The global magazine for corrosion resistant alloy users, suppliers and fabricators

WORLD STAINLESS STEEL



cover story:

Independent Forgings & Alloys: Building today for tomorrow

In this issue...

- Stainless steel strategy in modern EPC projects
- Repair, replace, or keep inspecting?
- Protecting stainless steel during break bulk sea transport

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Volume 38, November 2026

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STAINLESS WORLD STEEL

Volume 38, November 2026

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Group Director - KCI Media Group
Elisa Hannan
e.hannan@kci-world.com

General Manager, KCI Publishing B.V.
Pieter Dutman
p.dutman@kci-world.com

Editor-in-Chief
Joanne McIntyre
j.mcintyre@kci-world.com

Editorial Team (print & online)
press.ssw@kci-world.com
Iryna Mukha i.mukha@kci-world.com
Gert Wijbrans g.wijbrans@kci-world.com
Madeline McNabb m.mcnabb@kci-world.com
Lyndsey Denton-Fray l.dentonfray@kci-world.com

Sales & Marketing
Vera Solis Esquivel
v.solis.esquivel@kci-world.com

Subscription Coordinator
Renate Collet subs@kci-world.com

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Publishing House
KCI Publishing B.V., Leeuwenbrug 113
7411 TH Deventer, The Netherlands

Mailing Address
KCI Publishing B.V., PO Box 825,
7400 AV Deventer, The Netherlands
kci.deventer@kci-world.com
Tel: +31 575 585270
Bank account: ABNAMRO 56.64.05.164
BIC: ABNANL2A IBAN: NL50ABNA0566405164

China Office
KCI Shanghai, Room 603, 6F, #400 Zhejiang Mid. Road, 200001, Shanghai, China
info.shanghai@kci-world.com
Tel: +86 21 6351 9609 Fax: +86 21 6351 9607

Germany Office
KCI GmbH, Siemensstraße 32, D-47533 Kleve, Germany
info.kleve@kci-world.com
Tel: +49 2821 71145 0 Fax: +49 2821 71145 69

Canada Office
KCI Publishing Corporation, 214 King St W,
Suite 412, Toronto, ON M5H 3S6, Canada
info.toronto@kci-world.com
Tel: +1 416 361 7030 Fax: +1 416 361 6191

Singapore Office
KCI Asia Pacific Pte Ltd.,
Kitchener Complex, Block 809 French Road, #07-156
Singapore 200809
info.singapore@kci-world.com

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Defence reshaping metals demand

"The supreme art of war is to subdue the enemy without fighting."
Sun Tzu, 544-496 BC, Chinese military general, strategist & philosopher



This month, we're focusing on defence and aerospace. As a new investment cycle takes shape across Europe's and the United States' defence industries, its scale could create significant opportunities for stainless steel and special-alloy suppliers.

Defence expenditure by EU Member States is projected to rise to EUR 547 billion by 2029. Alongside this growth, the EU's Readiness 2030 initiative aims to mobilise up to EUR 800 billion in additional defence expenditure and fiscal capacity. Across the Atlantic, current US budget projections envisage USD 5.3 trillion in Department of Defence military-programme funding between FY2027 and FY2030.

Not all defence spending translates into demand for metals, of course. However, investment in ships, submarines, aircraft, manufacturing facilities and supporting infrastructure presents clear opportunities for stainless steels and other corrosion-resistant alloys.

Naval construction is perhaps the most obvious example. The US Navy's FY2027 budget request includes USD 65.8 billion for shipbuilding, covering submarines, destroyers, amphibious vessels, oilers and other ships. Such programmes require stainless steels and corrosion-resistant alloys across piping, valves, pumps, heat exchangers, seawater systems, exhaust systems and auxiliary equipment. Submarine and nuclear-powered vessel programmes can extend this demand into nickel alloys and specialised materials.

Aircraft and aerospace systems present another substantial market, with applications extending beyond conventional stainless steels to nickel-base superalloys, titanium and specialised high-strength and heat-resistant steels, particularly in engines, propulsion systems and high-temperature components.

For European suppliers, the changing structure of Europe's defence industry could be particularly significant. Security Action for Europe (SAFE), the EU's EUR 150 billion loan instrument, is designed to support increased common defence procurement. Meanwhile, the broader Readiness 2030 initiative seeks to expand Europe's defence industrial capacity and strengthen its manufacturing base. Equipment procurement by EU Member States had already reached EUR 115 billion in 2025.

This is unlikely to be a short-term investment cycle. At the 2025 Hague Summit, NATO members committed to investing 5% of GDP annually in defence and defence-related requirements by 2035. This includes at least 3.5% for core defence requirements and up to a further 1.5% for areas such as infrastructure, resilience and strengthening the defence industrial base.

For the stainless steel industry, new ships, aircraft and manufacturing plants, together with investment in energy, fuel, water and other supporting infrastructure, could make defence an increasingly important source of demand for stainless steels and special alloys over the coming decade.

Best wishes,

Joanne McIntyre
Editor-in-Chief of Stainless Steel World
j.mcintyre@kci-world.com



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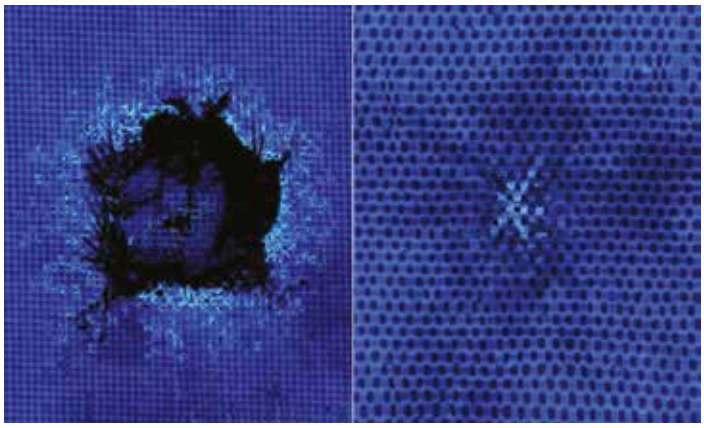


Engineers at the University of Wisconsin-Madison have developed a hybrid fibre-reinforced polymer composite that could help protect aircraft and other high-flying vehicles from lightning strike damage.

The protective material, developed by a team led by Pavana Prabhakar, integrates stainless steel yarn into carbon fibre fabric. The resulting drapable "blanket" can conform to complex aircraft geometries while providing a pathway for electrical charge to spread across the structure's surface.

Carbon fibre-reinforced polymer composites are increasingly used in aircraft because they are strong and lightweight. However, their relatively poor electrical conductivity can cause heat to build up when lightning strikes, potentially damaging the surrounding material.

The new design uses two metal-infused woven layers positioned perpendicular to each other, creating a bidirectional conductive network. This distributes electrical energy more effectively, reducing heat concentration at the strike location.

Alleima strengthens Airbus partnership



Alleima continues to strengthen its long-standing partnership with Airbus, supporting the aerospace leader with advanced titanium seamless tube solutions for some of its most demanding applications. The companies are deepening and expanding their current partnership, reinforcing Alleima's role as a strategic partner in helping Airbus meet evolving requirements for safety, performance, and sustainability across its aircraft programs.

The continued collaboration deepens and expands Alleima's contribution of advanced titanium seamless tube solutions to Airbus programs and complements Alleima's existing deliveries of stainless steel tube solutions. Together, the two companies will continue to advance technologies that support reliable, efficient, and more sustainable aerospace operations for years to come.

Valence acquires Cametoid Technologies



Valence Surface Technologies LLC, the independent aerospace surface finishing platform in North America, has announced the acquisition of Cametoid Technologies Inc., the provider of Ion Vapour Deposition (IVD) surface treatment to the North American aerospace and defence markets. Holding difficult-to-obtain industry approvals and operating six IVD chambers, Cametoid provides IVD coatings to leading manufacturers across the North American aerospace, defence, and energy supply chains. Financial terms of the transaction were not disclosed.

Cametoid's core capabilities include IVD coatings for steel and titanium alloys, stainless steel, and aluminum, as well as a patented process for coating non-metallic parts such as ceramics and composites, including PEEK and PEKK. The company also provides NDT, salt spray testing, blasting, complex masking, chromate conversion, and paint. Cametoid's experienced team operates out of a single facility in South Windsor, Connecticut, with capacity for future growth and expansion.

Cametoid represents the 13th add-on acquisition for Valence since inception, and Valence will continue to pursue attractive M&A opportunities in both North America and Europe.

Metallus and US Army strengthen defence materials

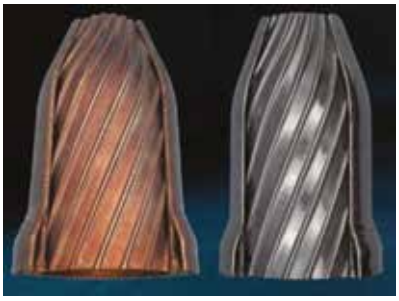


Metallus, a leader in high-quality speciality metals, manufactured components and supply chain solutions, was joined by representatives from the US Army, regional economic development organisations and government leaders to celebrate the commissioning of new manufacturing assets that will strengthen the domestic munitions supply chain and support US national security.

The ceremony, held at Metallus' Gambrinus facility in Canton, Ohio, marked the official commissioning of a bloom reheat furnace, roller furnace, and supporting equipment that expand the company's production capabilities. The investment was supported through the US Army's nearly USD 100M funding commitment and workforce and economic development support from JobsOhio.

For more than 30 years, Metallus has supplied specialty steel for essential Army artillery and mortar shell applications. The newly commissioned assets will improve operational efficiency, enhance product quality, and increase manufacturing flexibility while helping revitalize domestic manufacturing capabilities.

REM & Meltio partner on DED finishing



REM Surface Engineering and Meltio have partnered to demonstrate advanced surface finishing for components produced using wire-laser directed energy deposition (DED), combining Meltio's additive manufacturing technology with REM's Extreme ISF® Process.

The demonstration featured a 3.2 kg Stainless Steel 316L rocket engine nozzle with integrated internal cooling channels designed for fuel cooling. Wire-based DED can produce components with significant surface texture, often requiring secondary machining.

REM's Chemical-Mechanical Polishing process reduces external surface roughness and structural irregularities, while its chemical polishing technology can finish intricate internal cooling channels that conventional machining methods may struggle to access. The combined approach can improve surface quality while supporting enhanced fluid flow, increased fatigue life, and improved functional performance.

The collaboration highlights the potential of advanced chemical and mechanical finishing technologies to address post-processing challenges associated with complex wire-based DED components.

GE Aerospace advances XA102 engine assembly for USAF



GE Aerospace continues to advance toward assembly of the XA102 adaptive cycle engine under the US Air Force's Next Generation Adaptive Propulsion (NGAP) program, marking continued gains in the development of next-generation propulsion technologies for future combat aircraft.

The XA102 was designed utilising the latest model-based engineering practices to reduce development time and cost. These capabilities are being extended into manufacturing, inspection, and assembly to further reduce development time and enable the propulsion industrial base to innovate at speed. A key enabler is GE Aerospace's use of model-based definition (MBD) to convey the complete product definition in a machine-readable format that can be transparently consumed in downstream manufacturing processes.

The XA102 program is the first engine to be built using MBD, from design to assembly, in place of traditional two-dimensional drawings.

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Independent Forgings & Alloys: Building today for tomorrow

Marking its 25th anniversary in 2026, IFA is entering a new phase of growth with a major investment programme focused on the civil aerospace market. New ring-rolling equipment, presses, furnaces and automation will expand capacity while targeting greater repeatability, material efficiency and manufacturing control. At the same time, the South Yorkshire forging specialist is investing in its workforce and local supply chain as it positions itself for further growth in aero-engine components.

By Joanne McIntyre, Stainless Steel World

Aerospace has been a strategic focus for Independent Forgings & Alloys (IFA) for many years, and the company has steadily strengthened its position as a critical supplier to the sector. A strong quality team has supported this expansion by securing all the necessary industry accreditations and approvals, particularly Nadcap accreditation for forging. IFA holds all aerospace prime approvals.

A major step forward came in 2019, when IFA acquired Doncasters Precision Forge, located adjacent to its existing facility. The acquisition greatly increased the company's site to 204,216m^2 (670,000 ft^2) and marked its entry into precision blade and closed-die forging. Today it has a unique breadth of hot-working and forging capability on a single site. This diverse capability includes 7,000kg ingot conversions down to precision blades weighing as little as five grams.



The acquisition also broadened IFA's position within aerospace. With a strong presence in aero engines, adding closed-die forging enabled the company to expand into the aerostructures market. Today, its business focuses primarily on civil aerospace and power generation, with products exported globally.

25 years of growth

IFA's growth over the past 25 years has been substantial. The company began operations in 2001 with around 30 employees and turnover of approximately USD 3 million. Today, more than 300 people work on- site, while annual turnover has grown to around USD 100 million.

Much of this physical and commercial expansion has taken place during the past decade. As IFA celebrated its 25th anniversary in 2026, CEO Andy McGuinness emphasised that the people integral to its success were at the heart of the success. "The celebrations culminated in a barbecue attended by around 500 guests, bringing together employees past and present, their families and others who have contributed to the company's development over the years."

IFA's relationship with the surrounding community is particularly visible in the generations of local families who have worked for the company. In some cases, the grandchildren of original employees are now working in the forge themselves.

As a major local employer, IFA sees its continued development as closely connected with the wider South Yorkshire metals industry. This includes sourcing raw materials locally where possible and working alongside the region's established melting and metals supply base.

Andy explains: "Our ambition is to make South Yorkshire a regional powerhouse for global manufacturing."

USD100 million investment in civil aerospace

Civil aerospace, particularly the aero-engine market, is now a central focus for IFA. To support anticipated growth in engine production and address supply-chain capacity constraints, the company has secured close to USD 100 million in funding for a major expansion of its forging capabilities.

Bryan Wynn, Manufacturing Engineer, explained: "The investment will enable IFA to increase production capacity while introducing greater precision, repeatability and process control. These capabilities are particularly important for critical aero-engine components, where consistency and efficient use of high-value materials are key manufacturing requirements."

IFA processes a broad range of aerospace materials, including titanium, nickel and cobalt alloys, stainless steels and aluminium alloys. The new equipment will allow these materials to be processed with greater control, supporting IFA's ambition to expand its role in manufacturing critical aero-engine components.

Bryan added: "We're processing materials at a significantly more advanced level. We believe that our investment in the ring mills represents the next generation of forging technology and puts us ahead of the industry."

At the heart of the programme is a major expansion of IFA's radial-axial ring-rolling capability, with four new ring-rolling machines. Advanced control systems will provide much greater control over the forming process, improving dimensional consistency and repeatability while enabling components to be produced using less material. For costly aerospace alloys, reducing material input and waste offers both economic and sustainability benefits.



A major expansion of IFA's radial-axial ring-rolling capability is at the heart of the company's USD 100 million investment programme.

"It's highly advanced technology which is new to the industry. In fact, two of the machines we are investing in are the first of their type to be manufactured and will be game-changing technology," says Bryan.

The investment extends beyond ring rolling. IFA is also installing two new preform presses, 20 furnaces and four manipulators, creating additional capacity and greater control across the production chain. Together, the equipment is intended to provide a more integrated and automated manufacturing process, reducing variation between components while improving productivity, material utilisation and overall quality.

For IFA, the result will be not simply greater capacity, but a more controlled and repeatable manufacturing platform designed specifically to meet the increasingly demanding requirements of the civil aerospace supply chain.

Building the forge of the future

IFA describes the investment programme as its "Future Forge", introducing a new generation of digitally controlled, highly automated forging equipment designed to improve repeatability, quality and material efficiency.

The new ring mills and preform presses will use programmed processes to minimise variation throughout production. This is particularly important in aerospace, where stringent quality requirements demand consistently high-quality components with minimal defects and rework, Simon Walker, General Manager, explains. "We're achieving repeatability right through

the process chain. Digital simulations will allow manufacturing sequences to be modelled and optimised before production begins, reducing risk and avoiding unnecessary material use."
The investment will also change the skills required on the shop floor, with forge operators trained to programme and operate the new equipment while retaining their fundamental forging expertise.
For IFA, the Future Forge is about more than automation. By combining greater process control, simulation and advanced equipment, the company aims to reduce variation and waste while improving productivity and quality.
"We are calling it the Future Forge, as it is next-generation technology which will dramatically accelerate our journey," continues Simon.

Sustainability

IFA's expansion is also strengthening its links with the South Yorkshire supply chain. The company operates globally, increasing production volumes will require more raw materials and a resilient supply base.
Sustainability considerations extend into the manufacturing process itself. The company is seeking to use material more efficiently, reducing the amount required to produce each component and minimising waste throughout the process chain. Bringing its principal manufacturing activities together on a single site also offers opportunities to reduce its overall carbon footprint. IFA will also look to build on the circular economy of recycling raw material waste.
"Everything that we are doing is driving more efficient utilisation of material. To make any component, we'll be driving towards using the minimum amount of material," adds Bryan.



IFA manufacture a wide variety of components for the aerospace industry.

IFA's sustainability progress has been reflected in a favourable environment assessment. The forthcoming investments are expected to deliver further improvements in efficiency and process optimisation while simultaneously increasing product quality.
"As the global supply chain moves towards net zero, we are making significant progress in reducing our own emissions and environmental footprint. It's a journey, but it's an obligation we have to the future," Bryan concludes.

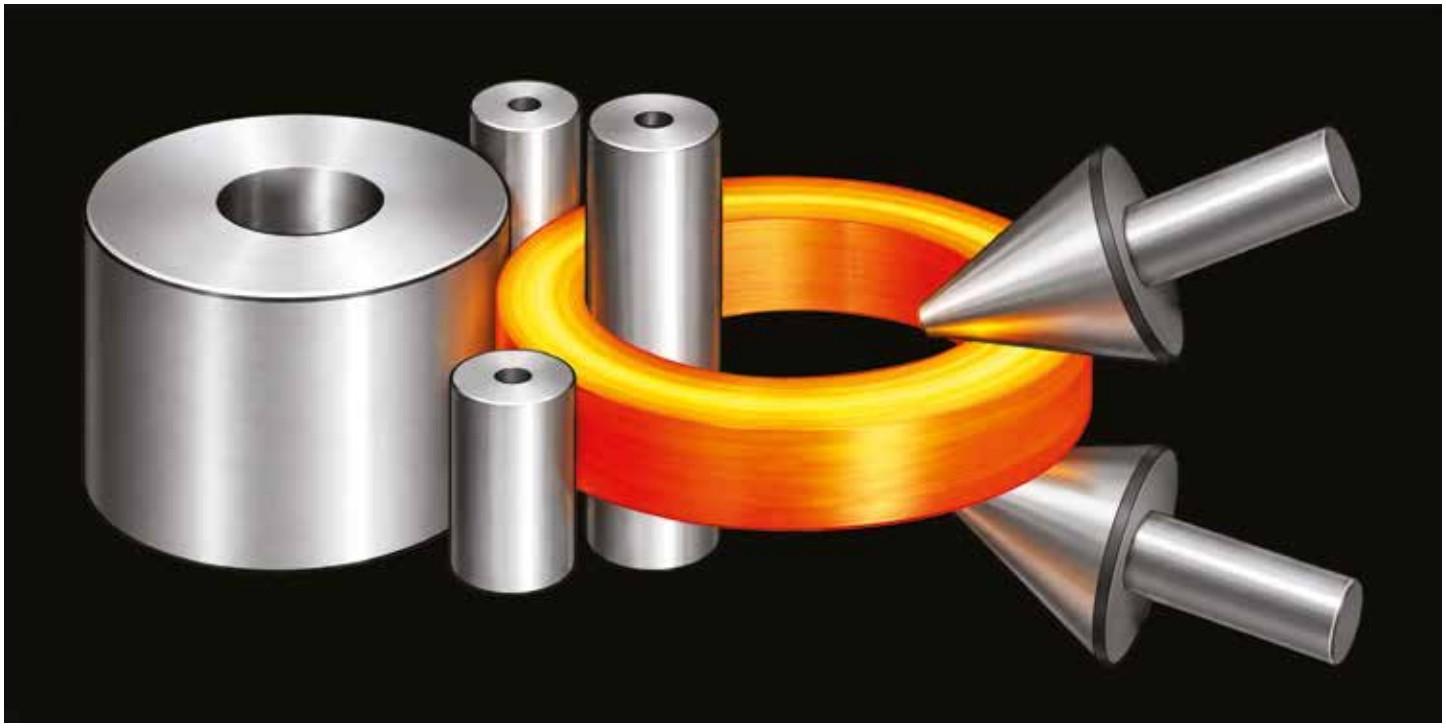
Recognition for international growth

IFA received the Queen's Award for Enterprise in 2008 and, in 2026, was recognised with a King's Award for Enterprise in the International Trade category, marking the company's continued growth in international markets.





IFA received the Queen's Award for Enterprise in 2008 and, in 2026, was recognised with a King's Award for Enterprise in the International Trade category.



New, highly advanced ring rolling control systems will provide much greater control over the forming process, improving dimensional consistency and repeatability while enabling components to be produced using less material.

