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CORROSION PROTECTION

an ipcm® magazine

ISSUE 7
JULY 2024

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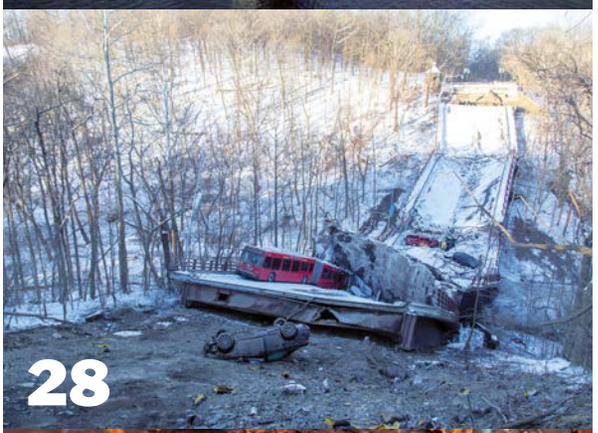


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FROM THE EDITOR

Alessia Venturi
Editor-in-chief

Any more or less severe damage that infrastructure suffers has an almost immediate impact on the lives of individuals and the environment. Just think of the collapse of a bridge, the leakage of an oil platform, the closure of a port or an airport. All these extreme – but not that rare – events are often related to maintenance problems that cause structural failures.

Infrastructure is an artificial work of great symbolic significance because it expresses the relationship between the individual and society.
Infrastructure connects, produces, transports, develops, defends, innovates. Infrastructure marks the territory, changes the landscape, shapes cities.
Infrastructure determines the development of civil society and its welfare.
According to the definition of Smart City coined by the European Union, cities can transform through investment in technologically advanced infrastructure, thus becoming economically sustainable, more efficient, and liveable.
For all these reasons, attention on infrastructure is always very high, also on the part of private citizens: any more or less severe damage it suffers has an almost immediate impact on the lives of individuals and the environment. Just think of the collapse of a bridge, the leakage of an oil platform, the closure of a port or an airport. All these extreme – but not that rare – events are often related to maintenance problems that cause structural failures.
“Build resilient infrastructure, promote sustainable industrialisation, and foster innovation” is one of the UN sustainability goals. The United Nations points to innovation and sustainable infrastructure as essential tools for productivity and income growth, with the aim of achieving better health and education outcomes.
The European Union, through the European Green Deal, has also put sustainability at the centre of its strategies for a new development model.
The funds of the Next Generation EU, the aid plan for the European countries most affected by the COVID-19 pandemic, are tied to spending 30% on sustainable infrastructure projects, with the intrinsic goal of mitigating climate change while reducing CO_2 emissions[1].
For infrastructure to be sustainable, it also needs to be long-lasting and require as little maintenance as possible, thanks to maintenance-free materials and coordinated design choices that extend its service life.
Dealing with infrastructure and maintenance, however, is extremely difficult and complex due to the variety of structures that fall under this classification and of the materials, disciplines, skills, technical and performance issues, management models, and stakeholders involved[2].
Infrastructure, especially its control and maintenance, is often the subject of Corrosion Protection’s articles. Already in 2012, on the pages of the then ipcm®_Protective Coatings[3], we anticipated that the challenge for infrastructure in the new millennium would be to implement materials and processes capable of postponing the first maintenance operation for as long as possible.
Let us look together at the state of the art of the technologies needed to measure, prevent, monitor, and fight corrosion in civil and industrial infrastructure.

[1] https://www.webuildgroup.com/en/discovery/articles/sustainable-infrastructure/

[2] https://www.manutenzione-online.com/articolo/ha-senso-parlare-di-manutenzione-delle-infrastrutture/

[3] The magazine rebranded to Corrosion Protection in 2023. The archive of all ipcm®_Protective Coatings issues can be accessed free of charge at www.ipcm.it.

WHAT'S NEW

Farwest Corrosion Control introduces eBook "Beneath the Surface"

Farwest Corrosion Control Company, a certified minority-owned business and recognized leader in cathodic protection and corrosion control products and services, is thrilled to announce the launch of its eBook, "Beneath the Surface." This publication, a first for Farwest Corrosion, offers tips and insights to help readers with corrosion control and cathodic protection issues. Leveraging Farwest's 65-plus years of industry experience, "Beneath the Surface" references the company's vast pool of knowledge, expertise and innovation. Designed to cater to newcomers and seasoned professionals in the field, the eBook provides expert advice, detailed explanations and invaluable information for dealing with corrosion control and cathodic protection issues.

Why "Beneath the Surface"?

■ Expert Insights: derived from Farwest's decades of industry leadership, this eBook presents decades of experience and wisdom directly to the reader.
■ Practical Strategies: it offers tangible solutions for everyday challenges like pipeline integrity, storage tank preservation and structural reinforcement, ensuring long-term asset protection.
■ Innovative Approaches: "Beneath the Surface" introduces insights and techniques in corrosion control and cathodic protection.

Troy Rankin of Farwest Corrosion Control expressed his excitement about the eBook's release, stating, "The launch of 'Beneath the Surface' marks a significant milestone in our mission to lead the industry not just through our products and services but through empowering our clients and the corrosion control community with knowledge and tools to combat corrosion. This eBook is a testament to our commitment to excellence and our passion for quality, offering an invaluable resource for anyone looking to enhance their corrosion control expertise."
"Beneath the Surface" is a product of Farwest Corrosion Control's industry experience and dedication to quality, integrity and exceptional service. This resource is complimentary.

About Farwest Corrosion Control Company

Farwest Corrosion Control Company, founded in 1956 and headquartered in Downey, CA, is a leader in cathodic protection and corrosion control services and products. Recognized as a Top Ten Corrosion Solution Provider by Manufacturing Technology Insights magazine, Farwest is committed to solving complex challenges with quality products, engineering solutions and onsite services. As a Certified Minority-Owned Business with operations nationwide, Farwest is known for its technical expertise and customer trust.

www.farwestcorrosion.com

Britt Meelby Jensen nominated to Hempel A/S Board of Directors

The global coatings manufacturer Hempel A/S has recently nominated Britt Meelby Jensen to its Board of Directors, who will replace Susanna Schneeberger.
Britt Meelby Jensen, CEO of Ambu A/S, has extensive experience in the life sciences industry, where she has held several leadership roles in global companies for more than two decades.
In addition, she holds a master's degree in marketing and international management from Copenhagen Business School (Denmark) and an MBA from Solvay Business School in Brussels (Belgium).
"I am thrilled that Britt Meelby Jensen has accepted to be nominated for the Hempel A/S Board of Directors. With more than 20 years' experience within healthcare and general management, alongside her contribution to the Hempel Foundation board and the Hempel Invest A/S board, we are convinced that Britt Meelby Jensen is the right profile to join the Hempel A/S Board of Directors. Britt Meelby Jensen brings to Hempel extensive international experience and expertise within leadership of global corporations and she will play an important role in Hempel's ambitious growth journey. The Hempel Foundation and Hempel Invest A/S have already greatly benefited from her profound business insight and strong leadership and we now look forward to bringing this expertise to the Hempel A/S board," has commented Richard Sand, Chairman of the Board of Directors of Hempel A/S.

www.hempel.com

Eugene Caldona wins AMPP's prestigious John Sedriks Seed Grant Award

The Association for Materials Protection and Performance - AMPP - has recently announced that Eugene Caldona, assistant professor in the Department of Coatings and Polymeric Materials at North Dakota State University (United States of America), won the John Sedriks Seed Grant Award thanks to his innovative proposal "Surface-Functionalized Ground Tire Rubber Additives for Isotropically Adhesive and Cohesive Dielectric Fluoropolymer Protective Coatings".

