEST-IN-CLASS WIRE ALLOYS

#### Additive manufacturing – popularly known as 3D printing – is one of the most revolutionary new manufacturing methods of our time.

Wire Arc Additive Manufacturing is a new disruptive technology that is being enthusiastically adopted at voestalpine Böhler Welding for its leading brand Böhler Welding.

It not only allows almost lossless processing of high-value material but also results in high-strength components with a flexibility that would not be conceivable using conventional methods. Up to now, manufacturing methods such as casting/milling and forging have been used for production of large components.

Material is removed from a casting or blank and creates scrap. The specialists at Böhler Welding are researching special materials for the optimized production of highest quality solid and seamless cored wires with excellent surface finishing and properties required for a stable 3D printing process.

Contact us personally and experience a new dimension in manufacturing.

Dr. Martin Peruzzi  
CTO, voestalpine Böhler Welding

### PIONEERING EXPERTISE

As a pioneer in innovative welding consumables, Böhler Welding offers a unique product portfolio for joint welding worldwide. More than 2000 products are adapted continuously to the current industry specifications and customer requirements, certified by well-respected institutes and thus approved for the most demanding welding applications. As a reliable partner for customers, “lasting connections” are the brand’s philosophy in terms of both welding and people.

As long ago as 1927 Böhler Welding developed the “Seelendraht” (“soul wire”) the predecessor of the modern-day flux cored wire. The company has been leading ever since, as current innovations, like the laser-sealed flux cored wires or the leadership in Wire Arc Additive Manufacturing, proves. Customers can rely on a outstanding product portfolio for all demanding welding tasks.

#### Wire Arc Additive Manufacturing (WAAM): Efficiency Meets Innovation

WAAM leverages the proven principles of welding and cladding to deliver a powerful alternative to traditional manufacturing methods like casting and forging. Using a wide range of wire feedstock WAAM offers unmatched flexibility and material compatibility.

With adjustable process parameters, WAAM achieves high deposition rates of up to 5 kg/h, and even more with e.g. twin wires, making it ideal for producing large-scale components within short timeframes. The near-net-shape approach minimizes machining efforts such as milling and drilling, while post-processing like heat treatment are sometimes used to ensure optimal mechanical properties tailored to each alloy group.

Especially as the Wire Arc Additive Manufacturing is based on the well-known technology of joining and cladding materials with a wide range wire feedstock from unalloyed, mid- and high alloyed steels. But also nickel- and cobalt base alloys can be used and combined, if metallurgical reasonable, to gradient structured parts.

Given the typical layer thickness applied, Wire Arc Additive Manufacturing is – compared to powder-based Additive Manufacturing – more suitable to generate low to medium complexity and up to large scale preform components.

Depending on the material alloy group post-machining and sometimes heat treatment are usually required to give the components the final properties.

#### Key Benefits for Wire Arc Additive Manufacturing

- » **Flexible deposition rates** – from low to high, adaptable to various applications
- » **Near-net-shape production** – minimizes material waste and optimizes efficiency
- » **Reduced machining time** – conventional processes like milling and drilling are minimized
- » **Gradient structures possible** – when metallurgically feasible, enabling advanced part design
- » **Shorter lead times** – faster turnaround for critical components
- » **Excellent structural integrity** – reliable performance under demanding conditions
- » **Ideal for low to medium complexity parts** – scalable for large preform components

#### Designed for Demanding Industries

- » Mechanical Engineering & Machinery
- » Oil & Gas – Upstream and Offshore
- » Chemical Industry
- » Power Generation
- » Aerospace
- » Shipbuilding & Shipyards
- » Maintenance & Repair Operations

INNOVATION BACKED BY EXPERTISE

At voestalpine Böhler Welding, innovation begins with purpose-built wire solutions. Each wire is engineered for its specific application, forming the foundation of advanced Wire Arc Additive Manufacturing.

With deep metallurgical expertise and hands-on application know-how, our materials specialists play a pivotal role in driving this technological transformation — empowering industries to manufacture smarter, faster, and more efficiently.

Wire Alloys: The Foundation of WAAM Innovation

Wire alloys are the essential building blocks of the Wire Arc Additive Manufacturing (WAAM) process—driving its performance and reliability. These alloys can be tailored from low- and medium-alloyed steels, aluminum, nickel, or titanium, each influencing the final properties of the printed component.