Andy explains: "The Award is a testament to IFA and the capabilities we have developed. We are a dynamic, flexible and agile company, committed to supporting our global customers and building strong, long-term relationships with both customers and suppliers."

With its latest investment programme, IFA is now looking to build on that international growth by strengthening its position within the global aerospace supply chain, particularly in the manufacture of critical aero-engine components.

"We will grow to be one of the major ring-rolling manufacturers for the aerospace engine industry."



Investments in highly integrated and automated manufacturing processes will reduce variation between components while improving productivity, material utilisation and overall quality.

Forging School of Excellence

While automation and digitalisation are increasingly important, IFA emphasises that skilled employees remain fundamental to its future.

The company has a strong continuity within its workforce; many of its original employees remain with the business, while some families are now represented by a third generation working on the shop floor.

The introduction of advanced equipment is expected to create new skills requirements rather than eliminate the need for traditional forging expertise.

IFA is therefore establishing an on-site Forging School of Excellence, through which experienced employees can pass their knowledge to the next generation.

"Our people are and will remain our most important assets. We aspire to be an employer of choice for the entire region," explains Andy.

The school is intended to preserve the fundamental metallurgical and practical understanding of forging while preparing employees to work with increasingly automated, digitally controlled equipment.

"Although we're moving to more automation, our staff still need the fundamental understanding of what forging involves. The School of Excellence will be a framework to ensure that this knowledge is passed on, preserving the expertise that is at the heart of our company's success today and in the decades to come." ▲

History beneath the forge

IFA's expansion has uncovered an unexpected connection with Sheffield's industrial past, following an archaeological investigation of the development site.

Bryan explains: "IFA carried out an archaeological dig to examine what activities may have taken place on the site in the past. The earliest record of transactions involving the site dates to 1581, while the remains of water channels indicate that water wheels once operated here."

York Archaeology spent approximately three months excavating the site and documenting its findings. The work subsequently attracted the attention of the South Yorkshire Archaeological Society and a television production company. The findings are now featured in a Channel 4 documentary series presented by Professor Alice Roberts examining the Great Sheffield Flood of 1864.



Raghu Vamsi Aerospace Group announces its planned superalloy manufacturing facility at Farnborough International Airshow 2026. Photo: Raghu Vamsi Aerospace Group

Raghu Vamsi Aerospace plans major superalloy facility

Raghu Vamsi Aerospace Group is planning a major investment in a new integrated nickel-based superalloy manufacturing facility in Telangana, India. Announced during the Farnborough International Airshow 2026, the project will expand India's domestic production of high-performance alloys for aerospace, defence and other demanding applications.

By Joanne McIntyre, Stainless Steel World

The new superalloy facility will occupy around 50 acres and is planned as one of a relatively small number of integrated Indian plants that can produce high-quality nickel-based superalloys. The site will bring together several production stages, including vacuum melting, forging, heat treatment, vacuum casting, powder metallurgy, and other forming processes.

Annual production capacity is expected to reach approximately 5,000 tonnes.

The product portfolio will include round bars, wire, forgings and castings, as well as tungsten carbide powders and other specialised products. Commercial production is currently targeted to begin in January 2028.

Aerospace & defence supply chain

Aerospace is expected to be an important market for the facility. Nickel-based superalloys are widely used in aero engines because they retain mechanical strength and resist oxidation and corrosion at temperatures where many conventional metallic materials cannot operate effectively. The materials produced at the new plant are also expected to serve space and defence systems, gas turbines, oil and gas equipment, nuclear applications, medical implants and emerging hydrogen technologies.

The investment also addresses a broader supply-chain issue. India currently imports a significant proportion of the nickel alloys required by its advanced manufacturing industries. Establishing additional domestic melting and downstream processing capacity could therefore reduce reliance on overseas material while supporting the country's expanding aerospace and defence manufacturing base.

For Raghu Vamsi, the investment will provide greater vertical integration and access to critical materials used by its existing aerospace, defence and energy businesses. The company says it has already received customer support for the product and process qualification work required ahead of commercial production.

The project will be led by Dr S.K. Jha, former Chairman and Managing Director of Indian special metals producer Mishra Dhatu Nigam Limited (Midhani). His appointment brings considerable experience in the production and development of strategic materials.

If completed as planned, the Telangana facility will add significant new capacity to India's domestic superalloy supply chain, covering the route from primary melting through to forged, cast and other finished material forms for high-performance applications. ▲



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S32053 N08367 S31254
N08031 N08904 N08020
N08354 N06625 N08825
N06022 N10276 N04400

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The sky's the limit!

Lightweighting is a key topic in the aerospace sector, driven by a need for ever-greater fuel efficiency. When coupled with ongoing investments in commercial aviation as well as governmental plans for defence modernization, this spells good news for suppliers of high-performance corrosion resistant alloys. With possible alloy applications ranging from engines to exhausts to structural elements and much, much more, the sky, it seems, really is the limit…

By David Sear, Technical English Services





Recent data from ADS in the UK speaks volumes for the aviation sector: worldwide, more than five times as many aircraft were ordered in July 2026 compared to July 2025 whilst the global commercial aircraft backlog has surpassed 17,000(!) aircraft for the first time.

Demand, it seems, is far outstripping supply. ADS indicates that whilst 794 aircraft were delivered from January to July 2026, orders were placed for a staggering 1573 aircraft within the same period. Single-aisle aircraft are by far the most popular with 1,261 orders recorded. ADS ascribes this to sustained passenger demand for short-haul travel and airlines' focus on fleet efficiency.

Not surprisingly, the world's hunger for air travel is amply reflected in market forecasts for key aerospace commodities such as stainless steel, titanium and nickel alloys.

For example, valuing the 2025 global aerospace titanium market at just under USD 4000 million, Fortune Business Insights envisages growth to over USD 7,500 million by 2034. Their reasoning is simple: offering exceptional strength-to-weight performance, corrosion resistance, and high-temperature stability, titanium will continue to be is an important structural and engine material in both commercial and military aviation.

Taking a wider look, Strategic Market Research believes that the global aerospace high performance alloys market will reach USD 14.3 billion by 2030, driven by superalloys, jet engines, turbine blades, lightweight alloys, and defence aerospace programs. Assessing CRA growth rates across multiple sectors, Persistence Market Research highlights the aerospace industry as the market with the greatest potential for growth in alloy consumption.



The business jet market is contributing to the strong demand for airplanes, with Gulfstream recently announcing the 400th customer delivery of its G500 and G600 fleet.

Firm orders

Market predictions are supported by recent news from the airlines themselves. Hence in September, Korean Air finalized its order for 103 jets (passenger and freight) across Boeing's widebody and single-aisle airplane family. In the same month Egypt's AIRCAIRO signed a firm order for 15 Airbus A320neo aircraft. Having grown rapidly from seven aircraft in 2021 to over 45 today, AIRCAIRO is planning a fleet of 130-plus aircraft by 2034.

Also in September 2026, ANA Holdings Inc. revealed plans to expand its E190-E2 fleet with an additional order for eight aircraft from Embraer. This deal builds on the airline's 2025 contract for 15 E190-E2 firm aircraft. ANAHD still holds five additional options for E190-E2 aircraft.

Meanwhile, at this year's Farnborough International Airshow, Airbus received an order from SMBC Aviation Capital for an additional 65 A321neo and 35 A320neo aircraft whilst Airbus Helicopters and Voyageur Aviation signed an agreement for the first purchase order of the Airbus U030 Flexrotor uncrewed aerial system (UAS).



Safran Aircraft Engines is upgrading its forging capabilities with the acquisition of a 30,000 metric ton hydraulic press

Supply chain news

Along the aerospace and defence supply chains, companies are looking to beef up capabilities by investing in equipment and developing new processing technologies. Hence in January 2026, Special Melted Products (SMP) announced a contract with Danieli Breda for a new forging press as part of its large capital expansion, Project Vulcan. The new press will enable SMP to produce high-integrity steels, superalloys and advanced components for highly regulated, mission-critical sectors such as aerospace, energy and civil nuclear.



ANA Holdings plans to expand its E190-E2 fleet with an additional order for eight aircraft from Embraer.

Safran Aircraft Engines is also upgrading its forging capabilities with a 30,000 metric ton hydraulic press to manufacture strategic parts for commercial and military aircraft engines. Valued at EUR 150 million, this project should be operational by 2029 and could almost double production across all engine families by 2035.

In April 2026, Voestalpine's High Performance Metals Division reported orders in the aerospace sector worth EUR 1 billion for the next five years. Airbus was part of this agreement that covers the entire range of services—from high-performance materials and complex forged parts to comprehensive global logistics services.

Meanwhile, interest continues to grow around 3D printing. During the summer, Norsk Titanium was selected for its first 'America Makes' project, joining the Joint Additive Qualification for Sustainment – Supplier Qualification program (JAQS-SQ). 'America Makes' is the United States' leading public-private partnership focused on advancing 3D printing and additive manufacturing, established to make the U.S. globally competitive by accelerating technology adoption. The project will enable Norsk Titanium to support qualification pathways for Rapid Plasma Deposition® (RPD®) that accelerate broader adoption of additive manufacturing across defence applications.

As a side note, Norsk Titanium has also received nearly USD 4.2 million from official US sources to fund development activities related to RPD®. Efforts will focus on both titanium and nickel-based alloys, reportedly to help strengthen the maritime and submarine industrial capacity.

In September, GE Aerospace announced plans to acquire Consolidated Precision Products, a leading manufacturer of highly engineered castings in super alloy, titanium, aluminium, magnesium and steel. "Investing in mission-critical casting capacity is needed to support the strong simultaneous demand across commercial engines, aftermarket and defense," commented GE Aerospace Chairman and CEO H. Lawrence Culp, Jr.

In June 2026, ATI Inc. revealed a new long-term strategic material supply agreement with BWX Technologies, Inc., strengthening the decades-long partnership supporting the U.S. Naval Nuclear Propulsion Program. The agreement runs through fiscal year 2030. Note that ATI provides high-performance titanium, nickel-based alloys, and specialty materials.

In July 2026, Aperam announced the establishment of a new Titanium Solids



Voestalpine's High Performance Metals Division has booked aerospace business worth EUR 1 billion for the next five years.

SpaceX Starship: from 301 to 304 to 30X



As reported by the BSSA and others, SpaceX relies on stainless steel over alternatives such as carbon fibre for the construction of its Starship rockets.

The choice for stainless was based on numerous factors such as material properties (e.g., porosity and flammability), manufacturing challenges, weldability, cryogenic properties (at liquid oxygen temperatures, the strength of the 300 series increases without becoming more brittle), beneficial heat shielding, elimination of paint, etc.

Initially focussing on stainless steel 301, SpaceX moved to 304 and ultimately developed a proprietary alloy, 30X, understood to surpass the performance of both 301 and 304.

At the time of writing, a Starship rocket has just successfully orbited the Earth for the first time.

Image shows a Starship prototype Mk1 rocket

Center of Excellence in Frankfort, New York, U.S. The facility is being created to support growing demand for recycled titanium materials from the aerospace industry, strengthen service to domestic U.S. customers, and enhance supply capabilities for international markets.
Also in the USA, Stainless Structurals outlined the launch of its newest division, Extralloys, located in Robinsonville, Mississippi. Extralloys will focus on delivering high-quality hot-extruded profiles, strengthening the company's ability to meet increasing demand across key industries including aerospace, defense, energy, industrial equipment, architecture, and construction.

Aircraft materials

Building an airplane requires a tremendous variety of materials – from metals to glass, and carbon-fibre composites to rubber. On balance, aluminium predominates in traditional aircraft, although carbon-fibre composites are finding more and more usage.

Materials such as stainless steels, titanium, and nickel alloys also play a huge role in aircraft construction and can be found in various components, from nuts and bolts in the cabin through to the landing gear and turbine blades. The following list does not pretend to be exhaustive but should indicate how versatile CRAs are in aerospace environments.

Stainless steels

- Landing gear (shafts, hydraulic components, high-strength structural parts)
- Hydraulic systems (tubes, fittings, valves)
- Fuel systems (tubes, fittings, valves)
- Engine/exhaust (manifolds, ducts, tailpipes, selected engine parts)
- Flight controls & actuation (shafts, pins, bushings)

Commonly used: 304/304L, 316/316L, 321, 347, A286, 17-4PH…

Nickel alloys

- Gas-turbine engines (turbine blades, vanes, casings)
- Combustion section (combustor liners, chambers, nozzles)
- Afterburners (flame holders, spray bars, exhaust components)
- Exhaust systems (cones, ducts, manifolds)
- Aircraft exhaust/thermal systems (ducts, brackets, shields)

Commonly used: Inconel 718, Waspaloy, Inconel 625, Hastelloy X…

Titanium alloys

- Airframe structure (frames, bulkheads, longerons)
- Wings (fittings, spars, attachment components)
- Landing gear (components, fittings, actuators)
- Engine (compressor discs, blades, shafts)
- Aircraft skins

Commonly used: Ti-6Al-4V, Ti-6Al-2Sn-4Zr-2Mo, Ti-6246, Ti-5553…

Porosity - why 1% may not be preferable to 2%

Materials destined for use in aerospace and defence applications have to pass



rigorous industry tests and standards, covering for example structural strength, fracture toughness, corrosion properties, thermal stability, fatigue resistance, etc. By way of example, porosity testing is routinely applied to alloys used in critical applications as pores can concentrate stress and initiate cracks, which can propagate under cyclic loading.

The most straightforward porosity measurement can be obtained using the Archimedes principle to calculate density, based on the sample's weight in air and its displaced volume when immersed in a liquid. The outcome is then compared to the theoretical density of the fully dense material.

Yet whilst this technique may indicate the degree of porosity, a sample with a lower porosity may not necessarily be considered superior to a sample with a higher porosity. Important considerations include the pore location, distribution, size and shape – all factors which can initiate or contribute to fatigue cracking. Other analytical techniques are therefore often deployed during materials testing, such as X-ray micro-computed tomography, metallographic microscopy, SEM/optical micrographs and gas pycnometry.

Research Papers

Readers interested in the latest scientific work on CRAs used in aerospace and defence might like to consider the following articles:

- *Rapid bulk residual stress relief of laser-welded aerospace alloys by electropulsing treatment*
  Journal of Manufacturing Processes, Volume 175, October 2026
- *Life cycle assessment in aerospace manufacturing processes: A review*
  Cleaner Environmental Systems, December 2026
- *Mechanical properties of aerospace titanium alloys fabricated by selective laser melting: A critical review of process–microstructure–defect–property relationships*
  Journal of Materials Processing Technology, October 2026
- *Cradle-to-grave life cycle assessment of titanium, basalt and natural fiber composite for aerospace structural applications*
  Next Nanotechnology, Volume 10, December 2026
- *Efficient and sustainable surface modification of TC17 dual-phase titanium alloy via dual-frequency ultrasonic cavitation for green aerospace propulsion*
  Aerospace Science and Technology, October 2026
- *Ultrasonic Vibration-assisted Turning of Aerospace-grade Titanium Alloy: Surface Quality Characteristics and Tool Wear Morphology*
  Procedia CIRP, Volume 144
- *A review of processing and performance of MAR-M247 nickel-based superalloy for aerospace applications*
  Results in Engineering, December 2026 ▲

About the Author

A freelance editor, David Sear has been fascinated by corrosion resistant alloys for over three decades. Suggestions, comments and critique are expressly welcomed and can be addressed to: info@teservices.nl.





In 2013 JGC landed the contract to construct a new petrochemical complex built around one of the world's biggest ethane crackers in Texas. Photo ©JGC

Stainless steel strategy in modern EPC projects

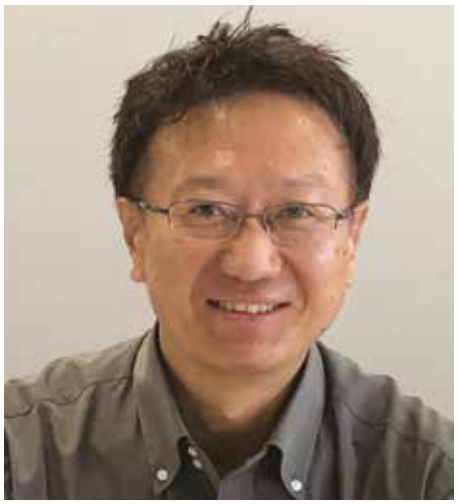
In the dynamic world of Engineering, Procurement, and Construction (EPC) projects, the selection and management of piping materials stand as critical pillars for ensuring safety, reliability, and sustainability. Mr Tatsuya Tobe, Expert Piping Materials/Execution at JGC Corporation, is a seasoned expert with over three decades of experience, having navigated the complexities of global projects spanning LNG, refining, and emerging sectors such as hydrogen and CCUS. His journey, from piping design engineer to leader in international standardisation, offers invaluable insight into balancing technical precision, cost efficiency, and innovation.

By Laura Wang & Joanne McIntyre, Stainless Steel World

Over the past 31 years, Mr Tobe has built his career within JGC, beginning in piping layout design before moving into field engineering roles on gas processing and refinery projects in the Middle East and Southeast Asia. For more than two decades, he served as a Piping Material Engineer and Lead Engineer on major EPC and FEED projects covering LNG, ethylene, refining, nickel refining and chemical facilities.

The scope of the piping materials function is extensive. "On large projects, more than 400 piping classes may be developed, each defining material combinations for pipes, fittings, flanges, valves, gaskets and bolting," explains Mr Tobe. "My responsibilities include preparation of detailed material specifications, vendor technical evaluation, document review and resolution of material-related issues during construction and commissioning."

From 2012, Mr Tobe led the Piping Material Group for 11 years and continues today to support technically complex FEED studies, conduct EPC technical reviews, develop corporate standards, and contribute to emerging applications such as liquid hydrogen and additive manufacturing. He is also a member of the ASME B31.3, contributing to the continuous revision of the Process Piping Code Subgroup on Materials, and the ASME BPV Section II International Material Specifications working group.



Mr Tobe: "The selection of piping materials is fundamentally driven by fluid conditions."

Materials challenges

One of the most demanding assignments of Mr Tobe's career came in his tenth year at JGC, when he was appointed piping materials lead for a major EPC project that combined both a refinery and an ethylene plant. These facilities are normally executed as separate projects, each governed by its own piping material philosophy and specifications. In this case, however, they were integrated into a single development.

"I took on the challenge of developing one unified piping materials specification," he explains.

The task required extensive coordination with the client and careful technical alignment across two fundamentally different process environments.

Mr Tobe proposed standardising materials across both facilities, prompting detailed technical discussions and multiple rounds of review. "We received numerous comments and worked through several refinements," he recalls. "Through this collaborative effort, we ultimately established an optimised set of piping material specifications that met all technical and project requirements."

The experience proved formative. It not only strengthened his technical judgement but also reinforced the importance of structured coordination and disciplined execution in large, integrated EPC projects.



Mr Tobe has over thirty years of experience with complex global projects spanning LNG, refining, and emerging sectors such as hydrogen and CCUS.

Upward trend in stainless

Mr Tobe observes a clear upward trend in stainless steel usage across recent EPC projects. "Yes, the use of stainless steel is steadily increasing," he says. Demand is particularly strong in LNG facilities, where stainless steels are essential for cryogenic piping systems operating at extremely low temperatures.

Beyond LNG, he notes growing adoption of stainless steels and corrosion-resistant alloys (CRAs) in emerging sectors such as hydrogen production, transportation and CCUS. "As these industries expand, the importance of stainless steels as reliable, corrosion-resistant materials will continue to strengthen," he explains.

In terms of grade selection, the most frequently specified materials remain SS304/304L and SS316/316L, typically supplied as dual-certified grades. "These materials offer a good balance of corrosion resistance, mechanical properties and availability," Mr Tobe states, emphasising their continued role as standard solutions across a broad range of process applications.



Mr Tobe inspecting an intermediate product valve during a vendor survey.

Increase in duplex

Duplex stainless steels play an increasingly important role in demanding service environments. Mr Tobe explains that they are "commonly applied in piping systems exposed to highly corrosive environments, particularly where chloride concentrations are elevated, such as seawater service."

Compared with conventional austenitic grades such as SS304 or SS316, duplex grades provide superior resistance to chloride-induced corrosion, making them better suited to aggressive fluid conditions. Their application is also well established in wet H_2S service, where duplex stainless steels are qualified in accordance with NACE MR0175 / ISO 15156-3 Annex A.

"As projects increasingly involve challenging environments such as seawater cooling, desalination or chloride-rich process streams, the adoption of duplex stainless steels continues to grow," Mr Tobe notes, citing their enhanced corrosion resistance, higher strength and favourable lifecycle performance as key drivers.

Influence of sustainabilty

Sustainability considerations are increasingly influencing material selection in EPC projects, and Mr Tobe sees stainless steel benefiting directly from this shift. "There is a clear industry-wide trend toward recognising stainless steel as a sustainable and environmentally responsible material," he says.

Several factors underpin this perception. Stainless steel has a high recycling rate,



In 2014 JGC was awarded a contract by Petronas for a floating LNG plant, the first for a Japanese company. Photo ©JGC

aligning well with circular-economy principles. Its superior corrosion resistance contributes to long service life, reducing replacement frequency and lowering lifecycle environmental impact. In addition, it typically requires little or no painting, which further reduces coating-related environmental burden.
"As sustainability becomes a core priority in EPC projects, the selection of stainless steel as a 'greener' material is expected to continue increasing," Mr Tobe concludes.