The John Sedriks Seed Grant is worth $35,000 and is designed to promote the development of research programmes in the field of materials protection and performance. It aims to address some of the most pressing challenges in these areas and encompasses several critical areas, including corrosion, coatings and degradation.

"I am deeply honoured to receive the 2024 Dr. A. John Sedriks Seed Grant. This grant not only recognises our team's creativity and hard work but also affirms the potential of our research to make meaningful contributions to the field of corrosion and materials science. We are excited to embark on this project, aiming to develop sustainable solutions that can significantly impact the durability and performance of protective coatings," has stated Eugene Caldona. "Eugene Caldona's proposal demonstrates exceptional technical merit and a deep commitment to advancing our understanding of material performance. His work promises to make significant strides in protective coatings, a testament to the legacy of innovation and excellence Dr. Sedriks championed throughout his career," has commented Douglas Hansen, chair of AMPP's Research Program Committee. Moreover, the Legacy NACE Seed Grant honours the memory of John Sedriks, a pioneer in corrosion control through metallurgical modifications. Indeed, his influential work left an indelible mark on corrosion research and the field of materials science.

www.ampp.org

Graco introduces the New Ultra XT and Mark XT HD airless sprayers

Graco recently introduced its new Ultra XT and Mark XT HD airless sprayers, featuring the revolutionary Xtreme Torque motor that increases spraying performance and pump durability.
Xtreme Torque is the first motor developed specifically for airless spraying by the international manufacturer of industrial painting and coating equipment.
Up to ten times quieter than normal available technologies, it offers very log-lasting pump durability and spraying performances through Endurance Vortex technology, which rotates the piston rod to extend its service life, and the ProConnect system, which eliminates downtime inactivity at work.
In addition, the sprayers offer the ability to select performance modes and clean faster and consume less water. As a result, maintenance directly on site is faster.
The Ultra XT Series includes the 490 XT, 495 XT (both Stand and Hi-Boy), 650 XT (Hi-Boy), 695 XT, 795 XT and 1095 XT (all Standard and ProContractor) models, with improved durability and performance.
The Mark XT HD 3-in-1 pumps – available in the V XT and VII XT models (both Standard and ProContractor) – have instead been specifically designed to meet the needs of contractors who require a reliable pump with proven performance, in order to increase production.

www.graco.com/xt

Sherwin-Williams introduced the new Pipeclad Frac-Shun erosion-resistant coating

The Protective & Marine division of the international paints and coatings manufacturer Sherwin-Williams has recently launched Pipeclad™ Frac-Shun, its new erosion-resistant powder coating system specifically developed to be applied inside pipes located near fracking wellheads, thereby reducing downtime maintenance costs and enhancing drilling productivity.
The inner walls of pipes – especially the elbows – located near wellheads can be eroded by fracking sand-flows within six to eighteen months. Such erosion also occurs inside storage vessels and tanks where gritty multiphase fluid flows strike interior surfaces. So, the operators are accustomed to frequent unexpected maintenance shutdowns following pipe wall thickness inspections.
The new patent pending erosion-resistant coating (ERC) technology protects pipe interiors from the inherent sandblasting action of grit moving rapidly through them, remaining intact far longer than other options and protecting the steel pipes from the significant metal loss that otherwise leads to potential leaks and early replacements in many operations. Once applied, the Pipeclad Frac-Shun ERC system forms a molecular-level composite that provides an ultra-high erosion-resistant barrier.
"High velocity fluids containing sand, rocks and other debris moving through a coated fracking pipe create a sandblasting action that's akin to removing coatings when preparing a surface for a new application. Once those coatings are gone, the steel will begin to erode instead. The new erosion-resistant coating system is able to withstand the impact of multiphase flows striking it without eroding or chipping away like most coatings," has stated Kristin Leonard, the director of the Energy segment for Sherwin-Williams Protective & Marine. "The ERC essentially spits the bullet back out after it's fired at the surface. With the coating intact, abrasive fluids have no chance at eroding the steel."
Various laboratory testing and long-term field trials have confirmed the adhesion and chemical and erosion resistance characteristics of the new Pipeclad Frac-Shun ERC technology. Autoclave testing – which uses a blend of water and hydrocarbons at elevated temperatures and pressures representative of wellhead conditions – showed excellent resistance to operating stresses and chemical exposures. In addition, ultrasonic testing performed on steel pipes confirmed no loss of wall thickness after six months of operation at an active wellhead.

https://industrial.sherwin-williams.com/na/us/en/protective-marine.html

Lubrizol test method for copper corrosion in EV motors wins SAE International Award

A team of experts from The Lubrizol Corporation have been recognized for their significant contribution to the fuels and mobility industry with the development of a new corrosion testing method. The innovation earned Lubrizol employees Gregory Hunt and Michael Gahagan the SAE International Award for Outstanding Research in Mobility Fuels and Lubricants at a recent ceremony and reflects Lubrizol's continued leadership in EV lubricant technology. The SAE International Award recognized Lubrizol's team along with other leaders for bringing about this innovative advancement to the mobility industry. Initial work on the test began in Lubrizol's research and development laboratories and culminated only after years of research and testing. The test addresses an industry-wide need to develop a corrosion test that accurately measures the performance of lubricants at actual application temperatures. The test is pertinent to all applications where corrosion is a concern and is particularly relevant in assessing copper corrosion in electrified powertrains.

The test was validated and widespread use made practical through the collaboration of industry partners in the automotive and e-mobility space.