At voestalpine Böhler Welding, the production of wire alloys is a core focus. Our materials and process specialists ensure precise chemical composition within tight tolerances and exceptional surface quality—critical for consistent feeding and optimal WAAM performance. This commitment to metallurgical excellence positions voestalpine Böhler Welding at the forefront of additive manufacturing innovation.



European Excellence in Wire Alloy Manufacturing

At voestalpine Böhler Welding, quality begins at the source. With state-of-the-art production facilities for solid wires in Hamm, Germany, and seamless cored wires in Kapfenberg, Austria, and Cittadella, Italy, we are equipped with the latest technologies for manufacturing wire alloys tailored for additive manufacturing. Our advanced laboratories enable in-house analysis and characterization of newly developed products—ensuring best-in-class quality, consistency, and performance for demanding industrial applications.

Collaborative Innovation in Material Research

In partnership with leading industrial and scientific institutions, voestalpine Böhler Welding is driving forward research and development in Wire Arc Additive Manufacturing. These R&D programs focus on understanding the behavior of wire consumables in additive processes—laying the groundwork for continuous improvement.

The insights gained enable the optimization of wire performance and the development of next-generation alloy compositions, tailored for advanced 3D printing applications and future manufacturing demands.

PRODUCT PORTFOLIO

Product Name	C	Si	Mn	Cr	Mo	Ni	R <sub>p0.2</sub>	R <sub>m</sub>	A <sub>5</sub>	
3Dprint AM 35	0.1	0.3	1.05	–	–	–	> 355 MPa	470-630 MPa	> 22 %	Low alloyed steel
3Dprint AM 46	0.1	1	1.7	–	–	–	> 460 MPa	560-720 MPa	> 22 %	Low alloyed steel
3Dprint AM 50	0.1	0.65	1.4	–	–	1.35	> 500 MPa	560-720 MPa	> 18 %	Low alloyed steel
3Dprint AM 62	0.1	0.65	1.6	–	0.4	1.1	> 620 MPa	700-890 MPa	> 18 %	Medium alloyed steel
3Dprint AM 70	0.08	0.6	1.7	0.2	0.5	1.5	> 690 MPa	770-940 MPa	> 17 %	Medium alloyed steel
3Dprint AM 80 HD	0.09	0.4	1.7	0.35	0.6	2	820 MPa	920 MPa	20 %	Medium alloyed steel (typical mech. Properties after post heat treatment)
3Dprint AM P22	0.08	0.5	1	2.5	1	–	> 310 MPa	515-690 MPa	> 18 %	Medium alloyed steel (mech. Properties after post heat treatment)

Chemical composition in wt.-%

Product Name	C	Si	Mn	Cr	Mo	Ni	N	
3Dprint AM 2209	0.025	0.5	1.6	23	3	9	0.14	Duplex steel (no heat treatment)
3Dprint AM 2205	0.025	0.5	1.5	22	3	5	0.15	Duplex steel (with solution annealing heat treatment)

Chemical composition in wt.-%

Product Name	C	Si	Mn	Cr	Mo	Ni	Cu	Nb	
3Dprint AM 304L	0.02	0.5	1.7	20	–	10	–	–	Standard low carbon austenitic stainless steel
3Dprint AM 316L	0.02	0.5	1.7	18.5	2.6	12.3	–	–	Standard low carbon austenitic stainless steel with Molybdenum
3Dprint AM 17-4 PH	0.02	0.4	0.5	16.5	–	4.5	3.3	0.25	Martensitic precipitation-hardening stainless steel
3Dprint AM 15-5 PH	0.02	0.5	0.5	14.8	–	4.5	3.3	0.28	Martensitic precipitation-hardening stainless steel – free of ferrite (aerospace grade)
3Dprint AM 410 NiMo	0.01	0.65	0.7	13	0.5	4.7	–	–	Martensitic stainless steel
3Dprint AM 430	0.07	0.8	0.7	18	–	–	–	–	Ferritic stainless steel