Understand service conditions

Balancing performance, cost and maintainability begins with a clear understanding of service conditions.
"The selection of piping materials is fundamentally driven by fluid conditions," Mr Tobe explains, pointing to operating temperature and pressure, H_2S concentration, chloride content and other corrosive or erosive characteristics as primary determinants. Where service conditions permit, carbon steel remains widely used.
"When fluid conditions allow the use of carbon steel, it is often the preferred choice due to its cost advantages, availability and shorter delivery time," he notes. Corrosion allowance is typically applied based on the required plant design life, increasing wall thickness to ensure long-term integrity. In contrast, stainless steels generally do not require corrosion allowance because of their inherent resistance.
"This enables the use of thinner wall thicknesses, which can reduce weight and improve constructability, even though the initial material cost is higher," Mr Tobe adds.
Ultimately, he emphasises that material selection must consider lifecycle performance, constructability and total cost of ownership. Only through a holistic evaluation of these factors can engineers optimise long-term reliability while remaining aligned with project budget and schedule constraints.

Material selection

Managing corrosion and wear risks begins with an accurate assessment of service severity. "Material selection is based primarily on the expected severity of the service environment," Mr Tobe explains. In highly corrosive conditions - for example, where carbon steel would require more than 6 mm of corrosion allowance - upgrading to stainless steel can significantly reduce long-term degradation risk. "The risk is significantly reduced by selecting stainless steel piping, which provides superior resistance and longer service life," he notes.
Looking ahead, Mr Tobe anticipates several shifts in piping materials over the next five years. Greater adoption of modular construction is expected, as modularisation improves construction quality and consistency while shortening schedules - a critical advantage in today's compressed project timelines.
He also foresees continued growth in the use of highly corrosion-resistant and low-maintenance materials as sustainability becomes more deeply embedded in project criteria. In parallel, efforts to reduce site welding and simplify maintenance are likely to drive increased demand for weldless fittings and tubing systems to replace small-diameter piping.

Suggestions for material suppliers

As plant capacities increase, so too do piping dimensions, placing new technical demands on material suppliers. Mr Tobe notes that manufacturers are increasingly expected to support larger and more advanced components capable of meeting the scale of modern industrial facilities.
One area where suppliers can make a meaningful impact is by expanding available steel plate dimensions to enable longer standard pipe sections.
"Increasing unit pipe length helps reduce the number of field welds required during construction," he explains. "Fewer welds improve productivity, reduce onsite labour requirements and enhance overall quality control."
Dimensional accuracy is another growing priority. "Improvements in roundness accuracy for large-diameter pipes are becoming increasingly important," Mr Tobe emphasises. Better geometric precision simplifies fit-up and alignment during installation, improves weldability and reduces the risk of costly rework in the field.
By strengthening manufacturing capability in these areas, he concludes, material suppliers can play a decisive role in improving construction efficiency and long-term reliability in next-generation process plants. ▲

GLOBAL EVENTS

KCI World organizes targeted events around the globe where professionals can meet and exchange ideas and information. These platforms include conferences, summits, seminars, exhibitions, master classes and plant tours, often augmented with social events.

Valve World Expo Düsseldorf Conference 2026

1 - 3 December 2026
Düsseldorf, GERMANY

Valve World Expo Americas Conference Americas 2027

14 - 15 July 2027
Houston, Texas, USA

Valve World Expo Southeast Asia Conference Southeast Asia 2027

15 & 16 September 2027
Bangkok, THAILAND

Heat Exchanger World Conference & Expo Americas

October 2027
Houston,Texas, USA

Stainless Steel World Conference & Expo 2027

16 - 18 November 2027
Maastricht, THE NETHERLANDS

Heat Exchanger World Conference & Expo Europe 2028

23 & 24 May 2028
Rotterdam, THE NETHERLANDS

Stainless Steel World Duplex Conference & Expo 2028

23 & 24 May 2028
Rotterdam, THE NETHERLANDS

Valve World Expo Asia Conference 2028

30 - 31 August 2028
Shanghai, CHINA

Stainless Steel World Asia Conference & Expo 2028

October 2028
SINGAPORE

Stainless Steel World Americas Conference & Expo

November 2028
Houston, Texas, USA

Please note: Event information was correct at the time of publication but can be subject to change. Check the individual websites for the latest information.

www.kci-world.com



Repair, replace, or keep inspecting?

Deciding whether to repair, replace, or continue inspecting aging equipment depends on the confidence behind the available data. Evaluating inspection quality alongside degradation uncertainty leads to more consistent mechanical integrity decisions.

By Frank Sapienza, Becht

Few decisions create more debate during turnaround planning than determining whether aging equipment should be repaired, replaced, or simply monitored until the next opportunity. Inspection data identifies degradation and remaining life calculations estimate when equipment reaches retirement criteria. But there is often no standardized guidance for choosing between repair, replacement, or continued inspection.

The most difficult choices often occur in the gray area between equipment that clearly needs replacement (for example, based on a fitness-for-service assessment) and equipment that may safely make it to the next outage. A piping circuit may still have several years of calculated remaining life, but contain a localized damage mechanism with insufficient inspection or a history of IOW exceedances. A vessel may be approaching a minimum thickness threshold, yet analysis has not been performed on weld buildup and repair vs. replacement.

The challenge comes from evaluating equipment condition today while also deciding how much confidence you have in your ability to assess future degradation. Bringing consistency to repair-vs.-replace decisions can help improve reliability and safety as well as asset utilization and maintenance spending.

Why remaining life alone is not enough

Remaining life calculations provide valuable information, but they are based on assumptions about future degradation. Consider two examples:

- A piping circuit with 100 mils of remaining corrosion allowance and a corrosion rate of 20 mpy
- A piping circuit with 25 mils of remaining corrosion allowance and a corrosion rate of 5 mpy

Both indicate approximately five years of remaining life. From a pure calculation, they appear identical; however, from a risk management perspective, they are clearly different. The first scenario provides more opportunity to validate corrosion rate assumptions through future inspection. The second requires a higher degree of confidence in the assumed corrosion rate.

Confidence in the remaining life prediction often matters just as much as the calculation itself.

How much confidence do you have in your data?

Managing the life of equipment requires data. When evaluating repair-vs.-replace decisions, organizations should ask several questions:

1. How recent is the inspection data?
2. How representative is the inspection coverage?

3. How well is the damage mechanism understood?
4. How much variability exists in the measurements?

Many replacement decisions are driven by isolated readings or limited inspection coverage. Experienced inspectors understand that thickness measurement locations are only samples of a much larger system.
If one location has reached retirement criteria, what does that imply about nearby areas that have not been inspected? Follow-up inspections are often required to understand the scope of a replacement. For example, it would be a significant gap if a single elbow in a piping circuit fell below retirement criteria and the site replaced only that elbow without inspecting or replacing the adjacent piping.
On the other hand, if inspection coverage is extensive, historical corrosion rates are consistent, and IOWs are in compliance, there may be high confidence in utilizing continued inspection rather than replacement.

Not all damage mechanisms behave the same

Another common mistake is applying the same framework to fundamentally different degradation mechanisms. General corrosion is relatively predictable. Inspection data often provides a reliable picture of equipment condition and future degradation.
Localized damage mechanisms are different. Examples include:

- Pitting corrosion
- Corrosion under deposits
- Erosion-corrosion
- Acidic damage mechanisms (e.g., HF, HCl)
- Corrosion under insulation

These mechanisms introduce uncertainty because the worst damage frequently occurs between inspection points. They change the question from "What is the remaining life?" to "How confident are we that we know where the worst damage exists?"
When uncertainty increases, replacement decisions become less about calculated life and more about confidence in the ability to detect the corrosion.

The hidden cost of over-replacement

Replacing equipment earlier than necessary may appear conservative, but excessive replacement carries its own costs:

- Increased turnaround scope
- Longer outage durations
- Higher capital expenditures
- Greater fabrication and installation risk
- Increased demand for inspection and maintenance resources

In some cases, organizations spend significant resources replacing equipment that could have remained safely in service through another operating cycle. The goal should be maximizing risk reduction per maintenance dollar spent.

"Remaining life calculations should be evaluated alongside confidence in the underlying inspection data"

How much should actually be replaced?

Even after replacement is justified, the appropriate scope should be evaluated. Should a single elbow be replaced? A complete spool? An entire piping circuit?
In conjunction with the confidence in inspection data discussed earlier, execution considerations must also be evaluated. A flange-to-flange replacement may ultimately be more efficient than replacing individual components, even when some portions remain in acceptable condition.
Similarly, vessel repairs must often balance engineering requirements against fabrication complexity, outage duration, and long-term reliability.
The objective is not necessarily to replace the minimum amount possible, but rather to identify the scope that delivers the best overall outcome.

The best decisions are multidisciplinary

The most important lesson is that repair-vs.-replace decisions should not belong to a single discipline. The strongest decisions emerge when multiple perspectives are considered:

- Inspectors provide an understanding of the equipment condition
- Materials or corrosion engineering provide insight into the damage mechanism
- Mechanical engineering develops mitigation strategies
- Operations provides unit operational context
- Maintenance and planning provide the constraints and realities of execution

By combining these perspectives, organizations are far more likely to arrive at balanced decisions that appropriately manage risk while controlling costs.

A shift in thinking

The most effective mechanical integrity programs consistently make sound decisions under uncertainty. That requires looking beyond remaining life calculations and individual thickness readings. Instead, it depends on understanding the quality of the data and the predictability of the damage mechanism – as well as the confidence behind the assumptions being made.
Repair, replacement, and inspection decisions are ultimately about managing risk. Organizations that excel in this area develop structured decision-making processes that integrate inspection data, materials expertise, risk assessment, and practical maintenance considerations.
Evaluating confidence alongside remaining life leads to more consistent, technically defensible outcomes. ▲

About the author



Frank Sapienza is an experienced corrosion and materials engineer within the refining industry. Through his time in the refinery, he has conducted corrosion reviews, damage mechanism assessments, asset strategy development, risk-based inspection and CCD implementation for HF alkylation units, FCCs, crude units, hydrotreaters, reformers, sulfur plants, amine units, tank systems, sulfolane and aromatics units. He also led metallurgical failure analysis as well as root cause failure investigations, materials selection and life cycle analysis, IOW development and MDMT 579 evaluations.



The USS Essex departing San Diego for training exercises. Photo: Dreamstime.

Snowbird prints stainless parts aboard USS Essex

Snowbird Technologies has successfully produced and machined a 316L stainless steel component aboard the USS Essex (LHD-2) during Rim of the Pacific Exercise 2026 (RIMPAC 2026), demonstrating expeditionary additive manufacturing capabilities in an operational maritime environment.

By Meltio & Snowbird Technologies

As part of the Naval Postgraduate School's Consortium for Advanced Manufacturing Research and Education (CAMRE) distributed manufacturing experiment, Snowbird's SAMM Tech (Snowbird Additive Mobile Manufacturing Technology) system was deployed aboard the USS Essex while underway from San Diego to Hawaii in support of RIMPAC 2026. During transit, the system successfully additively manufactured components from 316L stainless steel using laser-wire Directed Energy Deposition (DED) technology with nitrogen shielding gas before completing precision machining operations to achieve final part geometry and surface finish requirements.

The demonstration highlights SAMM Tech's ability to execute the complete manufacturing workflow at the point of need - additive manufacturing, machining, and finishing - within a single ruggedised, containerised platform.

"SAMM Tech was designed to bring advanced manufacturing capabilities directly to the warfighter, wherever the mission requires," said Karl Wojtkun, Vice President of Business Development at Snowbird Technologies. "Successfully producing and machining stainless steel components aboard USS Essex demonstrates the potential of expeditionary manufacturing to reduce logistics burdens, improve readiness, and deliver critical parts closer to the point of need."

Modular manufacturing

SAMM Tech is a patented, modular manufacturing platform that integrates metal additive manufacturing, plastic additive manufacturing, CNC machining, and digital engineering tools into a compact, deployable system. The platform is designed to support maintenance, repair, and sustainment operations in remote, contested, and resource-constrained environments.

At the core of SAMM Tech's metal additive manufacturing capability is the Meltio Engine Blue, an advanced laser-wire Directed Energy Deposition (DED) system integrated directly into the platform. By utilising commercially available wire feedstock rather than metal powders, the system enables

safe, efficient production of near-net-shape metal components in operational environments. Following additive manufacturing, SAMM Tech's integrated CNC machining capability allows parts to be finished to required tolerances without leaving the platform.

316L component production

The successful production of the 316L stainless steel components marks the first phase of Snowbird Technologies' participation in RIMPAC 2026. Following transit aboard USS Essex, SAMM Tech was offloaded at Pearl Harbour and relocated to Schofield Barracks, where it remained operational in support of distributed manufacturing activities across the exercise. There, the system will continue supporting CAMRE's advanced manufacturing network by producing components and evaluating expeditionary manufacturing concepts in a joint and multinational operational environment. This achievement builds upon Snowbird Technologies' participation in previous RIMPAC exercises, including successful at-sea manufacturing demonstrations during Naval Postgraduate School CAMRE's RIMPAC 2024. The 2026 effort expands the operational evaluation of advanced manufacturing technologies by showcasing both shipboard and land-based manufacturing operations in support of military readiness and sustainment objectives.

"NPS CAMRE's RIMPAC experiment provides a unique opportunity to evaluate advanced manufacturing technologies in realistic operational conditions," said Wojtkun. "As military logistics become increasingly distributed, the ability to print, machine, and deliver critical parts at the tactical edge will play an important role in sustaining readiness and supporting future operations."

Hosted by the Commander of the U.S. Pacific Fleet and led by the Commander of the US 3rd Fleet, RIMPAC 2026 brought together forces from 31 nations, approximately 40 surface ships, five submarines, over 140 aircraft, and more than 25,000 personnel. The exercise remains the world's largest international maritime exercise and serves as a premier venue for testing innovative technologies and strengthening multinational partnerships. ▲



The Meltio wirelaser metal additive manufacturing solution in operation during RIMPAC 2026. Photo: Meltio.



The modular Snowbird Meltio solution utilised during RIMPAC 2026. Photo: Meltio.

Who was involved?

Snowbird Technologies - Based in Jacksonville, Florida, Snowbird provides advanced manufacturing, environmental control, and atmospheric water generation solutions to defence, government, and commercial customers worldwide. The company specialises in ruggedised systems engineered to operate in extreme and austere environments.

FLEETWERX - a Partnership Intermediary Agreement (PIA) that connects the Naval Postgraduate School with industry, academia and government to bring new solutions into real-world military settings. By working directly with end users, FLEETWERX helps test, refine and move ideas into use faster.

NPS CAMRE - The Consortium for Advanced Manufacturing Research and Education at the Naval Postgraduate School focuses on how manufacturing can support military operations, improving how parts are made, repaired and delivered in the field.

Effects of isothermal ageing on microstructure and corrosion properties of cast 2205 duplex

This study investigates the precipitation behaviour and corrosion performance of cast 2205 duplex stainless steel during isothermal ageing. A precipitation sequence of nitrides → χ-phase → σ-phase was identified, with relatively slow kinetics compared to the wrought counterparts, with a maximum secondary phase fraction of ~1.19% after 3 h of isothermal ageing at 850 °C. Secondary phase formation led to chromium and molybdenum depletion, increasing the degree of sensitisation to nearly 6% and significantly reducing the critical pitting temperature from 85 °C in the as-received condition to approximately 60 °C after ageing.

*Asma Teghri[1,**], Djamel Hamana[2*], Mirko Pigato[1], Saira Sehar[1], Loubna Chetibi[2], Irene Calliari[1*]*

[1] *Department of Industrial Engineering, University of Padua, Padua, Italy*
[2] *Laboratoire des technologies des matériaux avancés, École Nationale Polytechnique de Constantine (ENPC), Constantine, Algeria*

Cast materials constitute a fundamental class of engineering alloys due to their combination of manufacturability, cost-efficiency, and mechanical integrity. Their optimisation is essential not only to minimise production costs but also to ensure stable and reliable performance under severe service conditions. Among these materials, Duplex Stainless Steels (DSS) have attracted considerable attention owing to their high mechanical strength, superior corrosion resistance, and reduced cost, particularly due to their low nickel content. The duplex microstructure was first described by Bain and Griffiths in 1927; however, their industrial development and commercialisation only began in the 1930s. DSS are produced through a controlled addition of ferrite- and austenite-stabilising elements, promoting a balanced microstructure with approximately equal phase fractions. The 22Cr-5Ni grade, commonly referred to as 2205, is the most used DSS grade, and its industrial applications continue to expand through ongoing research and development efforts. Cast DSS 2205 is extensively employed in the manufacture of pumps, valves, and fasteners, particularly in marine and offshore environments where its weldability, machinability, and corrosion resistance are highly valued[1]. More recently, 2205 DSS have attracted increasing interest in civil engineering applications, particularly to enhance durability and reduce the maintenance requirements[2].The corrosion behaviour of stainless steels is primarily governed by their ability to form and maintain a stable passive film during service. Owing to their strong passivation capacity, these materials exhibit excellent resistance to general corrosion; however, depending on their chemical composition, they may be susceptible to localized corrosion phenomena. The Pitting Resistance Equivalent Number (PREN) is an empirical index used to estimate the pitting corrosion resistance of stainless steels based on their chemical composition, mainly chromium, molybdenum, and nitrogen, which are the primary alloying elements governing localized corrosion resistance. G. Herbsleb in 1982[3] proposed one of the most widely used expressions of PREN, given by:

$$PREN = \%Cr + 3.3\%Mo + 16\%N$$

For the 2205, the PREN is generally in the range of 32–36, depending on the alloy composition. Higher PREN values are generally associated with improved resistance to pitting corrosion, primarily due to the beneficial effects of Cr, Mo, and N on passivation and localized corrosion resistance.
Despite their excellent combination of mechanical strength and corrosion resistance, DSSs are generally limited to service temperatures below 250 °C. At elevated temperatures, typically between 600 °C and 1000 °C, the ferritic phase becomes thermodynamically unstable, promoting the precipitation of deleterious intermetallic phases that severely degrade both mechanical properties and corrosion resistance[4]. This temperature range is critical during cooling after solubilization, hot forging and welding process. Among the secondary phases formed in DSS 2205, the sigma (σ) and chi (χ) phases are the most prominent, because of their high content of ferrite-stabilizing alloying elements such as chromium and molybdenum[5]. Their precipitation causes an inhomogeneous distribution of alloying elements and promotes sensitization, which severely deteriorates the corrosion resistance of the material[6,7]. The present work aims to investigate the kinetics of secondary phase precipitation in cast 2205 duplex stainless steel during isothermal aging, as well as the resulting effects on its corrosion behavior.

Experiment

Cylindrical bars of the cast 2205 DSS were supplied by the Italian steel company SAFAS and machined into specimens measuring 12*mm* in diameter and 4*mm* in thickness. The chemical composition is presented in Table 1.
The samples were subjected to isothermal ageing at temperatures ranging from 750 to 950 °C for durations between 10 and 180 min, followed by water quenching. Both the as-received and aged samples were characterised using optical microscopy (OM) and scanning electron microscopy (SEM). The amounts of chi and sigma were quantified on SEM-BSE images using ImageJ software. Corrosion tests were conducted in a conventional three-electrode cell, a Gamry Interface 1010E potentiostat was used, with the specimen as the working electrode, a platinum counter electrode, and a saturated calomel electrode (SCE) as the reference electrode. A potentiodynamic polarisation (PDP) test was conducted following the ASTM G5 standard using a 3.5 *wt.*% NaCl solution (simulated seawater). Critical pitting temperature (CPT) tests were performed according to ASTM G150

Table 1. Chemical composition of cast 2205 DSS

Elements	C	Si	Mn	Cr	Ni	Mo	N	Fe
%Comp (wt)	0.03	1.0	2.0	21-23	4.5-6.5	2.5-3.5	0.08-0.20	Balance

using a 1 *mol/L* NaCl solution at a constant voltage of +0.7 *VSCE* and a heating rate of 1 °*C/min*. Double-loop electrochemical potentiokinetic reactivation (DL-EPR) tests were conducted in 33 *wt.*% H_2SO_4 containing 1.5 *wt.*% HCl.

Results and discussion

The microstructure of the as-received material (Figure 1) consists of a ferritic matrix interspersed with austenite islands, with the two phases exhibiting distinct contrast following etching with a 20% NaOH solution. Quantitative phase analysis revealed 52% ferrite and 48% austenite, confirming the balanced ferrite–austenite phase distribution characteristic of DSS.