"SAE International's recognition of this important development in corrosion testing is gratifying, as it illustrates the impact Lubrizol researchers have on the industry as a whole," said Brenna Huovie, Vice President of Additives Technology at Lubrizol. "The Wire Corrosion Test is a shining example of the way collaboration and ingenuity can take a scientific concept through to commercial application." This achievement comes on the heels of several award wins and recognition Lubrizol has recently received, including customer, industry and innovation recognition across its portfolio. Earlier this year, the Wire Corrosion Test was recognized by the Rosefield Energy Tech Awards for technological advancement. In addition, Lubrizol secured the IRI Innovation Excellence Award for Digital and Technological Innovation for its Q.LIFE® testing and data analytics system.

www.lubrizol.com

AkzoNobel opened a wind turbine blade testing facility

The international paints and coatings supplier AkzoNobel has recently inaugurated a wind turbine blade testing facility at its Felling-based site (United Kingdom), a state-of-the-art facility equipped to conduct simulations.
This investment aims to enhance the development of AkzoNobel's International protective coatings brand, crucial for wind farms worldwide. As a matter of fact, the facility boasts the capability to simulate diverse global weather conditions – thus enabling researchers to increase rain erosion tests threefold on a weekly basis. Furthermore, its "helicopter" test can achieve speeds up to 176 meters per second at full capacity.
"Today marks an exciting new chapter in our long history of supporting sustainable innovation and product development. Bringing this type of world class testing in-house – where we can immediately generate the data, analyse results and prolong testing periods – will transform our contribution to innovation in the wind energy sector. As one of the market leaders, we'll be able to participate in a more meaningful way in lifetime prediction discussions on protective coating systems for wind turbine blades," has stated Ralph Slikkerveer, R&D Director of AkzoNobel's Marine and Protective Coatings business.
Moreover, to support the ultra-high-speed tests, the new facility has been fitted with a 1,000-liter water recycling tank. During testing, the water flow rates, and both the water and air temperatures can be adjusted as required.
"The protective coatings we'll be testing will help to future-proof our customers' blades, so they can withstand the most extreme weather conditions. We'll now be able to perform more cost-effective and accelerated testing on new products, offering the best possible solutions for our customers at a time when global investment in wind projects continues to grow," has added Ralph Slikkerveer.

https://www.international-pc.com/en

Teknos earned the Gold Medal for sustainability from EcoVadis

The Teknos sustainability performances have been once again rewarded with the gold medal from EcoVadis. The international manufacturer of paints and coatings is then included in the top 5% of over 130,000 companies rated across the globe. Teknos obtained very-high scores according to the environment, labour and human rights and sustainable procurement criteria.
"Sustainability is a cornerstone of the strategy of Teknos and the EcoVadis gold medal is confirmation of this commitment. It is clear that the coatings industry is in transformative phase, where safety and sustainability are being prioritised. At Teknos, we are working closely with our suppliers and customers to collectively innovate and develop the next generation of high-performance paints that have less impact on the environment, prolong the lifecycle of our products and those of our clients and are safer to handle and apply," has stated Paula Salastie, the CEO and owner of Teknos Group.
"We are proud that our persistent work to increase our ethical awareness, and to develop more sustainable operations and products, has been recognized once again with the EcoVadis gold medal. To be included in the top 5% of all rated companies is a great recognition that will inspire for the future."
More specifically, Teknos achieved:
■ A 95% reduction in the number of substances of concern relative to the total raw material consumption;
■ A 97% direct procurement spent covered by its Supplier Code of Conduct;
■ A significant improvement in safety performances, with the Lost Time Injury Frequency Rate[1] going down 21.3%.
"For us, being sustainable goes well beyond products and operations. Being a family-owned company, people are everything to us, with safety being our number one priority. We strive to create a great place to work where people can become the best versions of themselves. We believe in forging long-term relationships with all our stakeholders, from customers to the communities we operate in, to support them in achieving their sustainability ambitions," has concluded Salastie.
Since its founding in 2007, EcoVadis has grown to become one of the largest and most trusted provider of business sustainability ratings, creating a global network of more than 130,000 rated companies. Their methodology is built on international sustainability standards, including the Global Reporting Initiative, the United Nations Global Compact, and the ISO 26000, covering more than 220 spend categories and over 180 countries.

https://mediabank.teknos.com/l/gcJ-vJM2RR2N

[1] LTIFR: the number of incidents resulting in at least one full day of absence per one million hours worked.

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Qualicoat approved for Class 2, MEGAPOL® F SD ULC is a polyester finish specifically developed for the protection of steel and aluminum, recommended for applications requiring high durability, such as large architectural projects and ACE projects. This powder coating is characterized by its ambivalent curing regime: it can be cured at lower temperatures than conventional systems, resulting in energy savings, or it can undergo a faster cure by adjusting the temperature accordingly.
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MEGAPOL® F SD ULC is energy efficiency for any project.

About CIN
With over 100 years of experience in the coatings industry, CIN has been the Iberian market leader since 1995. In 2023 reached a turnover of 395 million ranking as the 10th largest European paint manufacturer* and the 36th worldwide **.
CIN operates in all four main market segments (Architectural, Industry, Protective Coatings and Yachting and Marine), with over 1639 employees in more than 15 countries, with a direct presence in Portugal, Spain, France, Italy, Poland, Angola, Mozambique, South Africa and Mexico; and exporting to various markets in Central Europe, Latin America and Africa.

www.cin.com

* European Coatings Journal, May 2024
** Coatings World Top Companies Report, July 2023

COVER STORY

PARRÓS GROUP: A DUPLEX POWDER COATING SYSTEM FOR PROTECTING RAILWAY METAL STRUCTURES AGAINST CORROSION

by **Alessia Venturi**, ipcm®

The PARRÓS Group (Bolaños de Calatrava, Ciudad Real, Spain) manufactures large hot-dip galvanised and powder-coated metalwork fabrications for various sectors, particularly high-speed railways worldwide.

PARRÓS is a family-owned business with over thirty-five years of experience in the supply of metal components for railway electrification infrastructure. This Group integrates different activities to combine the necessary technical and human resources to vertically and horizontally cover all the needs of its customers' construction projects. In 2001, it installed a hot-dip galvanising plant and a high-tonnage powder coating line to finish the large metal structures it produces in-house in a dedicated department, thus completing the insourcing of its entire supply process.

"In addition to innovating our services, we have installed state-of-the-art machinery at all levels, from profile processing devices and welding robots in our fabrication department to total process control systems in our coating line, in order to be adaptable and efficient in all the various projects we carry out, always with the highest standards of quality and safety," states Juan Antonio López García, the manager of the metal fabrication department at PARRÓS Group. "Our passion for the projects of our customers, which are mainly leading infrastructure construction companies in Spain, has brought us to a high level of competitiveness, marked by our commitment to on-time delivery and excellent quality. Our wide range of machinery and equipment, including the hot-dip galvanising and powder coating lines, further distinguish us in the iron and steel sector."