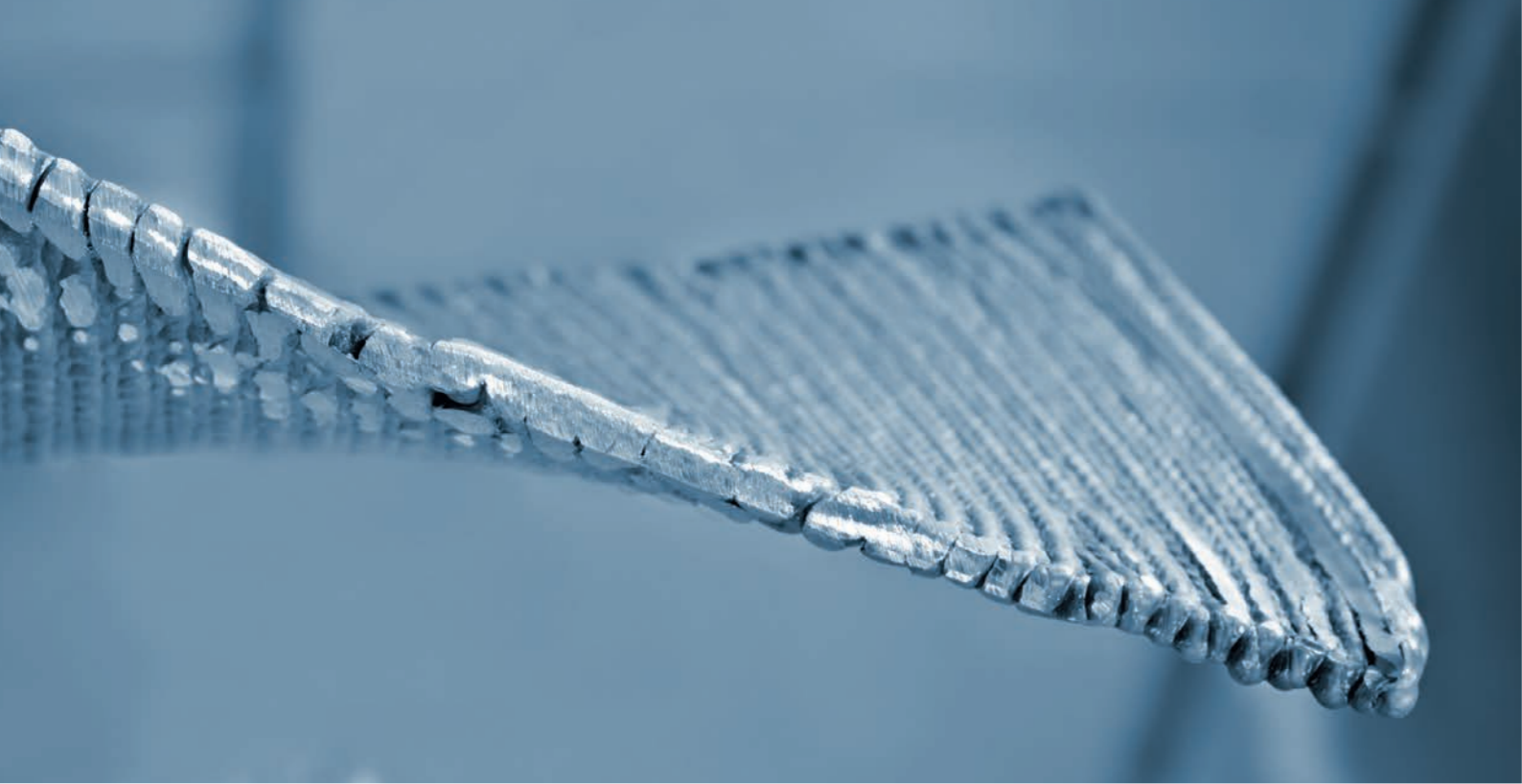
Chemical composition in wt.-%

Product Name	C	Si	Cr	Mo	Nb	Fe	Ni	W	Al	Ti	
3Dprint AM 625	< 0.03	< 0.25	22	9	3.6	0.5	bal.	–	–	–	Nickel base alloy with chromium, molybdenum and niobium
3Dprint AM 718	0.03	< 0.1	17.5	3	5	bal.	53	–	0.5	1	Precipitation hardening nickel base alloy

Chemical composition in wt.-%

Product Name	Mg	Ni	Fe	C	N	O	H	V	Zr	Mn	Al	Cu	Ti	
3Dprint AM Al 2219	< 0.02	–	–	–	–	–	–	–	0.18	0.35	bal.	6.3	0.14	Aluminium alloy
3Dprint AM Cu 6328	–	4.5	3.5	–	–	–	–	–	–	1	9	bal.	–	Copper-Aluminium alloy
3Dprint AM Ti-5	–	–	< 0.15	< 0.05	< 0.03	0.18	< 0.01	4	–	–	6	–	bal.	High strenght titanium alloy

Chemical composition in wt.-%



### Precision Chemistry for Reliable WAAM Performance

The chemical composition of 3Dprint wires is meticulously engineered for Wire Arc Additive Manufacturing. Due to the high heat input and low cooling rates typical of multi-layer deposition, the wire must deliver consistent mechanical integrity—even under repeated hardening and tempering cycles or post-process heat treatments.