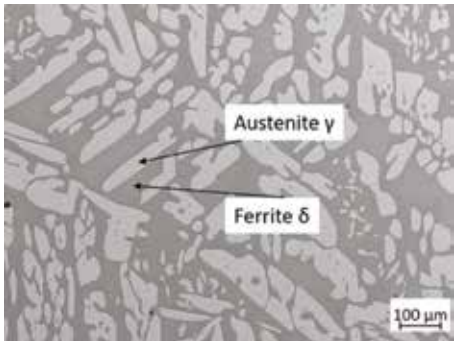


Figure 1. Optical micrograph of the as-received cast 2205 after electrochemical etching 20% NaOH

Isothermal heat treatments

Following isothermal aging, SEM observations were performed on unetched specimens in backscattered electron mode. At the lowest (750 °C) and highest (950 °C) aging temperatures, only a very limited amount of nitrides and secondary phases was detected (below 0.1%) even after 3 hours of isothermal aging and was therefore considered negligible. At 850 °C nitrides begin to appear after 10 min of aging and become more pronounced after 60 and 180 min (Figure 2.a). Secondary phases start to appear after 60 min of isothermal aging at 800-850 and 900 °C. As shown in Figure 2.b, secondary phases are observed as bright regions, preferentially nucleating at austenite–ferrite grain boundaries as well as within the ferritic phase. The brightest particles were identified by SEM–EDS as the χ phase, while the slightly less bright precipitates correspond to the σ phase. With increasing holding time, the amount of secondary phase precipitation increases, the total amounts of (σ+χ) are, respectively, in the range 0.32%-3.54% at 800, 0.24%-4.61% at 850 and 0.05%-3.55% at 900. Overall, the precipitation kinetics were relatively slow, with a maximum secondary phase fraction of approximately 1.19% after

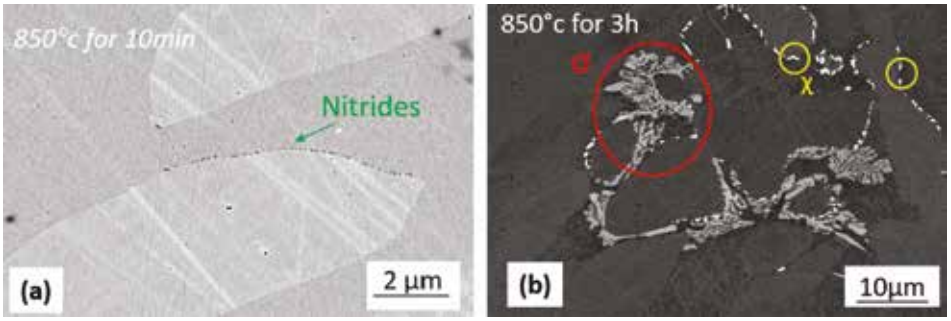


Figure 2. SEM micrographs of 2205 duplex stainless steel aged at 850 °C showing (a) nitrides after 10 min and (b) secondary phase precipitation after 180 min.

3 hours at the nose temperature of 850 °C. The precipitation of secondary phases during ferrite decomposition is controlled by diffusion mechanisms and is therefore strongly dependent on temperature and aging time[8,9]. Although only few studies are available on cast grades, comparison with the corresponding wrought 2205 alloy.[5,10] confirms that the cast material is less prone to secondary phase precipitation. The difference in precipitation behavior is associated with the distinct microstructural features of both conditions: the wrought material presents a refined morphology with a smaller inter-austenite distance (5.5 ± 0.69 µm), whereas the cast material exhibits a more widely spaced morphology, with an inter-austenite spacing of 25.20 ± 5.67 µm.

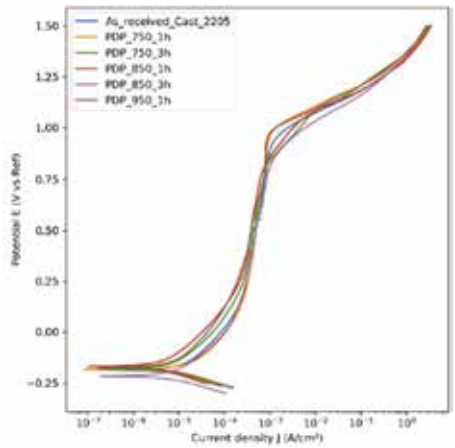


Figure 3. Potentiodynamic polarization curves of 2205 duplex stainless steel in 3.5 wt.% NaCl solution, showing the effect of aging and secondary phase precipitation on passivation behavior and breakdown potential.

Corrosion properties

Figure 3 presents the PDP curves obtained for the as-received (AR) and isothermally aged samples. The material exhibited a well-defined passive region, with a passivation current density of approximately 5 A/cm². Specimens containing higher precipitate contents required higher current densities to establish passivation. In addition, a progressive decrease in the breakdown potential was observed, indicating a gradual deterioration of passive film stability with aging.

Figure 4 a shows a progressive decrease in CPT with increasing secondary-phase content, reaching approximately 60 °C at the highest precipitate fraction. The samples were subsequently examined by SEM to confirm pit formation. As shown in Figure 4.b, pits appear as dark regions in the SEM micrograph. The pits preferentially initiate at ferrite–austenite phase boundaries and near the secondary-phase precipitates.

The degree of sensitisation (DOS) was evaluated using the DL-EPR technique to investigate the effect of chromium depletion caused by secondary phase precipitation.

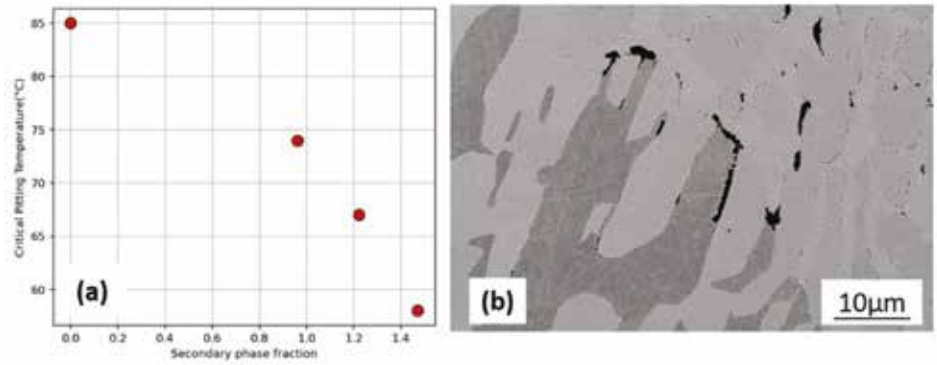


Figure 4. (a) Evolution of the critical pitting temperature (CPT) of 2205 duplex stainless steel in 1 M NaCl solution as a function of secondary phase content. (b) SEM micrograph of pit morphology after CPT testing.

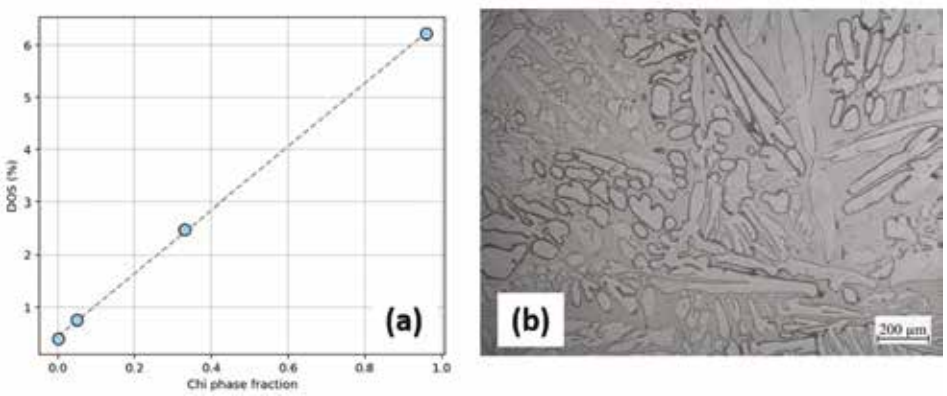


Figure 5. (a) Evolution of the degree of sensitisation (DOS) of 2205 DSS as a function of χ-phase content. (b) Optical micrograph after DL-EPR testing showing grain boundary attack

As shown in Figure 5.a, the DOS increased with increasing χ-phase content, indicating a progressive deterioration of corrosion resistance resulting from chromium depletion near the precipitates. Figure 5.b presents an optical micrograph showing grain boundaries as dark regions, indicating preferential corrosion attack associated with χ-phase precipitation.

Conclusion

In conclusion, for cast 2205 duplex stainless steel, a precipitation sequence was observed, with nitrides forming first, followed by χ-phase precipitation and subsequently σ-phase. Overall, the precipitation kinetics were relatively slow in the cast materials compared to the wrought counterparts, with a maximum secondary phase fraction of approximately 1.19% after 3 h at the nose temperature of 850 °C, this may be attributed to the larger inter-austenite spacing and less refined microstructure of the cast material. Secondary-phase precipitation resulted in a degradation of corrosion resistance, primarily attributed to chromium and molybdenum depletion. This degradation was reflected in an increase in the degree of sensitization (DOS), reaching nearly 6%, alongside with a marked decrease in the CPT from 85 °C in the as-received condition to approximately 60 °C after aging.

Acknowledgments

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References available on request ▲

About the author



Asma Teghri is a second-year PhD student working between the University of Padua in Italy and the National Polytechnic School of Constantine in Algeria. She holds an engineering degree in Materials Science and a master's degree in Functional Materials from Paris-Saclay University. Her research focused on heat treatment, thermomechanical processing and the corrosion behaviour of duplex stainless steels.

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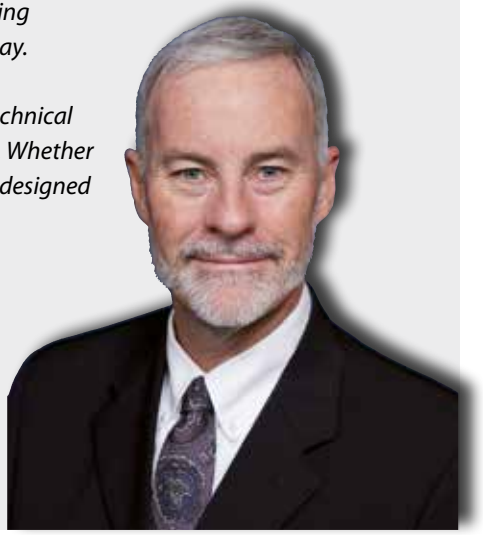
A WORD FROM OUR CHAIRMAN

Dear colleagues, industry partners, and future delegates,

It is with great pleasure that I invite you to the Stainless Steel World Americas Conference & Expo 2026, where we will bring together the leading minds and innovators from across the stainless steel supply chain.

This event serves as a key meeting point for professionals dedicated to advancing the production, supply, application, and performance of stainless steels in an ever-evolving industrial landscape. Engineers, metallurgists, researchers, fabricators, and end users will come together to exchange knowledge, explore emerging technologies, and discuss practical solutions to the challenges facing our industry today.



Over the course of the conference, we aim to foster insightful discussions, showcase technical advancements, and create meaningful opportunities for networking and partnership. Whether through expert presentations, interactive sessions, or the exhibition floor, this event is designed to inspire progress and strengthen connections across our global community.

I look forward to welcoming you to an engaging and productive conference.

David W. Barber
Senior Manufacturing & Engineering Fellow
Global Improvement Leader – Materials Engineering Discipline Leader
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CONFERENCE PROGRAM 9 NOVEMBER

Monday 9 November

8:45 a.m.	**Welcome from Conference Chairman David Barber, Dow Chemical Company**
9:00 a.m.	**Keynote:** The America First Refinery in Texas will be the first to be built in the USA in 50 years. How have the supply structure and technology developments evolved? *Deepak Mankar, Fluor Corporation*
9:30 a.m.	**Keynote:** Reaching for the stars – The growing use of stainless steels in the aerospace industry. *Adrien (Nick) Martinez, Amentum – NASA*
10:00 a.m.	**Networking coffee break**
	Session: STAINLESS STEEL APPLICATIONS *Moderator: Kerry Millen, OxyChem*
10.30 a.m.	Austenitic, precipitation-free, and subsea ready: Sanicro® 35 as a next-gen CRA bar option. *Ulf Kivisakk, Alleima*
10:50 a.m.	3CR12 ferritic stainless steel: Practical performance and design boundaries. *Kerry Millen, OxyChem Engineering*
11:10 a.m.	High-nitrogen austenitic stainless steel quarto plates: Production, properties, and limitations. *Blaž Žerjav Jereb, Acroni*
11:30 a.m.	Redefining high-temperature performance in hydrogen environments: The development of a lean-alloyed, fully austenitic alloy for 1250°C service. *Igor Nowak, Paralloy Group*
12:00 p.m.	**Networking lunch**
	Session: DESIGN & SPECIFICATION OF STAINLESS STEELS *Moderator: Deepak Mankar, Fluor Corporation*
1:00 p.m.	Flexural rigidity enhancement in deep-textured rigidized stainless steel sheets. *David Kukulka, Rigidized Metals Corp*
1:30 p.m.	Overcoming the barriers to replacing coated carbon steel with duplex stainless steels. *Peder Claesson, Sverdrup Steel*
2:00 p.m.	The effect of zinc containing coatings on liquid metal embrittlement of austenitic stainless steel at elevated temperatures. *Richard Colwell, Bechtel*
2:30 p.m.	**Networking coffee break**
3:00 p.m.	**PANEL DISCUSSION - Securing America's stainless steel supply chain** *Moderated by Markus Kind, Kind USA* The US stainless steel supply chain is being reshaped by trade policy, geopolitical uncertainty, changing global production patterns and growing pressure to strengthen domestic manufacturing. At the same time, manufacturers and end users need access to competitively priced material, specialist grades and products that may not always be readily available from domestic sources. This panel brings together mills, distributors, EPCs, and end users to examine where vulnerabilities exist in the stainless steel supply chain and how the industry can balance domestic production with the realities of a global market. *Panelists: Jose Comas, TotalEnergies; Dr Qiang Zeng, McDermott; Alan Souza, Alleima; Procurement expert, Fluor Corporation; Matthew Kouba, Böllinghaus Steel*
5:00 p.m.	**Networking reception on the Expo floor**

CONFERENCE PROGRAM 10 NOVEMBER

Tuesday 10 November

9:00 a.m.	**Keynote:** Desalination and water treatment options for a growing economy. *Paul Choules, Water Cycle*
9:30 a.m.	**Keynote:** Is the stainless steel industry moving from a globally optimized raw-material supply chain towards a strategically controlled, regionalized one? *Christophe Moulin, Benchmark Mineral Intelligence*
10:00 a.m.	**Networking coffee break**
	Session: DUPLEX STAINLESS STEELS *Moderator: Janardhan Saithala, Blade Energy*
10:30 a.m.	Duplex stainless steel case study: Seawater pump casings. *Richard Colwell, Bechtel Corporation*
11:00 a.m.	High-strength cold-headed duplex stainless steel fasteners: Mechanical performance and fatigue behavior. *Andrew Gadzic, Bumax AB*
11:30 a.m.	Duplex reimagined: Nikopolium NP 2205 and NP 2507 - Engineering solution bringing higher quality, longer life and lower maintenance. *Andrew Balev, Centravis*
12:00 p.m.	**Networking lunch**
	Session: WELDING INNOVATIONS *Moderator: Richard Colwell, Bechtel Corporation*
1:30 p.m.	Influence of thermal discipline and atmospheric stability on phase transformation and surface chemistry during super duplex welding. *Travis Field, Pipe Welding Institute*
2:00 p.m.	Microstructure, mechanical properties and fractography of friction stir-welded AISI 316l stainless steel. *Michael Regev, Braude College of Engineering*
2:30 p.m.	**Networking coffee break**
3:00 p.m.	**OPEN FORUM - Lessons learned: Stainless challenges, success stories, and discussions** *Moderated by David Barber, Dow Chemical Company* A series of short presentations highlighting material challenges and success stories involving stainless steel, and case studies of unique applications. • Root cause analysis of stainless-steel forged flange failure. *Deepak Mankar, Fluor Corp* • Case study of duplex flange failures. *Janardhan Saithala, Blade Energy* • Challenges and remedies in the fabrication and testing of duplex stainless steel. *Deepak Mankar on behalf of Jignesh Desai, Fluor Corp* **THIS SESSION IS OPEN TO ALL VISITORS, EXHIBITORS, AND DELEGATES**
5:00 p.m.	**Networking on the Expo floor**

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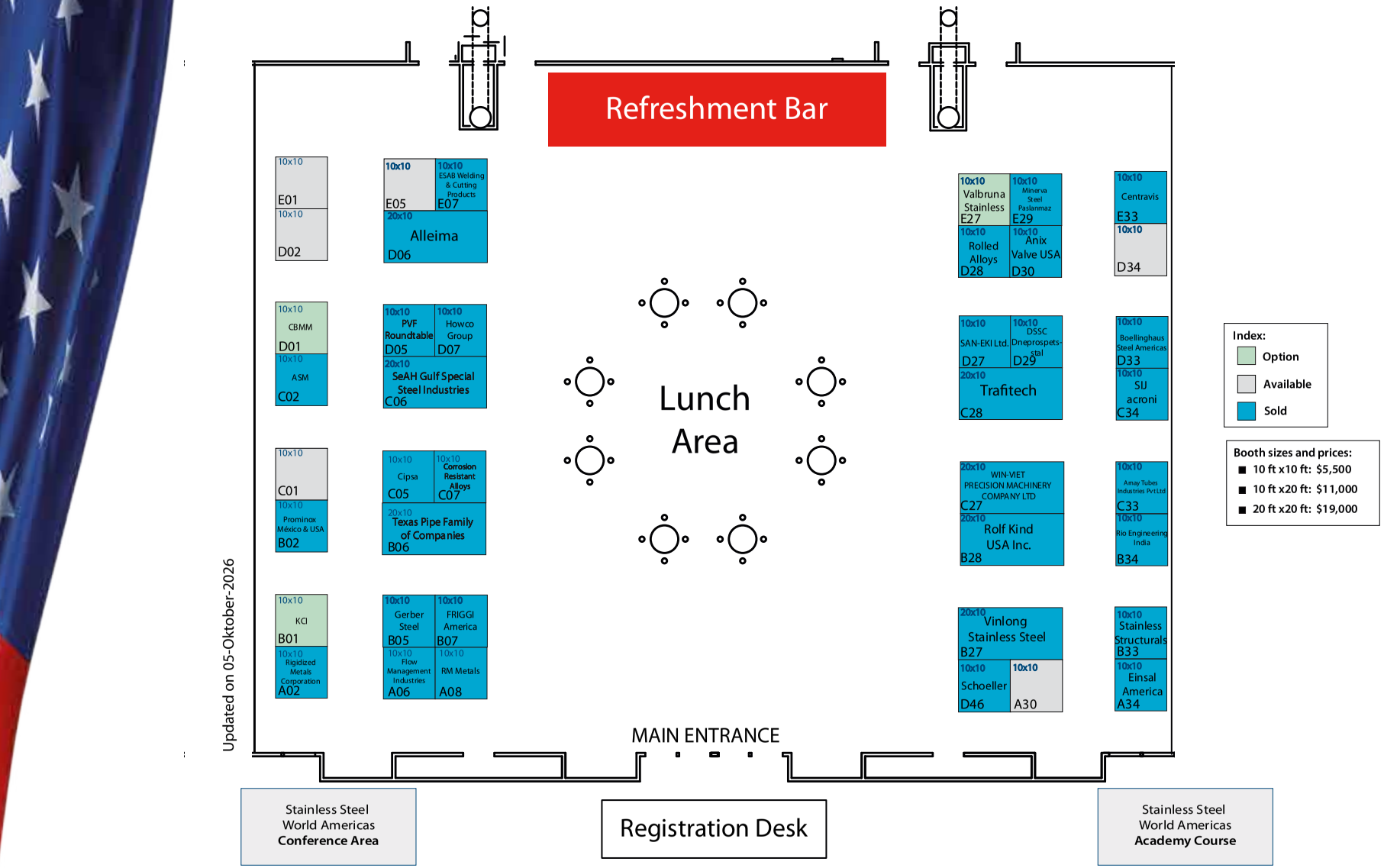

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Acquisition expands mission-critical casting capacity

In September, GE Aerospace announced it would acquire Consolidated Precision Products (CPP), a leading manufacturer of highly engineered castings, from private investment firms Warburg Pincus and Berkshire Partners.

Text by GE Aerospace

Following the announcement, GE Aerospace Chairman and CEO H. Lawrence Culp, Jr., said, "Investing in mission-critical casting capacity is needed to support the strong simultaneous demand across commercial engines, aftermarket and defence."

He added that by combining GE Aerospace's technology capabilities and FLIGHT DECK (the company's proprietary lean operating model) with CPP's manufacturing experience, GE expects to expand capacity, improve performance, and accelerate new engine technologies for the current fleet and next-generation platforms.

Highly engineered products

CPP, headquartered in Cleveland, Ohio, manufactures highly engineered castings and sub-assemblies primarily for the commercial aerospace and defence markets. Founded in 1991, CPP is one of the world's largest producers of investment and precision sand castings, producing complex superalloy, titanium, aluminium, magnesium and steel castings for a variety of leading commercial and military aircraft, weapon systems, commercial and regional/business jets, helicopters and industrial gas turbines. CPP has a global team of ~6,600 employees across more than 20 facilities. GE Aerospace has been a CPP customer for over fifteen years.

"Mission-critical casting capacity is needed to support... demand across commercial engines, aftermarket and defence."

Culp added, "We will leverage FLIGHT DECK to drive process and quality improvements, supporting higher output, and integrate design and manufacturing to bring engine technologies to market faster for our customers. These improvements will also ensure manufacturing readiness to deploy enhanced air foil technology for a more reliable ramp."