A company specialising in the railway sector

López García adds: "We have a technical department specifically devoted to the railway sector, which we especially supply with different materials for electrification catenaries (or overhead contact lines) such as poles, towers, gantries, metalware, and so on, where we develop the best solutions for our customers' wide-ranging requirements. When we tackle a new project, such as the new 450 km-long Medina-Mecca high-speed line, for which we supplied about 50% of the necessary structures for electrification, we start by checking what type of material needs to be provided and whether we already have the right machines or we can improve our existing ones, for example to reduce construction costs and thus be more competitive or to increase the quality of our products. That is the "mother" phase of our entire material supply process. In our metal fabrication department, we then build the elements required for our projects, including railway electrification material. Among our most recent projects in this field are the Lithuanian portion of the Baltic Corridor and railway electrification in Israel. Incidentally, PARRÓS never works as the principal contractor but as a subcontractor to major railway electrification groups, which contact us for the supply of the metal structures they need."

Sections of railway electrification poles awaiting finishing with the Duplex system (hot-dip galvanising + powder coating).

Hot-dip galvanising and coating are among the most commonly used methods to protect heavy metal structures against corrosion. Using just one of these coating systems guarantees short to medium durability. However, when long durability is required, it is possible to combine them both – hence the name Duplex by which this dual finishing system is known on the global market. Hot-dip galvanising forms a sacrificial, anti-corrosion base layer, whereas the liquid or powder coating acts as a protective and cosmetic finishing film. PARRÓS Group, a company integrating different activities related to large-scale metal construction (with a deep specialisation in auxiliary civil works for the railway sector) and the supply of structures for railway electrification, has chosen a Duplex powder coating system to protect its components, thanks also to the excellent commercial and technical collaboration with its main supplier of powders, AkzoNobel Coatings SLU (Vallirana, Barcelona, Spain).

The integration of hot-dip galvanising and powder coating processes in 2001 was motivated by the growing demand for high durability and corrosion resistance properties. “The specifications for the projects we carry out for railways outside Spain always include coating cycles that combine hot-dip galvanising and powder coating, the latter often with two coats of primer + finish. That is why PARRÓS needs a reliable partner with great technical expertise and significant laboratory resources for both research and quality control: working for railways all over the world, we need high-performance paint products with consistent quality. We found this partner in AkzoNobel.”

A difficult start to a long-standing relationship

“It took AkzoNobel a great effort to become PARRÓS’ main supplier of powder coatings,” Juan Antonio López García comments with a smile. “I am a rather cautious manager: once we attain controlled and effective processing parameters, I prefer not to change them. This company is not a coating contractor: price is important for us, but it is not the most crucial aspect of a work order. We rather strive to make and sell quality. That is why I do not tend to change well-controlled, efficient, and effective processing parameters for a matter of price alone. When AkzoNobel presented itself to PARRÓS, we started carrying out studies on a series of coating and quality parameters that were fundamental for us. These turned out to be the basis for everything we did together afterwards and an important technical prerequisite for the durability studies we are carrying out now. We have been receiving invaluable technical support and equally excellent service from AkzoNobel: no matter the problem or doubt, they are just a phone call away. That is what has made them our leading powder supplier, accounting for more than 95% of the powders we purchase.”

The Interpon technologies chosen by PARRÓS

“PARRÓS uses Qualicoat Class 1 architectural polyester coatings as a standard – in some specific RAL colours, including RAL 6009, a green tone specifically formulated for the materials it coats with the Duplex hot-dip galvanising and powder coating system,” indicates AkzoNobel sales representative Juan José Sanchez Maqueda. “It also works with our range of Interpon Redox primers, which are specially additivated to improve the outgassing of hot-dip galvanised steel: that is a common issue with this metal, which primers can only curb but not totally solve due to its very characteristics. Our project for the future, for which we have just started carrying out formulation trials, is implementing Interpon D1036 Low-E, a Qualicoat Class 1 low-temperature cure range, to lower the oven’s temperature and thus enable PARRÓS to save energy.”

PARRÓS needs a reliable partner with great technical expertise and significant laboratory resources for both research and quality control: working for railways all over the world, we need high-performance paint products with consistent quality. It found this partner in AkzoNobel.

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From top left clockwise:
- In 2001, PARRÓS entered the iron and steel industry by installing a hot-dip galvanising plant;
- Before entering the coating line, the parts are subjected to a slight manual roughening process to increase the adhesion of the powder film;
- Galvanised parts exiting the molten zinc tank. Combined with the subsequent coating phase, galvanising increases the corrosion resistance of metalwork fabrications;
- Overview of the coating line designed and installed by Geinsa (Bilbao, Spain).

Galvanised parts undergo a chemical pre-treatment process with a nanotechnology passivation stage provided by Proquimia (Vic, Barcelona, Spain) to promote paint adhesion and improve the substrate's corrosion resistance.

Automatic application of Interpon powder coatings in a Wagner booth.

"The issue of curing temperatures is critical to PARRÓS," confirms Juan Antonio López García. "Our metal parts have a very large mass, and lowering our oven's temperature by even a few degrees would result in considerable energy and cost savings. We have opted for a range of Qualicoat Class 1 polyesters instead of conventional industrial polyesters with a view to quality: a polyester approved for outdoor architectural structures certainly gives our products even higher durability than that already conferred by the Duplex system. With this system and Class 1 polyesters, we easily achieve the corrosion resistance class C5 in compliance with ISO 12944, as certified by an independent external laboratory."

"A special feature of AkzoNobel is that we perform the tests required by ISO 12944 on hot-dip galvanised and powder-coated materials down to the metal, i.e. down to the original steel substrate, even though the standard does not require us to do so," illustrates Juan José Sanchez Maqueda from AkzoNobel. "In fact, although it only requires checking the adhesion of the paint to the substrate on which it is applied – zinc in the case of hot-dip galvanised parts – AkzoNobel's laboratories have decided to be stricter and reach the base metal, i.e. steel, to give our customers an extra guarantee of durability."

Duplex system: a complex finishing process

"In a hot-dip galvanising process, zinc alloys with iron to form a metal alloy that is then powder-coated. To achieve high levels of quality, it is necessary to keep the entire metalworking and coating process under control from the beginning so that any non-conformity or error can be spotted in real time. This is what PARRÓS does," emphasises Juan Antonio López García. "After galvanising, we subject the components to chemical pre-treatment with a nanotechnology passivation stage developed by Proquimia (Vic, Barcelona, Spain), which contributes to increasing the substrate's resistance to corrosion. Then, we carry out a light manual roughening operation and finally apply a one-coat or two-coat powder system, depending on the project specifications. Our finish is essentially functional, but it actually also has good aesthetic characteristics."

Juan Antonio López García from PARRÓS (right) with Juan José Sanchez Maqueda (centre) and Marian Solís Gutiérrez from AkzoNobel.