Wire chemistry plays a critical role in:

- » Arc stability
- » Molten material fluidity
- » Minimizing silicate island formation, which can disrupt subsequent layer deposition

To ensure optimal performance, impurity levels and silicon content are tightly controlled. This precision enables smooth feeding, stable arcs, and high-quality builds—making voestalpine Böhler Welding wires a trusted choice for demanding WAAM applications.



U[V]/I[A] integral plot over time (blue star in the middle) of stable process which shows only minor deviations


### WHAT MAKES BÖHLER WELDING 3DPRINT WIRES DIFFERENT?

Böhler Welding 3Dprint wires are engineered specifically for Wire Arc Additive Manufacturing (WAAM), with every production step optimized to ensure exceptional wire feedability and arc stability.

**Key Differentiators:**

- » **Precision Drawing Process:** Delivers superior surface finish for smooth and consistent performance.
- » **Enhanced Feedability:** Achieved through specialized coatings that support reliable wire transport.
- » **Controlled Winding:** Spools and drums are wound within strict tolerances to ensure uniform feeding.
- » **Rigorous Endurance Testing:** Real-time monitoring of electrical parameters and wire resistance at the feeder validates arc stability and feedability under demanding conditions.

### Summarized benefits of Böhler Welding 3Dprint wires

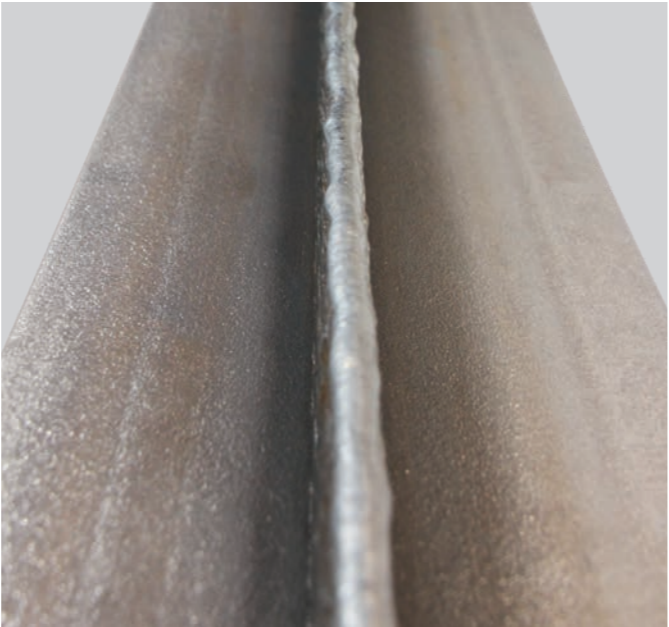
Metallurgical benefits	Process benefits	
» Made for low cooling rates and high heat input	» High process stability for Robotic MIG or other mechanised processes	
» Accepts multiple hardening/tempering cycles by multiple layers	» Drum and spool weights can widely be adopted to the weight of parts	
» Optimised for post print heat treatment	» Extended quality control to ensure consistent arc and feeding behavior	
» Tailor-made metallurgy for complex materials	» Optimised surface technology for long arc cycles, Liners stay clean, contact tips last longer	

# EXCELLENT PROPERTIES OF THE PRINTED METAL

A fine-tuned printing process together with the described benefits lead structures made with Böhler Welding 3Dprint wires to meet demanding industries requirements.