CPP CEO James Stewart, said, "As we advance our position as an industry leader in castings, GE Aerospace has expressed strong enthusiasm for supporting our continued growth and expanded vision. Together, we look forward to delivering meaningful value and advancing the success of both organisations."

Warburg Pincus Managing Director Dan Zamlong said, "CPP has been transformed into a leading precision casting company in the industry, with significant investments in its operations, technology, quality systems and talent, while expanding its ability to support customers across the commercial aerospace, defence, and power generation markets."

The purchase price of USD 11.75 billion will be financed with USD 7 billion in cash, with the remainder in new debt. The transaction is expected to close in the second half of 2027, subject to regulatory approvals and other customary closing conditions. ▲



Powerful material handling equipment is used to move, sort and prepare stainless steel scrap for further processing.

Recycling requires competitiveness

With the Clean Industrial Deal and the Steel and Metals Action Plan, the European Union is placing recycling more firmly at the heart of its industrial policy. However, the issue extends far beyond climate protection. The availability of high-quality stainless steel scrap, increasing quality requirements and international competition have turned recycling into both an economic and a geopolitical issue. High-quality scrap is becoming a strategic raw material, making competitiveness a prerequisite for a functioning circular economy. In discussions with Jan Hofmann, CEO of Aperam Recycling and CEO of Aperam Services and Solutions Americas, Stainless Steel World explores the challenges and opportunities facing the industry.

By Anett Leonhard, Stainless Steel World. Photos: Aperam Recycling

A tour of the Aperam Recycling site in Duisburg quickly reveals the scale of this business. Every day, a wide variety of materials are delivered, inspected, processed and prepared for further use among towering scrap piles, shears, presses and sorting facilities. What appears at first glance to be a conventional scrapyard is, in reality, a highly specialised raw materials operation.

"Recycling is not the end of the value chain. From our perspective, it is where the value chain begins," says Jan Hofmann, CEO of Aperam Recycling. This way of thinking changes the perspective on the entire industry. Without a continuous supply of high-quality secondary raw materials, downstream production processes come under increasing pressure.

Not all scrap is equal

Stainless steel is one of the few materials that can be recycled almost indefinitely without losing its properties. However, a high recycling rate does not automatically mean that sufficient suitable material is always available. This is precisely one of the industry's greatest challenges. Steel producers do not need just any scrap; they require precisely specified material qualities.

Alloying elements such as chromium, nickel and molybdenum must ultimately be present in the correct concentrations in the finished steel. The cleaner and more homogeneous the input material, the less effort is required during melting, and the fewer primary raw materials need to be added.
These requirements have become significantly more demanding in recent years. One reason is that steelmakers are striving to increase the proportion of scrap in their production to reduce their carbon footprint. Every addition of primary raw material negatively affects the overall climate balance. As a result, demand for high-quality scrap is growing. The challenge is that these qualities cannot simply be produced on demand.
"I can't manufacture purity. I can only separate it," Hofmann explains.
High-quality stainless steel scrap becomes available where products are manufactured and processed, or industrial facilities are dismantled. Consequently, the available volumes are directly linked to industrial value creation.



Not every type of scrap is suitable for every application. Material analyses and the precise determination of alloy composition are essential for high-quality recycling.

Why less industry means less recycling

This relationship is often underestimated outside the industry. When industrial production declines, the consequences extend beyond order books and plant utilisation – it also changes the raw materials market. If fewer vehicles, household appliances or machines are manufactured, less production scrap is generated. At the same time, industrial facilities remain in operation for longer, investments are postponed, and modernisation projects are delayed. As a result, less high-quality scrap from dismantling and decommissioning is available.
According to Jan Hofmann, these two developments are currently reinforcing each other. As European industrial output declines, so does the supply of high-quality stainless steel scrap. At the same time, steelmakers are demanding ever higher levels of purity. The result is growing competition for a limited supply of raw materials.
This mechanism illustrates why recycling cannot be viewed independently of industry. A functioning circular economy depends on a sufficient volume of suitable materials being generated within the production cycle in the first place. Without industrial activity, the foundation for high-quality recycling gradually erodes.



The quality of scrap determines its future use. The cleaner and more homogeneous the material, the more efficiently it can be returned to the stainless steel cycle.

Competitiveness begins with raw materials

Discussions about competitiveness often focus on energy prices, bureaucracy or international trade conflicts. While these factors undoubtedly play an important role, competitiveness in stainless steel recycling begins much earlier – with access to high-quality scrap.
For Hofmann, this connection is fundamental. Recycling companies and steel producers are part of the same value chain. If scrap prices remain permanently above a competitive level, European producers also come under pressure. The consequences may include higher production costs and, in extreme cases, an increasing shift towards primary raw materials or semi-finished products from other regions of the world.
This also explains why Aperam Recycling does not focus solely on its own margins. As part of an integrated stainless steel group, the company pursues a broader objective: preparing and supplying raw materials that enable downstream steel plants to remain competitive over the long term.
"If one day the steel plants are no longer there, we won't have a market for our products either," Hofmann says, describing this mutual dependency.
From his perspective, recycling can only remain sustainable if the entire industrial value chain is preserved.

A circular economy requires economic strength

This perspective also changes the way sustainability is viewed. For many years, the focus was primarily on environmental aspects: reducing CO_2 emissions, lowering resource consumption and increasing recycling rates. While these objectives remain valid, sustainability also depends on economic stability.

"If I don't exist, I can't do any good either," Hofmann remarks during the interview.

In his view, competitiveness and sustainability are closely interconnected. Only economically successful companies can invest over the long term in climate-friendly technologies, modern production facilities, and more efficient processes.

This also requires a realistic assessment of the political framework. Bureaucracy, extensive reporting requirements and high energy costs place an additional burden on energy-intensive industries. According to Hofmann, European industry is therefore increasingly focusing on measures with the greatest impact – such as increasing the use of scrap or improving energy supply – rather than investing resources in regulations that offer only limited practical benefits.



Before delivered scrap becomes a high-quality secondary raw material, it passes through numerous processing stages – from receiving and sorting to final preparation.

Europe discovers scrap as a strategic raw material

At the same time, the geopolitical importance of recycling is changing. While the circular economy has long been viewed primarily as an environmental initiative, security of supply has now become an increasingly important consideration. Europe has only limited domestic reserves of primary raw materials. At the same time, dependence on imports continues to grow, particularly for nickel and other alloying elements essential for stainless steel production. Against this backdrop, every raw material already available within Europe is gaining strategic importance.

"What is already here in terms of raw materials should stay here," says Hofmann. Beyond environmental considerations, this reflects a clear industrial policy objective. Every kilogram of stainless scrap that is returned to the European material cycle reduces dependence on international supply chains and strengthens the security of supply for European industry.

As a result, there is growing debate at the European level about keeping critical raw materials within the internal market and strengthening regional material cycles. Recycling is therefore evolving into a strategic pillar of European industrial policy - far beyond its traditional role as an environmental measure.



As a secondary raw material, stainless steel scrap forms the basis for the production of new stainless steel products and is becoming increasingly important as a strategic resource.

More than a closed loop

When discussing the circular economy, the term closed loop is frequently used. The concept is based on the idea that a company recovers its own production scrap and feeds it back into its manufacturing process.

In theory, this model is highly attractive. In practice, however, Hofmann sees limitations. Although such approaches exist in certain applications, they are only of limited relevance to the market as a whole. Today's stainless steel recycling system already operates through a dense network of producers, processors, scrap dealers and recycling companies. Hofmann says the key issue is not whether a company receives its own scrap back, but whether high-quality materials remain within the overall material cycle and are used where they deliver the greatest value.

From his perspective, looking at the entire material flow is economically more meaningful than focusing on isolated closed-loop systems. Over decades, stainless steel recycling has developed

established material flows that efficiently match supply and demand.

A global market with its own rules

Stainless steel scrap is traded worldwide. Thanks to its high material value, transporting it over long distances can be economically viable at times. As a result, trade flows between Europe, Turkey, North America and Asia continuously shift in response to market prices.
Another important factor is market volatility. Many scrap traders deliberately hold back material when prices fluctuate, hoping that market conditions will improve. Such speculation further reduces the availability of material and makes it more difficult to ensure a reliable supply for industry.
For recycling companies, this means constantly balancing market dynamics with security of supply. Their challenge is not only to procure sufficient material, but also to make it available at the right time in the required quality.

People remain the key factor

As technical as the business may appear, people ultimately determine its success. Modern equipment simplifies sorting, shredding and processing operations. However, the experience of employees, their knowledge of materials and their understanding of market dynamics cannot be automated.
The site tour clearly demonstrates how closely technical expertise and practical experience are linked. Different alloys must be identified, material flows assessed and qualities reliably separated. Every mistake has consequences for the subsequent melting process.
For Hofmann, transformation is therefore about far more than new strategies or investments. It succeeds only when employees embrace change and work together towards long-term goals. This conviction has shaped his professional career, which was characterised for many years by restructuring projects and is now increasingly focused on strategic development.



Recycling is high-tech—but it also remains a craft. Modern equipment and skilled employees together form the foundation of efficient recycling processes.

Recycling as the foundation of industry

In Hofmann's view, the future of stainless steel recycling will be determined less by technological breakthroughs than by the overall competitiveness of European industry. If Europe continues to manufacture, invest and modernise, the high-quality scrap required to sustain the circular economy will continue to be generated. If industrial value creation declines permanently, however, the circular system will gradually lose its foundation.

Recycling is therefore taking on a new role. It is no longer simply a contribution to sustainability or a building block of decarbonisation. Increasingly, it is becoming a form of strategic raw materials management that combines security of supply, competitiveness and climate protection.
The tour through the Duisburg facility makes one thing particularly clear: far more than secondary raw materials are created among the towering scrap piles. This is where an essential part of European stainless steel production begins. Whether this circular system remains as effective in the future will not depend on recycling companies alone. Ultimately, it will depend on Europe's ability to preserve its industrial base - and with it, the conditions required for a successful circular economy. ▲

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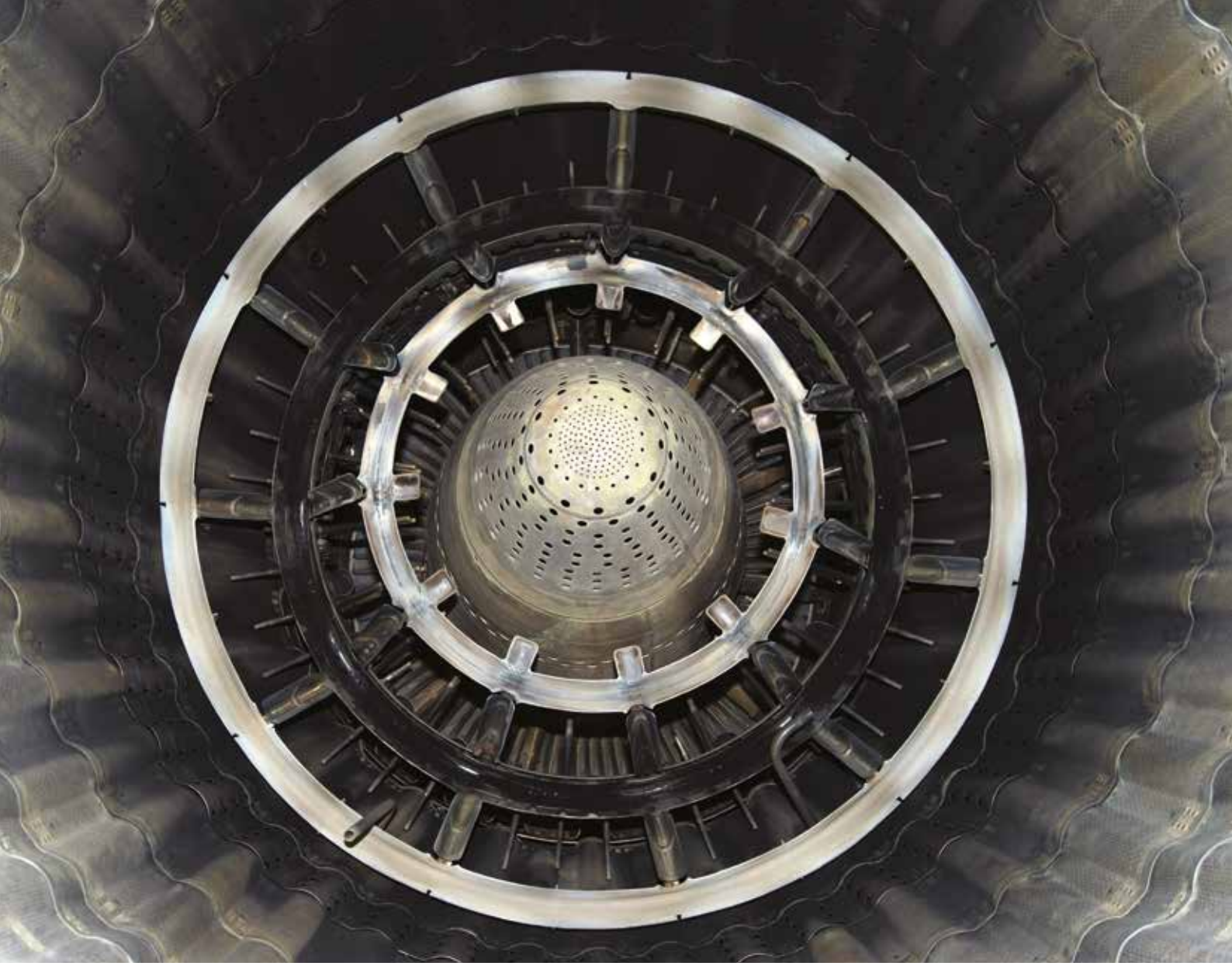


Material escalation and the manufacturing challenge of thermal systems

The usage of tough, high-performance materials for critical environments has spread significantly, from jet engines to thermal architecture in data centers, all to improve part resistance to corrosion, heat-flux, wear and more. This transition doesn't just encapsulate upgrading types of stainless steels, but nickel superalloys as well. Manufacturers, however, are struggling to deploy these high-performance materials at-scale, as the burdens of conventional machining methods continue to weigh down scalability. A solution may come in the form of pulsed electrochemical machining (PECM).

By Kirk Gino Abolafia, Technical Sales & Marketing Manager, Voxel Innovations, Inc

In the past, material usage of "tougher" high-performance alloys was generally reserved for a select few high temperature and heat-flux environments such as within propulsion engines or certain types of chemical processing infrastructure. These classes of materials, ranging from austenitic stainless steel grades to Inconel, are picked for their incredible resistance to corrosion, extreme temperatures and their ability to retain strength through high-stress or long-term wear environments. In the modern era, the uses for materials (from super austenitic stainless steels to Inconel) are traveling well beyond a commercial jet's heat exchanger or a sulfuric acid processing plant, and are being increasingly utilized in new areas ranging from medical imaging equipment to high-kW data center racks. A variety of economic and technological advancements have enabled this expansion of high-performance

materials in new applications. While many are industry-specific, a few broad reasons exist, including:

- *The rise in additive manufacturing capabilities*, which have not only allowed enhanced design and geometric freedom for engineers with improved rapid prototyping, but have unlocked new areas for certain high-performance and exotic materials, such as refractory metals.
- A push for *system miniaturization* across a wide range of industries. From medical devices to heat exchangers to consumer electronics, the trend towards compact architectures has forced many manufacturers to utilize higher-quality, higher-strength materials; a key reason being how smaller dimensions amplify the importance of issues like surface defects or thermal management capabilities, and how high-strength materials allow these microfeatures to flourish.
- Economic benefits for manufacturers, as while high-performance, exotic materials may be more expensive per-kilogram, doubling service life of critical parts or even allowing a 20% efficiency increase can entirely justify the increased initial material investments.

However, there are important caveats to the increased utilization of high-performance materials for critical and non-critical industries. Work hardening, burrs, recast layers, abrasive wear, tool wear, microcracking, chatter and heat-affected zones (HAZs) are but a few of *many* of the challenges associated with high-performance alloys being deployed into new environments, made worse with the increased demand and need for scalable manufacturing solutions.



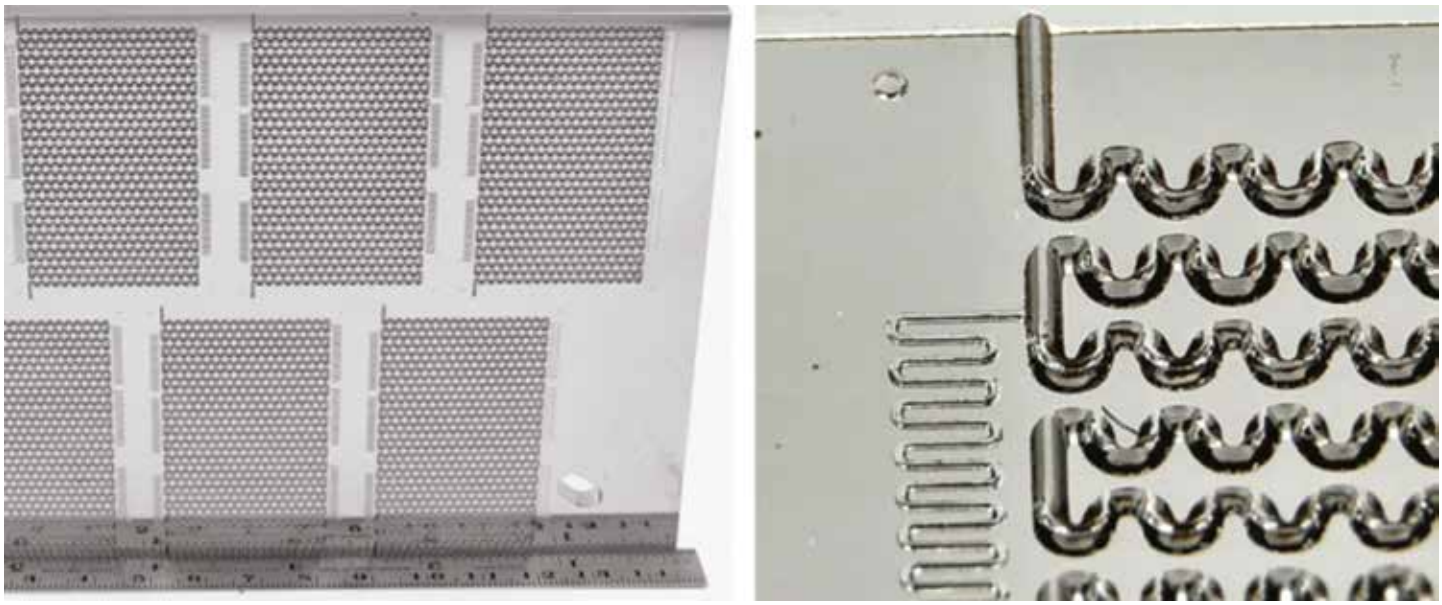
0.75mm wide, 2.5mm deep channels machined in stainless 420 via PECM.

In this article, we'll discuss stainless steel transitioning from ferritic to austenitic and even austenitic to duplex or higher-alloy austenitic in specific critical-industry applications, and how high-performance nickel or refractory alloys are finding their way into new areas beyond high-heat turbines. After discussing how manufacturers are working to alleviate these challenges, we will discuss solutions such as pulsed electrochemical machining (PECM) as a scalable material removal method designed for high-performance alloys at-scale.

Stainless steel industry transitions

There is reasonable evidence to conclude that certain sectors reliant on stainless steel are slowly shifting from the lower-grades of 316L towards higher austenitic-grade stainless variants, including but not limited to the worlds of chemical processing and hydrogen systems.

Historically, chemical processing architecture relied on 316L as a "default" material, such as for the production of phosphoric or sulfuric acid (critical for applications ranging from fertilizer production to food processing). However, due to intensifying processes, higher heat-recovery, and other factors, many chemical processing plants have slowly seen increases in chloride concentration and rising temperatures that have pushed 316L to its limits in



0.15mm and 0.05mm wide microchannels machined into Stainless 316L via PECM.

some applications. There has been a measurable shift in recent years towards higher-molybdenum and nitrogen-based stainless steels like 2205 duplex or super austenitic grades like 254 SMO, and tangible gains in service life and efficiency have been measured in acid evaporators and scrubbers that have been upgraded from 316L to high-molybdenum stainless alloys.

Another area seeing measured success in upgrading stainless steel variants is the world of hydrogen, as embrittlement (the process of atomic hydrogen diffusing into a metal, notably in defects or high-stress regions) is an especially challenging and prohibitive challenge to solve across hydrogen-related manufacturing operations– everywhere from oil & gas processing to emerging hydrogen fueling infrastructure.

Hydrogen embrittlement can cause tangible reductions in fatigue life, fracture toughness, and can even lead to outright part failure.