"Hot-dip galvanised metal is one of the most difficult materials to powder-coat," notes Juan José Sanchez Maqueda from AkzoNobel. "This is because when subjected to high temperatures, such as those needed to cure powders, it outgasses and creates pinholes on its surface. No paint product can solve this problem. However, one of Interpon's solutions for minimising pinholes on galvanised parts is using products with a low curing temperature because as the temperature drops, the outgassing phenomenon decreases. That is what we are doing with PARRÓS. We are developing a new colour from the D1036 Low-E range for this application, and we will test it on PARRÓS' equipment because their galvanising and coating process is perfectly controlled, and they are a technically very advanced and well-equipped company."
"I can only confirm what Juanjo is saying," Juan Antonio López García concludes. "We are working in close collaboration with AkzoNobel. "When we at PARRÓS have a doubt or a problem, its technical department is at our disposal."

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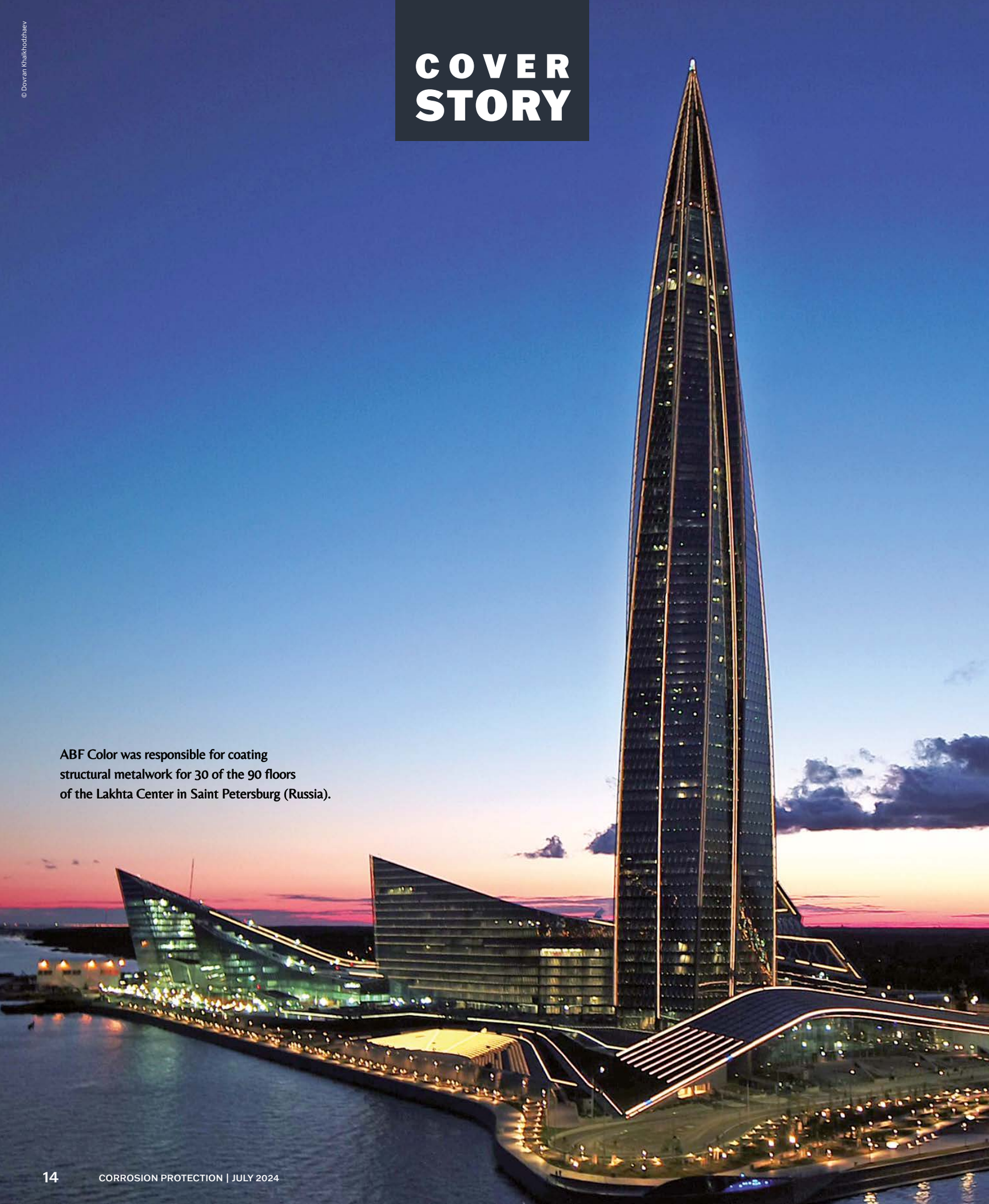

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ABF Color was responsible for coating structural metalwork for 30 of the 90 floors of the Lakhta Center in Saint Petersburg (Russia).

The perfect combination of mechanical and chemical pre-treatment improves the corrosion protection of the coatings applied on ABF color's heavy and light metal fabrications

by **Monica Fumagalli, ipcm®**

Powder coating contractor ABF Color has identified mechanical pre-treatment as the key to its success. This company was indeed one of the last coaters to be established in its area but one of the first to install a shot blasting machine from Carlo Banfi, now an OMSG brand, for the mechanical pre-treatment of large parts. In 2023, it acquired its third coating plant, retaining its trusted suppliers, including OMSG, Silvi, Gema, and Futura, and combining mechanical pre-treatment with a chemical stage for even more effective substrate preparation.

The optimal adhesion of paint layers and the effective corrosion protection of metal substrates cannot be guaranteed without adequate surface preparation. During machining, sheet metal surfaces are contaminated with either organic residues, such as lubricants used to reduce friction and/or heat, or inorganic residues, such as oxides and calamine resulting from hot machining stages or burrs and dust generated in stamping or cutting operations. For the latter, the introduction of laser cutting in manufacturing has brought many advantages over traditional mechanical systems, both from an economic point of view, because the process is faster, and in terms of results, since it allows for higher precision with a tolerance of +/- 0.1 mm, thus eliminating the need for further treatments. This type of operation does, however, result in the formation of inorganic residues such as dust and burrs, albeit in small quantities.

Many institutional representatives attended the inauguration of the new factory in 2019. Right photo: overview of the line installed in 2019, with a shot blasting machine, an oven, and a powder coating booth.

"Shot blasting is the ideal solution to ensure the complete removal of these limited amounts of contaminants that can, however, substantially affect the quality of the subsequent coating operation," states Adriano Baesso, the owner of ABF Color Srl (Curtarolo, Padua, Italy) with his brother Francesco. "This is one of the last companies established in our area to powder coat large-sized fabrications. As such, in an area – the Veneto region – dotted with many contractors offering the same service as ours, we chose to differentiate ourselves by specialising in the surface preparation of steel by shot blasting and immediately equipping ourselves with the first of three plants that we would go on to have OMSG - Officine Meccaniche San Giorgio (Milan, Italy) design and install for us. This strategic choice enabled us to win the trust of our customers in just a few months, which has grown exponentially since then."