# PRINTED METAL CHARACTERIZATION

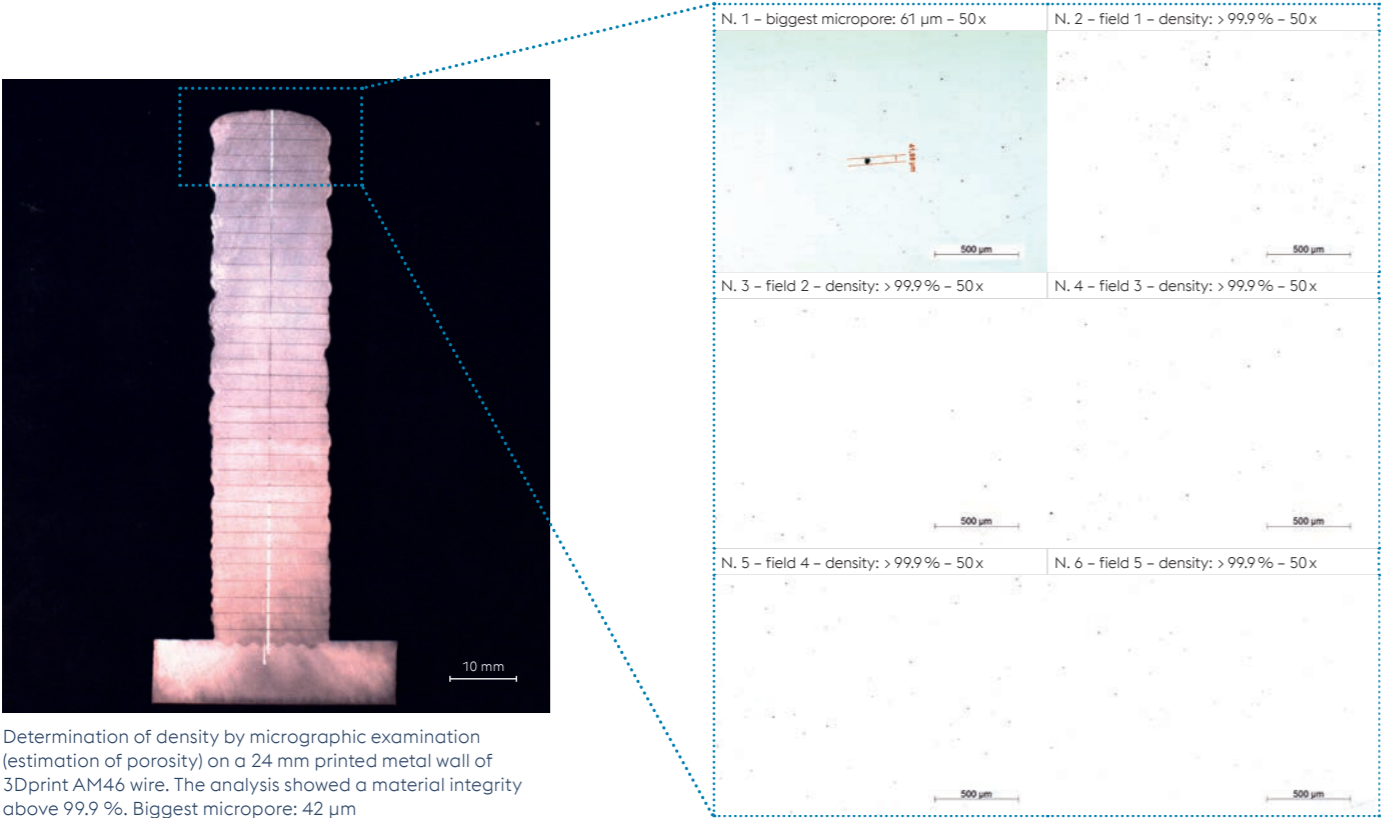
As far as materials properties are concerned, Böhler Welding is deeply involved in testing wires in wire arc additive manufacturing conditions, remarking analogies and differences with the conventional technologies as well as the welding conditions.



Wall made with wire 3Dprint AM 80HD for properties characterization

## Material Integrity

In this regard, microporosity assessment demonstrates that wire arc additive manufacturing using 3Dprint wires can provide an integrity level often comparable to forging and better than casting.

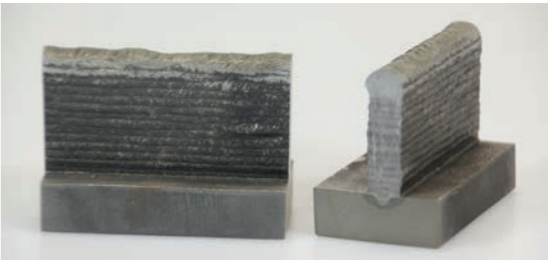


# Testing of printed metal in Wire Arc Additive Manufacturing Conditions

Böhler Welding is investigating specific geometry walls and blocks to reproduce the typical cooling rates of Wire Arc Additive Manufacturing, extracting specimen for tensile, impact energy, bending and any other relevant test depending upon the specific alloy.