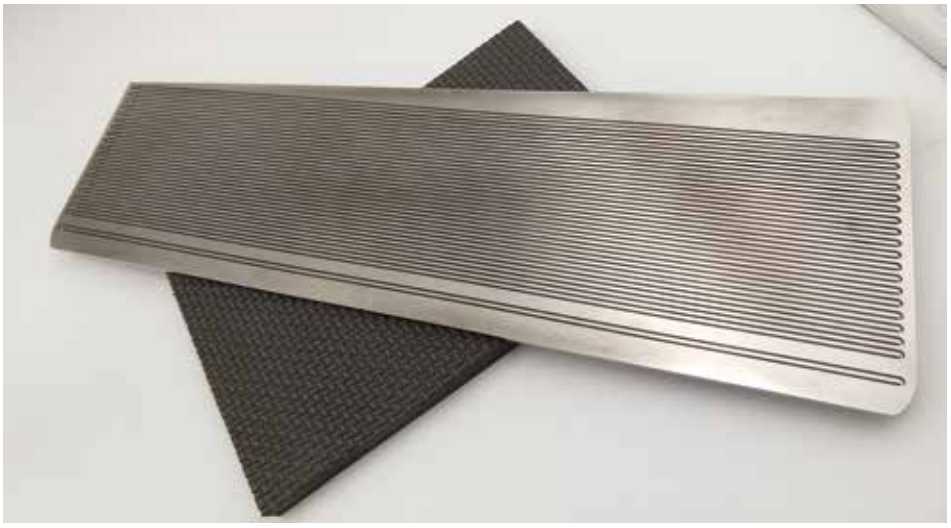
Austenitic stainless variants are generally more resistant to hydrogen embrittlement than their ferritic counterparts largely due to their differing crystal structure– specifically, their 'face-centered cubic' crystal structure, slowing hydrogen from diffusing into the lattice and accumulating in defects, crack tips, dislocations and more.

Extreme temperature environments & superalloys

Applications involving stainless steels are not the only industries seeking to transition critical infrastructure towards higher-performing materials. Look no further than applications involving high heat, ranging from the inside of turbofan engines to the inside of AI data center server racks.

These two applications operate in drastically different worlds of temperature—temperatures can range around ~85–95°C (185–203°F) in data centers or ~1300–1700°C (2372–3092°F) in turbofan engines. Yet despite these order-of-magnitude differences, a few common effects tend to accumulate over time:

- Temperature gradients (IE, the spatial change in temperature across a given material) tend to get steeper
- Thermal stresses tend to increase, and
- Surface irregularities and degradations tend to accelerate in the form of fatigue, creep or oxidation



Microchannel features machined out of Inconel 718 via Pulsed Electrochemical Machining (PECM).

As expected, many manufacturers are not only altering designs for improved heat transfer and dissipation (microhole arrays, cooling channels, etc.) but are actively substituting new material compositions to improve resistance to extreme temperatures and heat flux.

Within extreme environments such as engines, the material upgrades have largely occurred in the nickel family—such as certain aerospace and compact energy systems transitioning from Inconel 625 to Inconel 718.

While 625 has considerable corrosion resistance and capabilities at high temperatures, its creep strength becomes limited when compared to precipitation-hardened alloys. 718, on the other hand, boasts a precipitation-hardened process that forms nanoscale precipitation phases (gamma'' and gamma') within a nickel matrix that boasts improved dislocation resistance. In practice, that tougher molecular structure translates to higher yield strength and fatigue resistance under thermal cycling.

Interestingly, even 718 nears its limits in extreme heat-exchanger environments. As turbine exhaust recovery or advanced gas reactors begin to operate towards the 700-800C (~1300-1500F range), manufacturers are increasingly choosing materials with increased creep rupture strength, oxidation resistance and microstructural stability over long exposure, including Haynes 230.

Haynes specifically is structurally different due to its solid-solution-strengthened structure and increased presence of refractory metals like tungsten and molybdenum. Its superior creep strength and microstructural stability above ~700–750°C (1292–1382°F) allows it, and materials similar to it, better usage in more extreme high heat-flux environments like heat exchangers.

Superalloys like these used to live almost exclusively in gas turbines and some chemical processing plants, but advancements in additively manufactured heat exchanger profiles, high-performance vehicles, and hydrogen manufacturing architectures are allowing these alloys to enter entirely new markets. But new markets mean manufacturers must find a way to scale their manufacturing.

High-performance materials, low-performance manufacturing

Fundamentally, we can view the benefits of many of these corrosion, heat, and stress-resistant alloys as a double-edged sword, as ultimately, the same microstructural features that allow these advanced stainless steels and nickel superalloys to survive high-heat, high-pressure and high-corrosion environments are the very features that make them resistant to conventional machining, especially at-scale:

- First, their strength-retention features, such as the precipitation-hardened structure of Inconel 718, backfire during machining as its strength persists even at elevated temperatures during heat and contact-based machining processes. Higher cutting forces are often required, limiting material removal rates and increasing tool wear.
- Secondly, their lower thermal conductivity, which benefits them from slowing heat flow into the

bulk material and reducing creep, ultimately makes it more challenging for the heat generated at the cutting interface to dissipate into the bulk material. This can promote notching, edge chipping and a variety of other defects.

- Third, consider the work hardening capabilities of these alloys—many austenitic stainless steels and nickel alloys owe much of their toughness to this feature, but when being machined, it can incur significant burrs, heat-affected zones and thermal distortion, especially in sensitive areas like thin walls.
- Finally, the oxidation-resistant, chemically-stable surfaces of many of these alloys can provide protective oxide films that effectively counter corrosion. Unfortunately, this can lead to increased rates of chipping and scales of protective oxide, notably with high-temperature cutting environments.

A potential solution: Pulsed electrochemical machining (PECM)

Most of the "double-edged sword" challenges previously discussed were exclusively a result of contact-based and/or heat-based material removal processes, notably issues around heat dissipation, work hardening, and the ability of the materials to retain their strength in high-temperature environments. However, one material removal methodology, pulsed electrochemical machining (PECM), is capable of circumventing most of these challenges, owed to the fact that it is not a heat-based or contact-based machining method, rather relying on an electrochemical process that removes the workpiece material atom-by-atom in a controlled dissolution.

From a material standpoint, PECM is only concerned with conductivity rather than direct hardness or resistance to heat-flux or creep; PECM can machine nickel superalloys at similar speeds to copper for this very reason. It can also machine a wide range of stainless steels with similar capabilities, from 17-4 to 316 and 440C.

Another key benefit of PECM's lack of contact or heat is that the process incurs a significantly reduced rate of tool wear compared to other conventional processes, allowing it to not only machine tougher alloys, but accomplishing this task at-scale without a constant need for tool realignment or replacement.

By utilizing that custom-shaped cathode (tool), PECM is capable of machining unique, complex geometries as well, which are often found in the ever-miniaturizing environments of the alloys discussed in this article. For example, PECM has been leveraged as a postprocessing operation for certain additively manufactured Inconel turbine blades with poor surface quality in sensitive areas like thin walls or downskin surfaces.

As demand for these tough materials increases and diversifies across industries, PECM is also adept for the situation due to its high scalability. PECM's use of custom tooling allows it to easily scale horizontally, machining dozens or hundreds of parallel features or parts in a single plunging operation without significantly affecting its material removal rate. But importantly, its reduced rate of tool wear allows it to scale these operations into fully automated systems without frequent tool alignment or replacement requirements. ▲





Freeze drying chambers are commonly rectangular as they use the floor area efficiently.

Stainless steel for pharmaceutical freeze drying

Pharmaceutical freeze dryers place exceptional demands on stainless steel, combining vacuum and pressure loading, extreme temperature cycles and stringent hygiene requirements. From material selection and contamination control to welding, surface finishing and shelf design, every stage of fabrication plays a role in ensuring long-term reliability and product safety.

By Gabriele Da Re, TEC-SIM

A pharmaceutical freeze-dryer looks like a simple machine: a chamber, a door, and, inside, a stack of shelves carrying vials or trays. Its core is a pressure vessel that repeatedly moves between extremes. During primary and secondary drying, the chamber is evacuated to pressures in the range of tens of microbars up to a few hundred microbars, so the atmosphere presses on the outside of the vessel with close to a full bar. During sterilisation, typically with saturated steam at 121 °C or above, the same vessel is pressurised from inside. Between these extreme events, the shelves cycle through temperatures from roughly -50 °C to +60 °C or more, and the chamber is cleaned in place with aggressive detergents and sanitisers.

Therefore, the chamber must withstand external pressure, internal pressure, thermal cycling, and chemical attack over decades of service, while remaining perfectly cleanable and leak-tight. The shelf stack inside carries the product and must deliver uniform heat transfer to every vial. Both elements are custom-engineered, and their reliability depends first of all on material choice and then on how that material is processed.

Material selection in a demanding industry

The pharmaceutical industry is demanding and conservative for good

reasons. A failure can mean a lost batch worth millions, a contaminated product or a regulatory finding. Consequently, materials that have decades of validated use are preferred, and experiments are rare. For freeze dryers, this leads to a clear rule: austenitic stainless steel grade 316 (1.4404 / 1.4435 for the low-carbon variants) for every surface that faces the process, and grade 304 (1.4307 / 1.4301) for the outer, non-product-contact parts. Alternatives are generally not considered.

Grade 316 is chosen for the inner chamber because of its molybdenum content of about 2–3%, in addition to the roughly 16–18% chromium and 10–14% nickel it shares with 304. Chromium forms the thin, self-healing passive oxide layer that gives stainless steel its corrosion resistance. Molybdenum strengthens that layer against localised attack, particularly pitting and crevice corrosion caused by chlorides. Chlorides are everywhere in a pharmaceutical environment: in saline-based formulations, in buffer solutions, in cleaning and sanitising agents, and in process water. The chamber wall is also exposed to repeated steam sterilisation and cleaning cycles, which stress the passive layer. Using 316 gives a much larger safety margin against the slow surface degradation that would otherwise create roughness, particle release and eventually a contamination risk. Low-carbon versions (316L) are used in welded structures to limit carbide precipitation in the heat-affected zone, which would otherwise reduce corrosion resistance along the weld.

Grade 304 is used for the outer part of the chamber, such as insulation jackets, cladding, frames and external covers, because it is entirely adequate there. In fact, these parts never contact the product or the aggressive process media. What matters is good resistance to atmospheric corrosion, easy cleaning in the technical or grey areas of a plant, good formability and weldability, and a lower price than 316. Using 316 would add cost without any performance gain. The combination of 316 inside and 304 outside is therefore the technically rational choice as well as the traditional one.

Selecting and controlling the raw material

Standard grades alone do not guarantee a good result. The quality of the specific stainless steel batch matters. At TEC-SIM, only certified stainless steel of EU origin is used. This shortens the supply chain, simplifies traceability and ensures a well-understood regulatory framework.

Every delivery is checked upon arrival with 100% Positive Material Identification (PMI). This is typically done with a handheld X-ray fluorescence analyser that measures the alloy composition in seconds, confirming, for example, that a sheet marked as 316L actually contains the required molybdenum. Documents can be wrong, and materials can be mixed up in a warehouse, so measuring each item is the only way to be sure. All the certificates, usually 3.1 inspection certificates in accordance with EN 10204 that link the heat number to chemical and mechanical test results, are collected and compiled into an inspection book. That dossier follows the equipment and allows every plate, tube and flange in the finished chamber to be traced back to its origin.



Smooth surfaces are easier to clean, offer fewer places for residues to adhere and are less prone to particle release

Pitfall to avoid: contamination

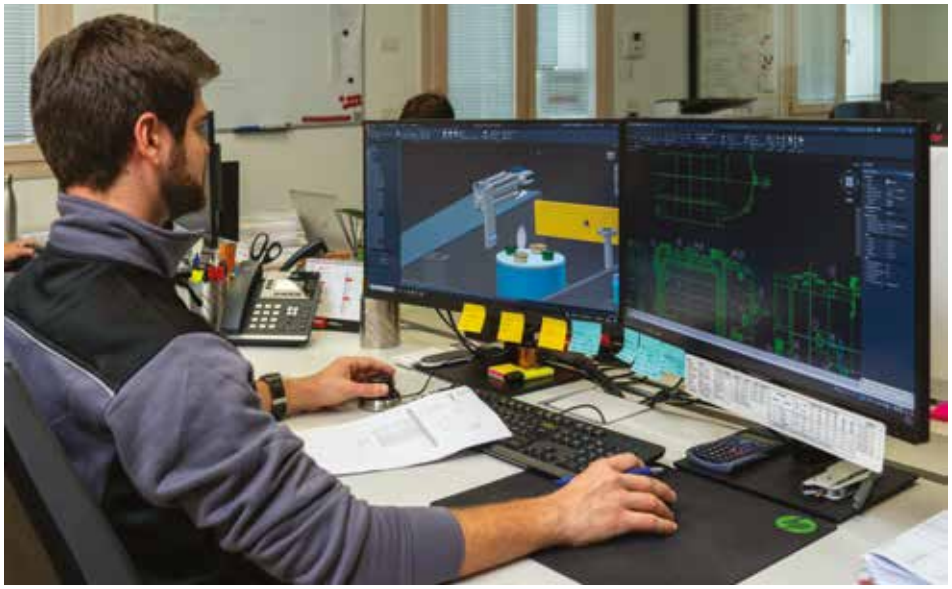
The most underestimated risk in stainless-steel fabrication is contamination. Stainless steel resists corrosion because of its passive layer, and that layer can be compromised if particles of ordinary carbon steel are embedded in the surface. Iron particles from grinding dust, tools, lifting chains or contact with carbon steel structures corrode readily. They can initiate pitting, leave rust marks and lead to the phenomenon known as rouging in pharmaceutical plants, where iron oxides appear on surfaces and can be released into the product environment. For this reason, TEC-SIM works only with stainless steel in the plant and allows no carbon steel in the production area. We use dedicated stainless tools and abrasives, and handle material in a way that avoids iron transfer. Stainless-steel components are always stored and moved lying on wood or stainless-steel supports, never directly on the floor, where they could pick up dust, iron particles and other residues. Such measures are simple, but they must be applied consistently, because a single lapse can compromise a surface that is expensive to restore.

Design first: Finite element analysis

With custom-built equipment, design determines most outcomes. A chamber under vacuum is loaded like a can that someone is trying to crush. Failure modes include buckling, which is sudden and depends on geometry and stiffness rather than on material strength alone, as well as local overstress around door frames, nozzles and supports.

Freeze drying chambers are commonly rectangular as they use the floor area efficiently. However, they are particularly demanding because flat walls do not carry pressure as efficiently as a cylinder and require stiffening.

To verify designs, Finite Element Method (FEM) analysis is used. The principle is to divide the chamber geometry into many small, simple elements, such as tiny shells or bricks, joined at nodes. This division is called meshing. For each element, the physical relationship



Finite Element Method (FEM) analysis is used to verify designs.

between force and deformation is known from the material properties, such as elastic modulus and yield strength.
A dedicated software combines all these element equations into one large system and solves it for the boundary conditions supplied by the engineering department: supports, pressure loads, temperature, weight of the shelf stack and so on. The result is the displacement of every node and, from it, the stress and strain in every element.
This lets the engineering department see where stresses concentrate, how much a door or wall deflects under vacuum, and whether the structure would buckle under external pressure. The stresses are compared with the allowable values of the applicable design code, for example the European Pressure Equipment (PED) Directive framework, the ASME Section VIII or the China Manufacture License (SELO). If a region is overstressed, the design is modified by adding stiffeners, increasing thickness locally or changing the geometry, and the calculation is repeated. Because this happens on the computer, a design can be optimised before any steel is cut, giving a chamber that is safe without being needlessly heavy.

Welding and finishing

The weld seams are the most critical part of a stainless-steel pressure vessel. Full penetration welding is used for the pressure-bearing seams, meaning the weld metal fuses through the entire thickness of the joint. This avoids unfused gaps on the process side, which could harbour product residue and cleaning agents and act as sites for crevice corrosion, and it ensures the joint has strength comparable to the base material. Full penetration is a claim that must be proven, and radiographic testing is the appropriate method. X-rays passing through the weld reveal internal defects such as porosity, lack of fusion or inclusions that are invisible from the surface. The films or digital images become part of the documentation.
After welding and forming, the surface is finished. Smooth surfaces are easier to clean, offer fewer places for residues to adhere and are less prone to particle release. Two finishes are typical: a satin finish with Ra = 0.6 µm and a mirror-polished finish with Ra = 0.1 µm – surface roughness is expressed as Ra, the arithmetic average of the deviation of the surface profile from its mean line. Either finish can meet the roughness level required by the pharmaceutical industry, with the choice depending on the product and on the user's specification. Weld seams are blended to match the roughness of the surrounding surface, since a weld that is rougher than the wall around it defeats the purpose of the finish.

The shelf stack

The shelves are the components that actually touch product vials, and they are much more complex than they look. Each shelf is a hollow plate through which a heat transfer fluid, usually silicone oil, circulates to cool the product during freezing and warm it during drying. It is made of two stainless steel sheets, and the main manufacturing challenge



Full penetration welding is used for the pressure-bearing seams.



Each shelf is a hollow plate through which a heat transfer fluid, usually silicone oil, circulates to cool the product during freezing and warm it during drying.

is joining the two sheets. The fluid channel is pressurised while the outside is under vacuum, so the sheets tend to bulge apart. If they do, the shelf loses its flatness, the contact with vials becomes non-uniform, and heat transfer varies across the shelf, which affects product quality. On top of this, every temperature cycle expands and contracts the plates, adding fatigue loads at the joints.

Several techniques are used to connect the two sheets. In brazed designs, a filler metal of different composition is melted between the parts to join them. In inner welded designs, the sheets are joined by welds made inside the shelf along defined points or lines, which also shape the flow pattern of the heat transfer fluid. In plug-welded designs, holes are made in the outer sheet at regular intervals. The hole is then filled with weld metal, which fuses the top sheet to the sheet beneath it and forms a series of anchor points across the plate. Each technique has its place, but they differ in durability. Brazing introduces a second material with different corrosion and fatigue behaviour, and the joint can be sensitive to repeated thermal cycling. TEC-SIM shelves are welded because a welded joint is made of the same stainless steel as the sheets, forms a continuous metallurgical bond and offers a longer service life under pressure and temperature cycling.

Conclusion

A freeze dryer is a vacuum and pressure vessel built to pharmaceutical standards, and its performance results from a chain of achievements: the right grade for each surface, verified and traceable material, contamination control from the first day, design proven by FEM, welds proven by radiography, surfaces finished to a defined roughness and shelves built to survive thousands of cycles. The quality of the equipment lies in never skipping any of them. ▲

About the author



Gabriele Da Re is CEO of TEC-SIM, a company specialised in bespoke design and custom manufacture of stainless steel pressure vessels for the pharmaceutical and chemical industries. It works with designers and producers of industrial plants to manufacture vacuum and pressure vessels that are exemplary in terms of safety, efficiency, durability, and aesthetics.

Global Mb production falls, usage rises

Global molybdenum production fell 3% to 167.2 million pounds (mlbs) in Q2 2026, compared with the same quarter of the previous year, and fell 1% from the previous quarter, figures released by the International Molybdenum Association (IMOA) show.

Text by IMOA

Global usage of molybdenum rose 8% to 177.5 mlbs in Q2 2026, a 2% fall compared with the previous quarter. China, one of the only regions not to see a fall in production in Q2, remained the largest producer of molybdenum at 79.5 mlb – this was almost static when compared to the same quarter of the previous year and a 1% rise when compared to the previous quarter. South America, the second-largest producer, saw the largest fall in production, down 9% to 39.9 mlbs from the same quarter of the previous year, and down 4% from the previous quarter. Production in North America remained static at 33.3 mlbs compared with the same quarter of the previous year, a 1% fall from the previous quarter. Production in Other Regions fell 7% to 14.4 mlbs compared with the same quarter of the previous year, a 5% fall from the previous quarter.

China remained the largest user of molybdenum at 90.2 mlbs up 10% from the same quarter of the previous year, although a 1% fall when compared to the previous quarter. Europe remained the second-largest user of molybdenum at 30.7 mlbs, up 1% from the same quarter of the previous year and up 3% from the previous quarter.



Use in other regions rose 13% to 24.5 mlbs compared with the same quarter of the previous year, a 2% fall compared to the previous quarter. Use in the USA saw the largest increase, 12%, to 17.1 mlbs compared with the same quarter of the previous year, although this represented a 12% fall from the previous quarter. Use in Japan rose 5% to 11 mlbs compared with the same quarter of the previous year, although this was a 4% fall from the previous quarter. Use in the CIS saw the largest fall, 21%, to 4.1 mlbs compared with the same quarter of the previous year, although it rose 4% compared with the previous quarter. ▲

Stainless steel profiles for the Aquarium of Genoa

More than a decade after its completion, the cetacean pavilion at the Aquarium of Genoa remains a strong example of how thoughtful material selection can contribute to the long-term success of an architectural project. Built for a demanding marine environment, its stainless steel components continue to combine structural performance, corrosion resistance and a light architectural appearance. The project demonstrates how stainless steel can help ambitious designs stand the test of time.