ABF Color's production volumes grew well beyond expectations. At the end of 2023, it inaugurated a new factory with a third coating plant, which is now fully operational.

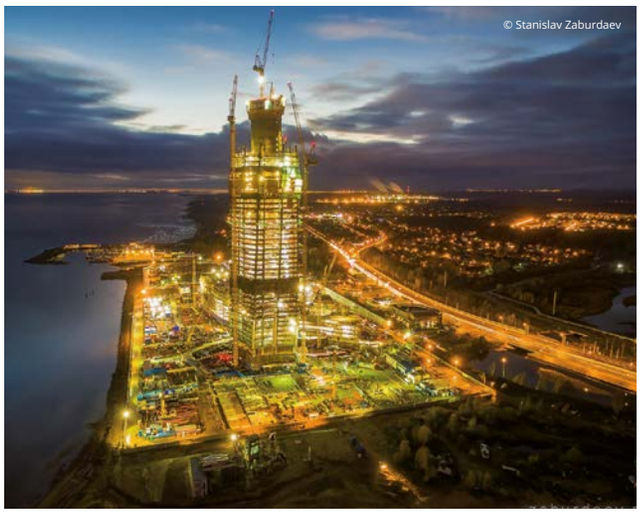
Previous experience

The Baesso family is the heir to a long-standing company celebrating its 130th anniversary this year. "My father runs Fratelli Baesso, which has been producing wine-making machines since 1895," Adriano tells us, "and has an in-house coating department for the steel they are made of. ABF Color's experience in surface coating comes from there – an incredible training ground, as the regulations governing food-contact coatings are among the strictest. Partly due to the family business' celebrity, the establishment of ABF Color in 2013 raised a lot of curiosity but also mistrust on the part of other local companies. Such scepticism, probably motivated by the fact that my family's name was linked to the wine industry and not to the coating one, was, however, quickly overcome. Within a few months, we had presented all the region's leading metalworking companies with our services, promoting shot blasting as an alternative to traditional surface preparation. As mentioned, we were among the first to install a shot blasting plant for structural steelwork in our area, and this choice was the springboard for our business."

The Veneto region's coating cluster

"We have also gained a lot of trust from institutions. In 2019, several regional and European government representatives attended the inauguration of our new factory, built in partnership with company Peruzzo Srl, which produces machines for public green care and sports facilities. The event's appeal enabled ABF Color to become known in a wider geographical area. At the same time, our business ethics soon led us to collaborate with other

local companies offering the same services as us to create a coating cluster that today also attracts customers from other regions. We can perform special cycles with an excellent quality/price ratio, and this has also been a winning weapon." As a result, ABF Color's production volumes grew well beyond expectations. At the end of 2023, it inaugurated a new factory with a third coating plant, which is now fully operational. "We dismantled our first plant, installed in 2013," indicates Adriano Baesso, "and we currently manage our volumes using the other two lines: the 2019 one handles large-sized, heavy-duty components, whereas the newest one coats lighter and smaller parts, such as the ones intended for the agricultural sector."



One of the construction phases of the Lakhta Centre in Saint Petersburg.

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ENERGY MAINTENANCE

The coating plant for heavy-duty components

The coating line built in 2019 has a step-by-step monorail conveyor built by Silvi (Lesmo, Monza e Brianza, Italy), which also acted as the prime contractor and took care of the design and installation of the curing oven. The plant can treat components up to 11 m in length, 3 m in height, 1.6 m in width, and over 5 tonnes in weight. “This is the only line in the region with these characteristics,” says Baesso. “Silvi’s technical team developed for us a unique structure to handle very heavy components. It collaborated with OMSG – which had already supplied us with our first shot blaster in 2013 and, for this project, provided a shot blasting machine from Carlo Banfi, the brand it acquired in 2017 – and Gema – which designed and installed a custom booth equipped with 12 guns (6+6) and Venturi injectors to powder coat the peculiar components we are required to treat. All of these three companies have been our trusted suppliers since 2013. Futura Convogliatori Aerei became one of them more recently after supplying us with the conveyor for the latest coating line.”

The parts coated here are predominantly beams, metal mezzanines, and large structural metalwork, which undergo mechanical pre-treatment, with spherical steel abrasive designed in partnership with supplier Winoa to achieve the SA 2½ cleanliness grade and the roughness profiles required by customers, and the application of one- to three-layer coating systems for iron and stainless steel, up to corrosion class C5 for hot-dip galvanised steel. “Our next milestone will be obtaining ISO 12944 certification, confirming the corrosion protection effectiveness of our coatings.”

From top to bottom:

The plant installed in 2019 can treat components up to 11 m in length and over 5 tonnes in weight.

The exterior of the Carlo Banfi shot blasting machine, using spherical steel abrasive.

A heavy-duty component entering the shot blasting system.

The Gema booth equipped with 12 guns (6+6).

The curing oven designed and installed by Silvi.

Involvement in major projects

One of the projects of which ABF Color is most proud is the one realised for the Lakhta Center in Saint Petersburg (Russia), which houses the offices of Gazprom. “We coated the structural metalwork of 30 of the 90 floors of this building facing the Baltic Sea and, therefore, subjected to a high degree of salinity, successfully exceeding all specified quality standards. Lately, we have also been making a name for ourselves in the naval sector, thanks to a customer that manufactures components for the British navy: after an initial request to coat material for three ships, we have received an order for six ships, confirming that our coating results are excellent and guarantee perfect resistance to the saline environment. We also coat furnishings for cruise ships: the tests conducted on them also proved their excellent degree of corrosion resistance after one year of daily exposure to the marine environment.”

The coating plant for light-duty components

“The decision to build a new line arose from the need to relieve the larger plant of batches with smaller parts – mainly intended for the agricultural sector, whose major brands, such as Kubota, have certified our coating cycle – and speed up our production flow,” explains Baesso. “Unlike the other plant, where we only perform mechanical pre-treatment, this line can perform a chemical, mechanical, or combined chemical + mechanical pre-treatment operation to prepare the surfaces adequately depending on the type of finish required by the customer.”

Silvi’s technical team developed a unique structure to handle very heavy components. It collaborated with OMSG, which provided a shot blasting machine from Carlo Banfi - the brand it acquired in 2017 - and Gema, which designed and installed a custom booth equipped with 12 guns (6+6), and Venturi injectors to powder coat the peculiar components ABF Color required to treat.

The two units performing chemical (left) and mechanical (right) pre-treatment on light-duty metal components and the Tunnelblast shot blasting machine installed in 2023.