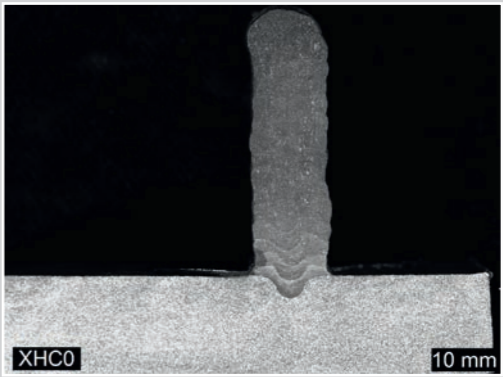
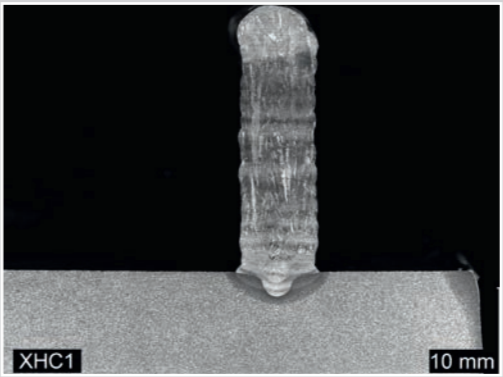
Printed coupon and destructive tests on precipitation hardening martensitic stainless steel 3Dprint AM 17-4 PH deposit



# PRINTING OF CHALLENGING MATERIALS

Böhler 3Dprint product portfolio includes a wide range of high technology sophisticated alloys. An adequate knowledge of these materials behavior when printing is a pre-condition to achieve high level results.

Böhler Welding makes available wire arc additive manufacturing experts and application engineers to support customers whenever it is needed.



Macro of precipitation hardening martensitic stainless steel 3Dprint AM 17-4 PH deposit as printed and after heat treatment



## Transparency on the Environmental Impact is important to us

Today's Manufacturing companies are requested to provide certified data on the environmental impact of their production processes. In Wire Arc Additive Manufacturing (WAAM), this includes not only the process itself but also the manufacturing of the wire—a key factor in sustainability analysis. With certified EPDs, Environmental Product Declarations, voestalpine Böhler Welding provides the data you need.

## Our commitment

EPDs for Böhler Welding solid wires are verified by IBU and published on our website. voestalpine Böhler Welding is the first company in the welding industry to offer EPDs to the market, setting a benchmark for sustainability. EPD typical information:

- » Raw material sourcing
- » Energy consumption
- » Emissions and waste
- » Lifecycle impact
- » Global warming (TCO<sub>2</sub> Eq.)

## voestalpine TechMet – Tailor-Made Melts

For WAAM and advanced applications, voestalpine Böhler Welding offers custom wires with specific chemical analysis, thanks to our TechMet facility providing fine-tuned hot rolled wires. TechMet includes the following manufacturing processes:

- » Ladle preparation
- » Induction furnace (5 t)
- » Ladle furnace with electro-plasma heating
- » Vacuum degassing
- » Vertical segment caster

# JOIN! We connect Metals and People

As a leader in the world of welding and part of the voestalpine steel and technology group, we are close to you with more than 100 years of experience, 50 subsidiaries and 4,000 sales partners worldwide. Thanks to our comprehensive product portfolio, welding expertise and global orientation, we know your needs and, as a total solution provider, ensure the best results for your most demanding challenges. Perfectly interlinked and as unique as your business.



**Lasting Connections** – Perfect alignment of welding machines, consumables and technologies combined with our renowned application and process know-how provide the best result for your requirements: A true and proven connection between people, products and technologies. The result is what we promise: The Perfect Weld Seam for Lasting Connections.



**Tailor-Made Protectivity™** – Proven under the toughest conditions: Our products protect metal surfaces from wear and corrosion. With over 70 years of experience and the broadest product portfolio in the industry, we are your preferred partner for Surface Protection solutions. We deliver what we promise: Surface Protection tailored to your needs.



**In-Depth Know-How** – As a manufacturer of soldering and brazing consumables, we offer proven solutions based on 60 years of industrial experience, tested processes and methods, made-in-Germany. This in-depth know-how makes us the internationally preferred partner to meet your soldering and brazing challenge through innovative solutions. The result is what we promise: Innovation based on in-depth know-how.

The Management System of voestalpine Böhler Welding Group GmbH, Peter-Mueller-Strasse 14-14a, 40469 Duesseldorf, Germany has been approved by Lloyd's Register Quality Assurance to: ISO 9001:2015, ISO 14001:2015, OHSAS 18001:2007, applicable to: Development, Manufacturing and Supply of Welding and Brazing Consumables. More information: [www.voestalpine.com/welding](http://www.voestalpine.com/welding)