Text and images from Inossidabile magazine n° 243 by Centro Inox

Located in Genoa's Porto Antico (Old Harbour), the city's historic port area, the Aquarium of Genoa is the largest aquarium in Italy and one of the most important in Europe. Opened in 1992, the facility currently houses around 12,000 animals representing more than 500 species, accommodated in tanks and exhibition environments that recreate marine and aquatic ecosystems from around the world, from tropical seas to the Antarctic regions. Since its opening, the aquarium has undergone several expansions. Among the most significant additions is the cetacean pavilion, which provides a particularly interesting example of the integration of architecture, engineering and stainless steel. The pavilion is an extension of the existing complex and is dedicated to the observation and management of bottlenose dolphins. Located between the main aquarium building and the Biodiversity Pavilion, the structure was added in 2013 and designed by architect Renzo Piano to integrate into the Porto Antico setting with the minimum possible visual impact.



Figure 1. The walkway at water level. Courtesy of Costa Edutainment PH Merlofotografia

The structure covers an area of approximately 7,000 m² and contains four open-air tanks: a main exhibition tank, a nursery tank, a medical tank and a holding tank. One of the most interesting aspects of the project is its spatial configuration. The pavilion rises just three metres above sea level, with much of the structure extending below the waterline to accommodate the tanks and the underwater visitor route.

Visitors can observe the dolphins from two different perspectives. A continuous glazed walkway, approximately 30 metres long, provides an elevated view of the animals as they swim at the surface, while a curved acrylic tunnel approximately 15 metres long, together with two additional acrylic viewing sections, extends partially into the main tank, allowing visitors to observe the dolphins from an underwater perspective. This two-level visitor route is one of the distinctive features of the project and strengthens the visual connection between visitors and the aquatic environment.



Figure 2. Stainless steel was the ideal material for this high-chloride marine environment. Courtesy of Costa Edutainment PH Merlofotografia

Stainless steel plays a crucial role

The walkway at water level (Figures 1 and 2) is where stainless steel plays a particularly important role. Due both to its location within the harbour and the presence of salt water in the tanks, the structure is continuously exposed to



Figure 3. The lightweight building was constructed off site then transported by sea to its final location. Courtesy of Costa Edutainment PH Merlofotografia

the marine environment and therefore to chlorides. These are well-known aggressive conditions in which material selection is of fundamental importance. For the window and door frames and glazed façades of the walkway, satin-finished profiles manufactured by roll-forming stainless steel strip were produced in EN 1.4401 (AISI 316) stainless steel, a material widely used and particularly suitable for this type of environment. The project requirements were especially demanding. As well as providing resistance to the marine environment, the structure needed to be lightweight and compact to facilitate the transport and installation of the floating structure.

This was necessary because the building was not constructed on site, but at the La Spezia and Voltri shipyards. It was subsequently transported by sea (Figure 3) and finally positioned at its permanent location by means of a controlled sinking operation.

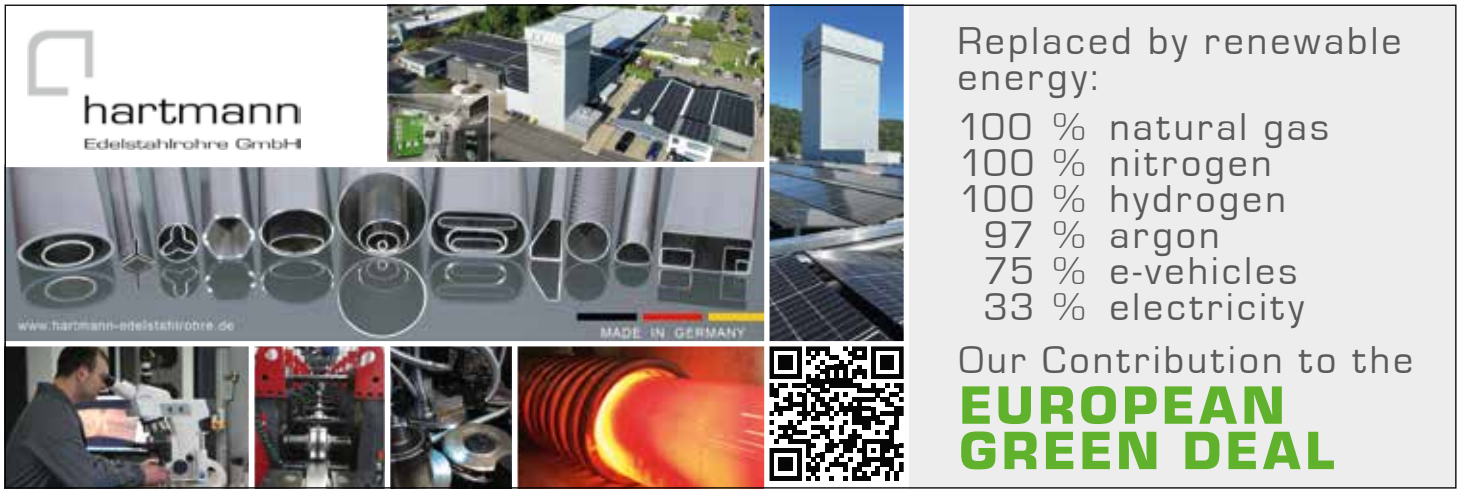
The stainless steel profiles met these requirements, providing not only corrosion resistance in the marine environment but also high structural strength with relatively small cross-sections.

Architectural transparency

The slenderness of the uprights also contributes to the architectural transparency of the walkway, reducing the visual impact of the structure and promoting continuity between the built space and its surroundings. The pavilion therefore provides a practical example of how stainless steel can contribute not only to the strength and durability of an architectural structure, but also to its visual character, particularly where the design objective is to create lightweight, transparent structures that integrate seamlessly into a marine environment. ▲

About Centro Inox

Published with the kind permission of Centro Inox, the Italian stainless steel development association. Centro Inox is a non-profit-making association founded in 1962 to study and promote the use of stainless steel in Italy. For information, visit www.centroinox.it





Cargo ship loading wire coils at Nador Port (Morocco). Photo: Wikimedia Commons, Niels Johannes

Protecting stainless steel during breakbulk sea transport

Successful shipment depends on controlling moisture, contamination, handling and stowage risks from the supplier's premises through to final delivery.

By Konstantin Kalnyi, CEO and Founder of Kiev Shipping Ltd

Stainless steel is valued for its corrosion resistance, appearance and performance in demanding industrial environments. These qualities can create a misleading impression that it requires little protection during transportation.

In practice, stainless steel products are vulnerable to physical damage, surface contamination and moisture exposure. Coils, sheets, plates, pipes, bars and fabricated components may lose commercial value without suffering structural damage. Scratches, dents, edge deformation, staining or contamination by ordinary carbon steel may be sufficient for a receiver to reject the cargo or require costly corrective work.

Safe breakbulk transportation therefore requires more than selecting a vessel with sufficient capacity. Protection must be planned throughout the complete logistics chain, including packaging, inland delivery, terminal storage, lifting, stowage, sea fastening, ventilation and discharge.

Define the cargo accurately

Vessel selection and stowage planning should begin with a final cargo list. Each unit must be described by its exact dimensions, gross weight, packaging and approved lifting method.

Breakbulk cargo is transported as individual units - such as coils, bundles, crates or pallets - rather than in containers or as dry or liquid bulk.

For coils, the information should identify whether they are shipped eye-to-sky or eye-to-side, together with their diameter, width and weight.

Plates and sheets require details of bundle dimensions, supporting points and stacking limitations. Pipes should be described by length, diameter, wall thickness, bundle configuration and protective end covers.

Irregular fabricated units may have concentrated weights or high centres of gravity. Their lifting and supporting points must be confirmed before the vessel is nominated.

Preliminary data may support a budget estimate, but firm vessel selection requires final figures. A late change in unit weight or packaging can affect crane capacity, stowage, lifting gear and securing calculations.

The cargo owner should also identify product-specific limitations, including maximum stacking, prohibited contact materials and requirements for underdeck storage.



Protective film may preserve a finished surface, but it does not replace robust external packaging. Photo: Dreamstime.

Packaging is the first protective barrier

Packaging must suit the product, handling method, voyage duration and expected environmental exposure.

Protective film may preserve a finished surface, but it does not replace robust external packaging. Depending on the product, waterproof wrapping, edge protection, strapping, timber supports and durable outer coverings may be required.

Packaging must remain stable during lifting and securing. Loose wrapping can tear, while improperly positioned straps can cause indentation or abrasion. Sharp edges should be protected, and lifting equipment must not compress or cut the packaging.

Moisture trapped inside an apparently waterproof package is another risk.

The cargo should be dry before wrapping. Desiccants, vapour barriers or corrosion-inhibiting materials may be appropriate for sensitive products and longer voyages.

Each package should be clearly marked with its weight, dimensions, approved lifting points and handling instructions. These markings must remain visible throughout the shipment.

Prevent carbon steel contamination

Contamination by ordinary carbon steel is a significant risk. Small particles can become embedded in a stainless surface and later rust, creating staining that may appear to be corrosion of the stainless steel.

Contamination can arise from dirty cargo holds, rusty lifting equipment, steel-wire slings, grinding residue, welding work or direct contact with unprotected ship structures.

Before loading, the vessel's holds should be inspected to confirm that they are clean, dry and free from previous cargo residues, loose rust scale, metal fragments and abrasive dust.

Direct contact between stainless steel and the vessel's structure should be avoided. Clean timber, rubber or other approved separation materials can be placed beneath and between cargo units.

Lifting gear must also be suitable. Clean synthetic slings, protected chains or purpose-designed lifting devices may be required. Bare steel wires should not be placed against finished surfaces.

If welding or cutting is necessary for sea fastening, the cargo must be protected against sparks and grinding debris.



Lifting gear must also be suitable; clean synthetic slings, protected chains or purpose-designed lifting devices may be required. Photo: Kiev Shipping Ltd

Inspect the vessel before loading

The vessel must be suitable for the dimensions and characteristics of the individual cargo units - not merely their total weight.

Underdeck stowage generally provides the best protection from rain, spray and seawater. The charterer should verify hatch-opening dimensions, hold geometry, tank-top strength and the complete lifting path into the proposed stowage position.

A unit may fit inside the hold but still be impossible to lower through the hatch because of sling angles, crane outreach or structural obstructions.

Tank-top and deck capacity require particular attention when heavy coils or concentrated units are carried.

Cargo weight is transmitted through a limited contact area, and load-spreading material may be necessary.

Hatch covers, drainage arrangements and bilges should also be examined. Evidence of leakage or standing water must be investigated before loading. Where deck stowage is unavoidable, the packaging and securing system must be designed for direct weather exposure. This option should be accepted only after the increased risks have been evaluated.

Control lifting and handling

Many damage incidents occur during handling rather than during the sea passage.

Cranes, forklifts, spreader beams, coil lifters, C-hooks, clamps and slings must be selected for the particular cargo. Their rated capacity should be checked against the actual unit weight and working configuration.

Coils require special care. Forklift forks can damage the coil eye or edges if incorrectly positioned. Chains and wires may cut packaging, while unsuitable attachments can distort the product. Long pipes and plate bundles may bend if lifted from too few points. A spreader beam can maintain suitable sling angles and distribute forces more evenly.

Terminal personnel should receive the handling instructions before operations begin. Markings such as "Keep Dry," "Do Not Use Hooks" and "Lift Here" are effective only when stevedores understand and follow them.

Operations during rain must be controlled according to the product specification and packaging. Loading should be suspended if moisture can enter the wrapping or remain trapped between closely packed surfaces.



Underdeck stowage generally provides the best protection from rain, spray and seawater. Photo: Dreamstime.



A final cargo list must describe exact dimensions, gross weight, packaging and approved lifting method. Photo: Kiev Shipping Ltd.

Plan stowage and separation

The stowage plan should protect the cargo against movement, compression, contamination and incompatible neighbouring cargoes.

Stainless steel should not be placed where residues, liquids or dust from other cargoes can reach it. Chemicals, fertilisers, salts and moisture-generating cargoes may create an unsuitable environment even without direct contact.

Separate finished products from rough steel, machinery, and other units that could shift or damage their surfaces.

Appropriate dunnage (supporting material such as wooden planks) should prevent contact with the vessel and distribute weight across the supporting structure.

Coils require properly designed beds or chocks to prevent rolling. Excessive stacking can deform lower units or damage their packaging.

Plate and sheet bundles should be supported evenly to prevent bending.

Timber between tiers should be aligned vertically so that weight passes through the intended supporting points.

The discharge sequence must also be considered. Cargo for the first port should remain accessible without unnecessary restowage, as every additional handling operation increases cost and damage exposure.

Engineer the securing arrangement

Sea fastening must restrain the cargo against forces produced by the vessel's rolling, pitching and heaving.

The securing arrangement depends on cargo weight, centre of gravity, stowage position, voyage route and expected conditions. A high or narrow unit may require considerable lateral support even when its base appears stable.

Securing may include chains, wire lashings, timber chocks, welded stoppers, steel frames and anti-slip materials. Components must have adequate capacity and connect to approved securing points.

Lashings must not damage packaging or finished surfaces. Protective material should be placed wherever chains, wires or tensioning devices could contact the cargo.

Welded stoppers must be positioned so that heat, sparks and grinding particles cannot affect the stainless steel. The cargo should remain shielded during both installation and removal of the sea fastenings.

The completed arrangement should be inspected before departure.

Lashings may also require checking and retensioning during the voyage, particularly after heavy weather.

Manage moisture and ventilation

Stainless steel is corrosion resistant, but it is not immune to damage from an unsuitable transport environment.

Condensation can form when a vessel moves between regions with different temperatures. Moisture may collect on the cargo, inside packaging or on the vessel's structure and then drip onto the products.

Ventilation decisions should be based on external and hold conditions rather than a fixed routine. Ventilating at the

wrong time may introduce warm, humid air that condenses on colder cargo. Cargo holds should be monitored when appropriate. Hatch covers must remain weathertight, bilges should be maintained, and any water ingress investigated immediately.
Damaged packaging should be repaired before sailing. Even a small opening may allow salt-laden air and moisture to enter while preventing the package from drying effectively.

Document the cargo condition

Detailed condition records protect all parties and help establish when damage occurred. Inspect the cargo before loading, with photographs showing packaging, markings, and any existing defects. Make further records during lifting, stowage, and securing.
For high-value or sensitive products, a cargo surveyor can document hold condition, handling equipment, dunnage, separation, weather and sea fastening.
At discharge, packages should be examined before being moved. Wetting, deformation or damage must be recorded immediately. Suspected contamination should not be cleaned before it has been properly documented.
This record should continue through inland delivery because damage attributed to the sea voyage may actually occur during terminal handling or final road transportation.

Protection starts before the fixture

The safest and most economical time to resolve transport risks is before the choice of vessel is fixed.
Cargo information, packaging, lifting methods, port equipment, vessel geometry, stowage and securing requirements should be reviewed during freight negotiations. The selected vessel must be technically suitable for the particular stainless steel products being shipped.
The lowest freight rate may not produce the lowest final cost if it requires unsuitable deck stowage, extra handling or extensive modifications. A vessel with a moderately higher rate may provide better hold access, appropriate cranes and safer underdeck stowage.
Stainless steel is commercially sensitive cargo. Successful transportation depends on preserving its finish, cleanliness and market value as well as its structural integrity. When packaging, handling, stowage and moisture control are treated as one continuous operation, breakbulk sea transport can be completed safely and efficiently, with the cargo arriving in the condition expected by the receiver. ▲

About the author



Konstantin Kalnyi is CEO and Founder of Kiev Shipping Ltd, an independent shipbroking company established in 2000. He has more than 25 years of experience in international ship chartering and maritime brokerage, arranging dry bulk, breakbulk and project cargo transportation worldwide. Kiev Shipping Ltd provides professional breakbulk cargo chartering, see kievshipping.com for information.

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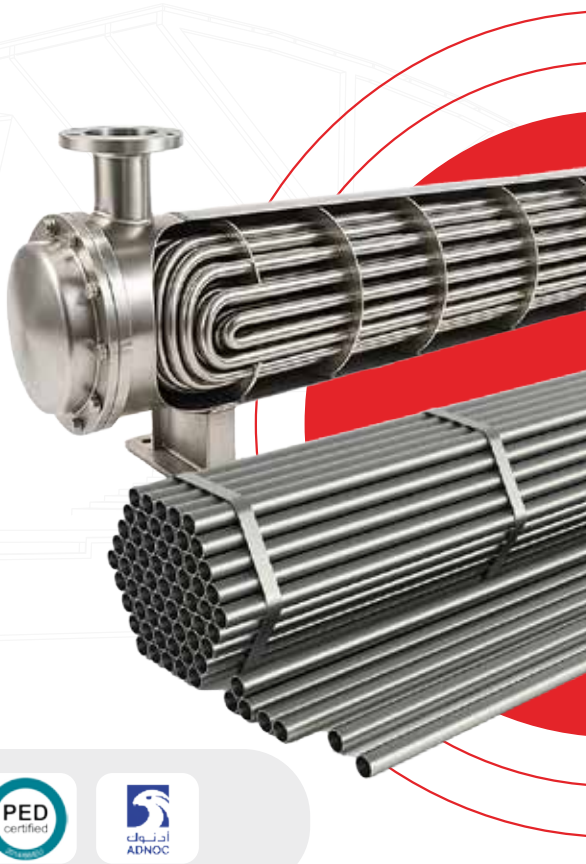

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Gain exciting insights into the stainless steel industry through authentic voices straight from the industry. CEOs and metallurgy experts as well as production employees or accountants dealing with certificates and regulations share their expertise and views on events in the stainless steel industry.

The laid-back discussions not only provide a place for relevant knowledge and opinion exchange, but also personal, relatable and funny moments between the personalities of this industry.

EUROCORR 2026 rocks Dublin!

EUROCORR 2026 brought the international corrosion community to Dublin from 6–10 September, with the Convention Centre Dublin hosting five days of technical presentations, discussion and networking. More than 1,200 delegates from 48 countries and regions attended, while the technical programme comprised 656 conference abstracts and 158 posters.

By Joanne McIntyre, Stainless Steel World

Under the theme "Investing in our future: corrosion challenges for green technologies", this year's European Corrosion Conference placed particular emphasis on the changing demands being placed on materials as industries move towards lower-carbon technologies. Hydrogen, renewable energy, carbon capture, electrification and other emerging applications may contribute to decarbonisation, but they also introduce demanding operating environments in which corrosion, materials degradation and long-term reliability cannot be overlooked.
That theme ran through a programme covering practically every area of modern corrosion science and engineering. Established subjects including high-temperature corrosion, marine environments, coatings, cathodic protection, corrosion in oil and gas, refining and petrochemicals, nuclear corrosion and environment-sensitive fracture sat alongside rapidly developing areas such as corrosion in green and low-carbon energy technologies, additive manufacturing and AI-supported corrosion testing.

For the stainless steel community, the wider message was familiar but increasingly important: new energy technologies do not eliminate traditional materials challenges. In many cases, they intensify them. Material selection, surface condition, fabrication, welding, operating environment and an understanding of degradation mechanisms remain fundamental to achieving the service lives required from new infrastructure.
The scale of the programme also demonstrated how corrosion research itself is changing. Joint sessions addressed subjects including imaging techniques, microbial corrosion and biofouling in marine environments, wear and corrosion in green energy systems, polymeric materials for CO_2 applications and artificial intelligence in corrosion testing.

Broad perspective

The integration of the 67th Corrosion Science Symposium also provided a platform for students and early-career researchers alongside established specialists.



Technical sessions covered topics ranging from inorganic coatings to corrosion, Cathodic protection & scale inhibition.



Lunch breaks were ideal for networking, meeting exhibitors, and checking out the 158 posters on display.



The team from Stainless Steel World, Conference Manager Kiyo Ichikawa and Editor-in-Chief Joanne McIntyre, visited EuroCorr 2026 and met with European Federation of Corrosion (EFC) President Gareth Hinds and Chief Operating Officer Pascal Collet.

The plenary programme reflected this broad perspective, with speakers including Professor Mary Ryan of Imperial College London, Professor En-Hou Han of the Institute of Corrosion Science & Technology in Guangzhou, Professor Arjan Mol of TU Delft and Neeraj Kumar of Microsoft Ireland.
Beyond the lecture rooms, EUROCORR retained the networking and international exchange that have long characterised the congress. Dublin provided an appropriately lively setting, with the social programme culminating in the conference dinner at the Guinness Storehouse.
EUROCORR 2026 ultimately highlighted a significant point for the materials community: corrosion control is not peripheral to the energy transition. As technologies and operating environments change, understanding how materials degrade, and how that degradation can be prevented, will remain central to making new infrastructure safe, reliable and economically sustainable. ▲

EUROCORR 2027 will take place in Prague on 12-16 September. See www.eurocorr-icc2027.org for information.



Community Update

SteelTrace strengthens team



Teresa Chong



Maxim Dicusari

SteelTrace has strengthened its technology and commercial team with two additions. Maxim Dicusari has rejoined SteelTrace as Full Stack / AI Developer. With more than seven years of software engineering experience, Maxim will further develop and scale the SteelTrace platform, with a particular focus on integrating AI deeper into its quality and compliance workflows.

Teresa Chong was appointed Sales Agent for Southeast Asia. With more than two decades of experience in the Oil & Gas industry, Teresa will focus on building partnerships with operators, EPCs and supply chain companies across the region.

Aker Solutions appoints Eikeseth CEO



Paal Eikeseth

Aker Solutions has appointed Paal Eikeseth as the company's new President & CEO. Eikeseth succeeds Kjetel Digre, who steps down after six years as CEO.