This new line, therefore, consists of a continuous-flow, boxed, monorail conveyor from Futura (the largest in the range of this type of overhead conveyor) with 3 m load bars with a capacity of 500 kg each and a speed of 1 m/minute; a Tunnelblast shot blasting machine supplied by OMSG; a four-stage chemical pre-treatment tunnel; an oven divided into two zones, one for drying after chemical pre-treatment and one for powder curing at 180 °C; and a Magic Cylinder EquiFlow booth from Gema, also equipped with 12 guns and two stations for post-finishing to reduce the scrap rate.

Characteristics of the Tunnelblast machine

"The Tunnelblast 1525/12 series system," illustrates Enzo Dell'Orto, the CEO of OMSG, "is the third shot blasting machine installed by OMSG at ABF Color. It is a tunnel-type plant suitable for treating medium and large-sized components moved horizontally, combined with an overhead conveyor (monorail or power&free type). The maximum workpiece dimensions are 1.5 m in width and 2.5 m in height. The shot blasting operation is carried out through 12 7.5-kW, single-disc turbines equipped with a direct drive motor, which project the metal abrasive at about 80 m/s over each workpiece's entire surface as it moves through the tunnel. 12 inverters control the rotational speed of the turbines and the resulting kinetic energy of the abrasive, preventing the deformation of thin sheets. The plant is also equipped with 12 special valves to feed the turbines, with two pneumatic cylinders. One of the main features of this shot blasting machine is that the rubber bands acting as screens to prevent the abrasive from escaping can be opened automatically by a device operated by pneumatic cylinders, to enable the workpieces that do not need to be subjected to shot blasting to pass through quickly. Finally, the machine is managed by a Siemens S7-1200 PLC with a 12" touch panel, already prepared to comply with the Industry 4.0 parameters and be integrated with the company's management system, which is currently in the ramp-up phase."

One of the main features of this shot blasting machine is that the rubber bands acting as screens to prevent the abrasive from escaping can be opened automatically by a device operated by pneumatic cylinders, to enable the workpieces that do not need to be subjected to shot blasting to pass through quickly.

The pre-treatment tunnel and the drying and curing oven

The pre-treatment tunnel consists of four stages: 180-second degreasing, two rinses of the same duration (60+60 seconds, one with mains water and one with demineralised water), and a nanotechnology no-rinse passivation stage. “Identifying the right size for each zone was crucial to avoid any product overflow or dragging that would pollute the adjacent stages,” emphasises Silvi CEO Daniele Fumagalli.

“The system we supplied to ABF Color is 28.3 m long, 1.6 m wide, and 4.68 m high, and the workpiece maximum dimension is 1.2 x 2.5 m. Both the upper part, which houses the actual tunnel where the spray bars are placed, and the lower part, where the tanks are located, are made of AISI 304 stainless steel. The tanks are also insulated with rock wool with a thickness of 60 mm. The tunnel has three doors for inspection and an access ladder. The demineralisation plant can treat 3,000 litres of water per hour.”

Silvi also designed and installed the drying and curing oven: “The drying oven, which operates at a maximum temperature of 180 °C, consists of a robust supporting structure made of electro-welded galvanised steel profiles and an insulating layer of highly insulating rock wool. Our technical department has developed a special type of high-efficiency, backward electric fan to circulate the heating air. A plenum space is placed over the entire base of the oven for even distribution of hot air. Suction is regulated with adjustable shutters located on the underside of the oven. A fan specially positioned on the roof ensures the discharge of the products resulting from the curing of powders. At the same time, this air mass is compensated with filtered air intake. Finally, the curing oven has two combustion chambers totalling 300,000

From top left clockwise: Components exiting the shot blasting system; The rubber bands can be opened automatically through a device operated by pneumatic cylinders so that the workpieces that do not require a shot blasting treatment can pass through quickly; The 4-stage pre-treatment tunnel.

From left to right: The inside of the pre-treatment tunnel; The powder centre; Alessia Venturi from ipcm® with Adriano Baesso, the owner of ABF Color.

kcal/hour and can reach a maximum temperature of 240 °C. ABF Color uses it under special operating conditions."

A peculiar operational choice

"Our two- or three-coat cycles," Baesso confirms, "include a dry-on-dry application process with two or three dwells in the curing oven for 50 minutes. We decided on such a long curing phase because we noticed that the paint layer can flake off more quickly if it lasts less. Originally, the oven temperature was up to 180 °C, but the temperature of the parts leaving it did not exceed 120 °C. However, we need them to reach 180 °C as well. Therefore, we have them dwell longer than standard in the curing oven, with excellent results for both high sheet thicknesses (55 mm) and reduced thicknesses (35 mm)."

Long-standing, winning partnerships

As Adriano Baesso emphasised several times in our interview, ABF Color has always been supported in its growth path by the same suppliers. "Since our establishment, we have strived to select the best technologies on the market. In the case of OMSG, we started collaborating as early as 2013, and we immediately established an excellent personal relationship with its owner, Enzo Dell'Orto, which went well beyond the professional partnership. The reliability of this company is undisputed, as is the efficiency of its service: it has always solved any issue faced by ABF Color in a very short time. Silvi, represented by its owner Daniele Fumagalli, acted as the prime contractor for the two most recent installation projects: I chose it because it presented us with solutions that I had not considered at all and whose effectiveness I was able to assess by visiting several plants installed by this Monza-based company. As for Gema, in addition to providing the best application equipment in terms of performance and speed, it offers truly innovative solutions. One of its latest innovations I would like to implement in our new plant is the Dynamic Contour Detection system, whose laser scanners ensure greater coating precision, increased transfer efficiency and finishing quality, and faster production flow with reduced touch-up frequency. Once I will verify its degree of performance, I may consider installing it on the older line as well.

"I would like to conclude by emphasising that we would not have grown up to this point without the collaboration of all these partners: their know-how and expertise have always compensated for the investment made in their equipment," says Baesso. And ABF Color's growth will not stop here: the company has already acquired another one-hectare plot of land on which it plans to build a new coating plant.

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SCIENCE OUTLOOK

Evaluating the throwing power of surface-applied zinc galvanic anodes for the cathodic protection of concrete structures

By **Hadi Beirami**, Ph.D. of Corrosion Engineering and NACE-CP4 Cathodic Protection Certified Specialist - Trento, Italy, hbeirami@cormit.it

Maryam Ehteshamzadeh, Professor of Materials Engineering, Shahid Bahonar University of Kerman - Kerman, Iran

Cathodic protection (CP) is an effective method for mitigating corrosion in concrete structures contaminated with chloride ions. The implementation and monitoring of this system, especially using sacrificial anodes, have been simplified; however, determining the effective protection distance of these anodes remains a challenge. This study investigates the throwing power of zinc sheet anodes applied on the surface of reinforced concrete samples with varying chloride ion concentrations. Results indicate that increasing the added chloride ions content in the samples from 0% to 1.2% by weight of cement reduces the throwing power of the sacrificial anodes from 410 mm to 230 mm.