Eikeseth is an experienced business leader with a strong track record in operational growth, performance improvement and transformation. Since 2022, he has headed Aker Solutions' Life Cycle business and has previously held responsibility for operations and growth in the UK, Angola, Canada, and Asia. Throughout his career, Paal has worked on improving project and business performance, restructuring operations, scaling organizations, and delivering profitable growth in both mature and emerging markets.

Tyler appointed BP Chair



Ian Tyler

BP has appointed Ian Tyler as Chair of the company. Tyler joined the Board as a non-executive director in April 2025 and was appointed Interim Chair on 26 May 2026. He has worked alongside more than 15 chief executives during his extensive non-executive career spanning listed and private companies across oil and gas, natural resources and engineering businesses. He is currently Chair of Grafton Group plc and Senior Independent Director of Anglo American plc.

Venus Pipes approves Directors



Venus Pipes & Tubes has approved the re-appointment of its executive leadership, including CMD Arun Kothari and Whole-time Directors Megharam Choudhary and Dhruv Patel, for five-year terms during its 12th AGM. This move guarantees leadership stability as the company expands its manufacturing capabilities and transitions toward high-margin integrated piping solutions. Additionally, four Independent Directors - Kailash Nath Bhandari, Shyam Agrawal, Pranay Surana, and Komal Khadaria - were re-appointed for their second terms, ensuring governance and strategic continuity through 2031.

AWI Manufacturing appoints Johnson CEO



Brent Johnson

AWI Manufacturing, a provider of stainless steel products in the food and beverage industry and custom metal fabrication, has appointed Brent Johnson as Chief Executive Officer. Johnson, who has most recently served as Vice President of Sales and Marketing, has been with AWI for more than 20 years and assumes the role as the company enters a deliberate new phase of growth and generational transition.

Enbridge names new CEO



Greg Ebel

Enbridge Inc. has announced that Greg Ebel will retire as President and CEO effective December 31, 2026, and that Michele Harradence has been appointed to succeed him as President and CEO and to the Board of Directors effective January 1, 2027. Ms. Harradence is currently Enbridge's Executive Vice-President and President, Gas Distribution and Storage. Mr. Ebel will remain a member of the Board through his retirement date and serve as an advisor to the Board and Ms. Harradence from January until May 2027.

United Oil & Gas appoints COO



Donal Meehan

United Oil & Gas Plc (UOG), the oil and gas company with a high-impact exploration asset in Jamaica and a development asset in the UK, has appointed Donal Meehan as Chief Operating Officer. Donal previously served as United's Head of Commercial and brings over 20 years of upstream oil and gas experience across senior reservoir engineering, commercial, and leadership positions. He began his career at ExxonMobil before joining Providence Resources plc, gaining extensive international experience across the full upstream lifecycle, from onshore production operations to deepwater frontier exploration.

Industry Update

Moselstahlwerk appoints KRUDO Industrial for EAF sales



MSW Moselstahlwerk GmbH has appointed KRUDO Industrial to manage the sale of its electric steelmaking facility in Trier, Germany. The offering represents an opportunity for steel producers looking to expand existing production capacity or establish new electric steelmaking operations through the acquisition and relocation of a proven European facility.

At the center of the operation is a 60-ton TENOVA CONSTEEL® Electric Arc Furnace melt shop, supported by secondary metallurgy and a DANIELI Centro Met 3-strand continuous billet caster. The melt shop has a production capacity of approximately 560,000 tonnes per year and incorporates the principal stages of steel production from scrap charging and melting through refining and billet casting for 160 x 160 mm billets.

The facility underwent a significant modernisation program, with Moselstahlwerk investing approximately EUR 80M in the modernisation and technological upgrading of the operation in 2008, strengthening the plant's steelmaking capabilities and production efficiency.

API International launches NSF-Certified CleanLine set

API International, a manufacturer and engineered solutions provider of flanges, fittings and piping components, has launched CleanLine, a new range of NSF-certified stainless steel products for drinking-water and sanitary process applications.

The product line expands the company's waterworks and sanitary process offering to meet demand for components specifically requiring NSF certification. CleanLine products are certified to NSF/ANSI/CAN 61 for health effects related to drinking-water



system components and NSF/ANSI/CAN 372 for lead-content requirements.

CleanLine products are domestically produced, supporting projects with applicable domestic-content requirements, including American Iron and Steel (AIS) and Build America, Buy America (BABA) provisions.

Applications include municipal drinking-water systems, water treatment plants, pump and valve connections, filtration and reverse-osmosis systems, potable-water storage, and food and beverage and pharmaceutical equipment.

ROSTFREIE
EDELSTAHLBLECHE
VOM LAGER

GÜTEN	DICKEN
1.4301	1 -150 mm
1.4541	1 -150 mm
1.4571	1 -150 mm
1.4404	1 -150 mm
1.4462	2 -100 mm
1.4410	3 - 80 mm
1.4539	2 - 60 mm
1.4435	8 - 50 mm
1.4313	8 -100 mm
1.4828	1 - 60 mm
1.4841	1 - 60 mm
1.4845	1 - 60 mm
1.4835*	3 - 40 mm
1.4878	1 -150 mm
1.4016	0,5 - 5 mm

* äquivalent zu 253MA

NICKEL ALLOYS	
2.4816	3 - 40 mm
2.4856	3 - 40 mm
2.4858	3 - 40 mm
2.4819*	3 - 20 mm

* Alloy C-276

TELEFON: +49 2102 70077-0
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Sacchelli completes Swiss Steel Brasil acquisition



Aços F. Sacchelli, the national distributor of steel for mechanical construction, has concluded the acquisition of 100% of the capital stock of Swiss Steel do Brasil Indústria e Comércio de Aços Ltda. Aços F. Sacchelli will assume the integral management and operations of Swiss Steel do Brasil. Swiss Steel do Brasil will maintain a commercial partnership with the Swiss Steel Group, ensuring the continuity of the supply of Swiss Steel products to the Brazilian market.

With the effective integration of Swiss Steel do Brasil, Aços F. Sacchelli immediately incorporates into its portfolio a complete line of tool steels, stainless steels and special alloys, which adds to its traditional leadership position in the segments of steels for engineering and mechanical construction.

SupAnchor stainless steel hollow anchor



SupAnchor, a manufacturer and exporter of self-drilling anchor systems, has announced the launch of its stainless steel self-drilling hollow anchor, designed for coastal, marine and industrial projects exposed to demanding corrosive environments.

The new anchor combines stainless steel corrosion resistance with SupAnchor's self-drilling technology, providing a solution for applications where conventional carbon steel anchors may face accelerated degradation from saltwater, chemicals, moisture and aggressive soils.

Featuring a 3-in-1 design, the hollow anchor functions as a sacrificial drilling rod, injection tube, and reinforcing bar. This enables simultaneous drilling and grouting, helping reduce the need for temporary casing and simplifying installation in unconsolidated or cohesive ground conditions. The approach can also help reduce installation time, labour requirements, and equipment needs.

The stainless steel anchor is suited to port foundations, seawalls, offshore wind infrastructure, coastal tunnels, chemical plants, wastewater facilities, slope stabilization and permanent structural reinforcement.

Jindal Stainless signs pact with JFE Steel



Jindal Stainless has entered into a Technical Assistance Agreement with JFE Steel Corporation, Japan, to strengthen its manufacturing capabilities for selected ferritic stainless steel grades. The collaboration will focus on enhancing product quality, manufacturing practices, and process efficiency through technical assistance.

Global demand for stainless steel is accelerating, driven by increasing adoption across automotive, infrastructure, railways, process industries, and other value-added applications.

Industry estimates indicate that the global stainless steel market, particularly the ferritic segment, is expected to witness steady growth over the coming decade, supported by rising demand for cost-efficient and sustainable material solutions. Ferritic stainless steel grades are widely used in automotive components, railway coaches, kitchen equipment, industrial machinery, construction, and several other value-added applications, making them an important growth segment for the future. JFE Steel will support Jindal Stainless' ongoing efforts to strengthen product quality and manufacturing practices.

Klingspor launches welding dealer program



Klingspor Abrasives Inc., a global manufacturer of high-performance abrasive technology, has launched a new welding dealer program designed to make its industrial sandpaper and abrasives available for over-the-counter purchase through welding-supply retailers.

The program enables participating dealers to offer industrial-grade cutting, grinding and finishing abrasives directly to customers, supported by Klingspor's broad product portfolio, technical expertise and retail merchandising resources. The offering is backed by more than 130 years of abrasive manufacturing and engineering experience.

Dealers gain access to a comprehensive range of products, including cutting discs, grinding discs, fibre discs, flap discs and abrasive mop discs, as well as specialised sizes and materials for diverse fabrication applications.

MWL strengthens presence in energy markets



Mangalam Worldwide Limited (MWL) has achieved a significant international milestone by becoming an approved vendor with Abu Dhabi National Oil Company (ADNOC).

Through its MWL-Tubicore business, the company is now among the selected global suppliers eligible to provide tubes to ADNOC. The approval marks an important step in MWL's efforts to expand its presence across international energy markets and strengthens its credentials as a supplier capable of meeting stringent quality and technical requirements.

The ADNOC approval follows a series of vendor approvals secured by MWL earlier in the financial year from major organisations, including QatarEnergy, BHEL, Engineers India Ltd and Gujarat State Fertilisers & Chemicals. The company manufactures a diversified portfolio of stainless-steel products, including billets, ingots, hot-rolled and forged bars, bright bars, seamless pipes and tubes, heat exchanger tubes and U-tubes.

Mazak productive pallet automation



Yamazaki Mazak has launched the CP-450, a fully integrated 12-pallet automation solution designed to help manufacturers increase machine utilisation and achieve dependable unattended production.

Developed for selected Mazak machining centres, including the CV5-500, CV5-700, VCN-500, VCN-600 and VARIAXIS C-600, the CP-450 is aimed at high-mix, low-to-medium volume production environments. The system enables manufacturers to extend productive machining hours, create additional capacity, and reduce reliance on skilled labour without adding a standalone automation control system.

The CP-450 integrates machine and automation functions within a single production platform, providing machine control integration, simplified commissioning and one operator interface. Pallet sequencing is managed through an intuitive interface integrated into Mazak's MAZATROL Smooth control, with an optional dual-monitor configuration also available.

WELTEC BIOPOWER builds biomethane plant in Spain



WELTEC BIOPOWER has begun construction of a new biomethane plant in Colmenar Viejo, north of Madrid, in partnership with environmental services provider PreZero and Enagás Renovable. The facility is expected to generate up to 60 gigawatt-hours of renewable energy annually, equivalent to the energy needs of approximately 11,700 households or 30,000 residents.

The plant will process up to 75,000 tonnes of organic waste each year into renewable biomethane and injected directly into the gas grid. WELTEC BIOPOWER is supplying three stainless-steel digesters, each with a capacity of 5,067 cubic metres, along with a 1,177-cubic-metre pre-storage tank. The stainless-steel construction is designed to provide corrosion resistance, operational reliability and low maintenance under demanding biological and chemical conditions.



Sulzle stainless fittings for Heligoland port

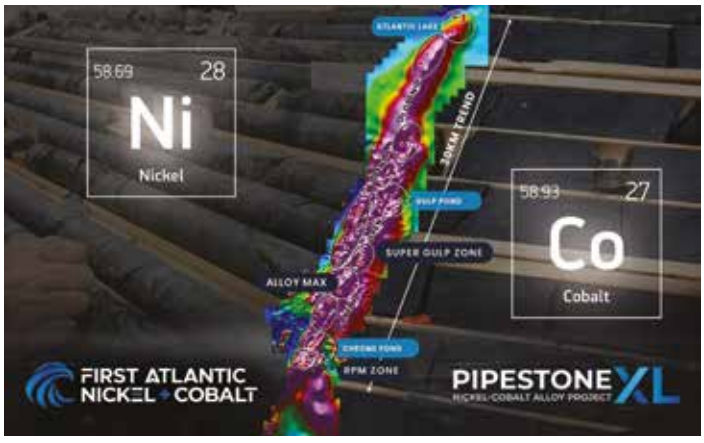


Sulzle Stahlpartner has started supplying about 2,500 tons of stainless steel fittings for the West Pier at the Heligoland Port in the North Sea.

The western pier protects the port in the south of the island. For the 563-meter protective structure to continue to withstand the enormous loads of the North Sea, large-scale repairs and technical modernisation will be carried out on it until 2028. A key element was the high-strength stainless steel reinforcement Top12 manufactured by Steeltec AG. It uses steel grade 1.4003 with a chromium content of more than 12%, designed for use in conditions of increased exposure to chlorides. In areas where the structure is constantly exposed to splashes and tides, this material provides significantly higher strength compared to conventional reinforcing steel.

Supplies will be carried out from the Sulzle stainless steel plant in Bad Zeckingen in southern Germany. The company also announced that it plans to produce stainless steel fittings at its plant in Salz, Lower Saxony.

First Atlantic Nickel raises CAD 6.15M for Pipestone XL



First Atlantic Nickel & Cobalt Corp. has closed a non-brokered private placement, raising gross proceeds of CAD 6.1575M to accelerate exploration and development at its Pipestone XL Nickel-Cobalt Alloy Project in Newfoundland.

The financing involved the issuance of 8.21 million flow-through common shares at CAD 0.75 per share, with no warrants issued. The proceeds will primarily fund follow-up and expansion drilling across the project's Alloy Max South, Alloy Max North and RPM zones, as well as exploration of additional awaruite targets along the approximately 30 km mineralised trend.

Pipestone XL is a wholly owned project covering the Pipestone Ophiolite Complex, which hosts multiple zones of awaruite (Ni_3Fe), a naturally occurring nickel-iron-cobalt alloy. First Atlantic says the mineralisation can be concentrated through its ONSHORE MAX process without conventional smelting, roasting or high-pressure acid leaching.

Mukand Sumi partners with Roofsol on 3.7 MWp solar project



Mukand Sumi Special Steel Limited (MSSSL), a leading manufacturer of special and alloy steel products, has signed a Power Purchase Agreement (PPA) with Roofsol Energy Pvt. Ltd. for the development of a 3.7 MWp OPEX-based solar power project at Koppal, Karnataka.

The project is part of MSSSL's ongoing efforts to integrate renewable energy into its manufacturing operations and strengthen its focus on resource-efficient and sustainable production. The OPEX-based model will enable MSSSL to access solar power without making the project's upfront capital investment, supporting the company's approach towards adopting cleaner energy solutions in a commercially viable manner.

As a special and alloy steel manufacturer serving the automotive and engineering sectors, MSSSL continues to explore opportunities to make its manufacturing processes more sustainable while maintaining its focus on quality, reliability and operational excellence.

El Jarudo earns best plants honor

Cooper Standard's El Jarudo manufacturing facility in Juárez, Chihuahua, Mexico, has earned recognition for manufacturing excellence as one of four winners of IndustryWeek's 2026 Best Plants Awards. The program recognises plants located in North America on the leading edge of efforts to increase competitiveness, enhance customer satisfaction, and create stimulating and rewarding work environments.

The El Jarudo facility manufactures stainless steel fuel rails, cooling hoses and air lines for leading global automakers and suppliers, supported by Lean Manufacturing, Six Sigma and digitisation initiatives designed to improve safety, efficiency, consistency and quality.

The facility's performance has also been recognised across Cooper Standard's global operations. El Jarudo was named the Company's 2025 Fluid Handling Plant of the Year and has earned Diamond Plant designation for three consecutive years, demonstrating consistent achievement against Cooper Standard's manufacturing and operational standards.

Outokumpu EvoMaterials for low-CO_2 metal production



Outokumpu has unveiled EvoMaterials®, a proprietary technology platform aimed at producing low-CO_2, high-purity metals while improving resource efficiency. The company is advancing the technology towards pilot-scale production, initially focusing on enriched ferrochrome and chromium metal.

EvoMaterials builds on advanced sulfidation-based process technology designed to increase chromium content and the chromium-to-iron ratio of ferrochrome. Outokumpu says the technology could later be extended to strategic materials including nickel and molybdenum, while also enabling metal recovery from industrial side streams.

The company's Kemi mine in Finland, the EU's only chrome mine, provides a strategic source of chromite for the technology. Outokumpu says the resulting materials could support demand from sectors including aerospace, defence and space, while potentially contributing to a Western supply chain for critical chromium materials.

Development began in the United States in 2021, with Outokumpu subsequently scaling the process through research and development activities. Testing and modelling are currently being conducted at the company's laboratory in Haverhill, Massachusetts. From 2030, the company intends to explore applications in specialty alloys, nickel, molybdenum, and other material streams.

Tenova supplies EAF to Nippon Steel



Tenova, a developer and provider of sustainable solutions for the metals and mining industries, has been awarded a contract by Nippon Steel Corporation through Daido Steel Co., Ltd. as EPC contractor, to supply a Consteel® Electric Arc Furnace (EAF) for Nippon Steel's Hirohata plant in Himeji, Hyogo Prefecture, Japan. The new furnace, with a heat size of 110 tons, will be the second Consteel® EAF installed at the Hirohata Works, following the success of Hirohata 1, commissioned in 2022. Designed for the production of high-grade special steels through electric steelmaking, the new state-of-the-art furnace sets a new standard in operational flexibility and process efficiency. Building on the experience gained from the first installation, Tenova's technology allows for high adaptability. Combining continuous scrap preheating with advanced automation systems, the new EAF optimises energy consumption, melting performance, and process stability. The installation demonstrates Tenova's commitment to circular, low-emission steel production and its ability to tailor cutting-edge technologies to each customer's transformation path.

Amentum secures UK nuclear contract



UK nuclear site operator Sellafield Ltd has selected an Amentum joint venture as preferred supplier for an asset care and asset creation program valued at up to USD 2.78 billion (GBP2.1 billion). Under the Projects and Asset Care Execution (PACE) framework contract, Amentum and its supply chain partners will support Sellafield Ltd's spent fuel management and retrievals mission by providing full lifecycle capabilities including engineering and design, procurement, installation and plant modification, project management and controls, commissioning, dismantling, removal and ongoing asset care.

John Heller, Chief Executive Officer of Amentum, said: "PACE provides a significant, long-term growth opportunity for Amentum at Sellafield, building on our existing capability and relationships while also enabling us to deliver a broader, integrated full lifecycle scope on higher value projects across engineering and asset care."

Stirlings Performance Steels announces MD

Stirlings Performance Steels has appointed Patrick Stirling as Managing Director, marking the next chapter in the company's more than 50-year history serving the Australian stainless & performance steels industry. Patrick's appointment follows his progression through the Stirlings business, where he has developed extensive experience across the company's commercial operations, supply chain & distribution, customer relationships and strategic direction. Under Patrick's leadership, Stirlings will remain focused on strengthening its core stainless and performance steel offering while continuing to invest in its people, inventory, processing capabilities, technology and customer experience. The company will continue to develop its relationships with customers and international supply partners, ensuring Stirlings remains responsive to changing market requirements and the evolving needs of Australian industry. The appointment provides continuity of the values and customer focus that have underpinned Stirlings since 1973, while establishing the leadership for the company's next phase of development.

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Tokyo, 141-8688
Japan
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Ahoyweg 10
3084 BA Rotterdam
The Netherlands
Conference
Mrs Joanne McIntyre
tel: +31 575 585 298
j.mcintyre@kci-world.com
Exhibition
Mr Jan Dieperink
tel: +31 575 585 299
j.dieperink@kci-world.com
Mr Sjoerd Hesseling
tel: +31 630 996 476
s.hesseling@kci-world.com
https://stainless-steel-world-duplex.com/

Heat Exchanger World Europe 2028
23 – 24 May 2028
Rotterdam Ahoy
Ahoyweg 10
3084 BA Rotterdam
The Netherlands
Conference
Miss Iryna Mukha
tel: +31 (0) 65 149 26 99
i.mukha@kci-world.com
Exhibition
Mr. Jan Dieperink
tel: +31 (0) 575 585 299
j.dieperink@kci-world.com
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tel: +31 (0) 630 996 476
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Stainless Steel World Asia Conference and Expo
Conference
Ms. Joanne McIntyre
tel: +31 575 585 298
sswasia.conf@kciworld.com
Ms. Jie Zhou (Jojo)
tel: +86 150 2121 5180
Exhibition
Mr. Peter Ong
General Manager
p.ong@kci-world.com
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Forum 100
6229 GV Maastricht
The Netherlands
Conference
Mrs Joanne McIntyre
tel: +31 575 585 298
j.mcintyre@kci-world.com
Ms Kiyo Ichikawa
tel: +31 575 789 260
k.ichikawa@kci-world.com
Exhibition
Mr Jan Dieperink
tel: +31-575-585-299
j.dieperink@kci-world.com
Mr Sjoerd Hesseling
tel: +31 630 996 476
s.hesseling@kci-world.com
www.stainless-steel-world.net

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Main: +1 312 781-5180
Conference:
Mr Karim Ayache
tel: +1 (416) 361 7030
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h.wang@kciworld.com
Exhibition
Mr. Peter Ong
General Manager
p.ong@kci-world.com
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Wenzhou Kaixin Metal Co.,LTD					■	■		■			■						■	■	■	■			■	■
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