The durability and safety of reinforced concrete structures such as bridge decks, piers, and foundations in marine environments are of significant economic importance. The primary cause of deterioration in these structures is the corrosion of steel reinforcement. In the alkaline environment of concrete (pH 12.5-13.5), a passive layer forms on the reinforcement, providing protection. However, this layer is destroyed by chloride ions and carbon dioxide, leading to corrosion and subsequent concrete damage due to the expansive nature of corrosion products. The volumetric expansion of iron oxide layers can be over six times that of the original metal, generating stresses on the concrete influenced by the concrete composition, corrosion products, hydration level, and structural conditions.

Normally, steel reinforcement remains passive in concrete. However, exposure to seawater or similar corrosive environments leads to chloride ingress, damaging the passive layer and initiating corrosion and pitting. Carbonation resulting from CO_2 infiltration lowers the concrete's alkalinity, neutralizing it and promoting reinforcement corrosion. Factors like temperature, humidity, concrete strength, and air pollution affect carbonation rates, though the corrosion rate in carbonated conditions is lower than with chloride ingress. Ultimately, corrosion products cause concrete cracking, exposing reinforcement to the corrosive environment directly.

Various methods have been proposed to prevent corrosion in reinforced concrete structures, usually by reducing the rate of corrosion and preventing salt from entering the concrete. These methods include plastering the concrete surface, using corrosion inhibitors, and applying protective surfaces and coatings in new structures. However, for existing chloride-contaminated structures, these protection methods are insufficient. According to the Federal Highway Administration, cathodic protection is the only technique that can protect concrete structures from corrosion regardless of chloride content, making it widely used in corrosive environments [1]. This method is also suitable for new structures in coastal areas. Currently, cathodic protection is a cost-effective and widely accepted method to protect concrete structures against corrosion, demonstrating significant success.

The galvanic CP system employs sacrificial anodes like zinc, which have a lower electrochemical potential than steel, to generate a protective electrical current. This process relies on the anodic consumption of the anode material to protect the steel cathode. The sacrificial anode CP method is advantageous in remote locations without electricity access, as it eliminates the need for an external current source and the risk of short circuits between anode and cathode [2].

Despite its advantages, sacrificial anode CP has limitations, mainly due to the fixed resistance between the anode and steel, which controls the current flow. Understanding the protection distance of these anodes is crucial, with computer simulations aiding in addressing this issue, though validation through laboratory tests is necessary. This research evaluates the performance and throwing power of surface-applied zinc sheet anodes in galvanic CP systems on reinforced concrete to assess their effectiveness in preventing corrosion. Surface-applied CP uses zinc sheets with ionically conductive adhesive, where zinc undergoes anodic oxidation, releasing electrons that flow to the steel, preventing steel corrosion by diverting electron loss from the steel. Anions, such as chloride

ions, can migrate to the anode via the adhesive, completing the circuit, and the anode sacrifices itself to protect the steel.

Methodology

The samples were prepared with dimensions of 450 x 100 x 100 mm, as illustrated in **Figure 1**. Each concrete beam sample contained a deformed steel rebar with a 10 mm diameter positioned centrally. To eliminate corrosion, one end of each rebar was coated with epoxy, leaving 400 mm of the rebar length exposed to the concrete. Portland cement was used for the concrete mix, with the proportions detailed in **Table 1**. Sodium chloride (NaCl) was added to the mixing water to introduce chloride ions (Cl^-) into the concrete mix, achieving Cl^- concentrations of 0% (standard sample), 0.6%, and 1.2% by weight of binder. These chloride levels simulate corrosion damage typical of marine environments. Subsequently, cathodic protection (CP) was applied using a surface-applied zinc sheet sacrificial anode attached to the side surface of each sample. The steel rebar was connected to the anode with a copper wire to apply the galvanic cathodic protection system. CP parameters, including ON-potential and Instant-OFF potentials were measured at the same distances after 210 days from the preparation of the samples. Temperature and humidity conditions at the sample installation site were recorded. **Figure 2** schematically shows the circuit used and the method of potential measurement during this research.

Result and discussion

Table 2 presents the potential readings of the samples. During the measurements, efforts were made to maintain constant temperature and relative humidity to ensure the comparability of results. As observed, the addition of chloride ions caused the native corrosion potential of steel in concrete to become more negative. Additionally, the level of protection on the rebar decreased with increasing distance from the anode. In some sections with higher chloride content, the polarization achieved on the rebar was less than the minimum required for protection, indicating that these areas were not adequately protected.

Concrete cathodic protection (CP) criteria have been established by NACE International (now AMPP), as well as British and European standards organizations [4, 5]. The relevant NACE publication providing guidance on CP criteria is NACE SP0216, "Sacrificial Cathodic Protection of Reinforcing Steel in Atmospherically Exposed Concrete Structures." According to NACE SP0216, the criteria for CP are:

- The potential of the steel in concrete should be more negative than -720mV versus a copper/copper sulphate reference electrode (CSE) with the sacrificial anode disconnected, or
- A minimum of 100mV of polarization should be achieved at the most anodic location.

Here is the process that was used to measure polarization (V_p) [5]:

1. Base Potential Measurement:

The natural or "native potential" of the steel reinforcement was measured without the sacrificial anodes connected. This was done before applying the CP system to allow the reinforcement to reach its natural potential. The potential was measured relative to a copper/copper sulphate reference electrode.

2. Instant Off Potential Measurement:

The "instant off potential" was measured by briefly interrupting the connection between the sacrificial anodes and the steel reinforcement, recording the potential immediately (one second) after the interruption. This method helps to eliminate the IR drop error caused by current flow through the concrete.

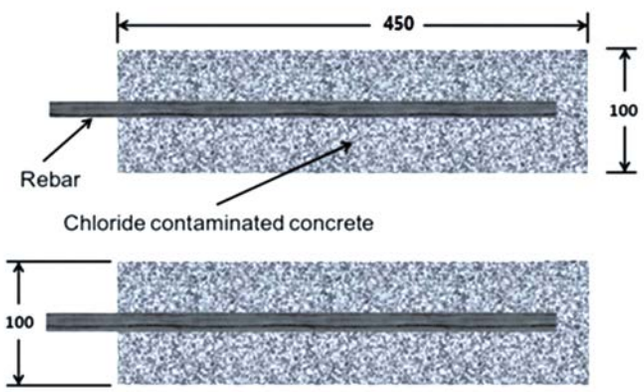

Figure 1 - Schematic of concrete samples for checking corrosion and applying cathodic protection.

Name	Cement Kg/m³	Water Lit/m³	Gravel Kg/m³	Sand Kg/m³	Chloride Kg/m³	Density Kg/m³
PC1	350	179	895	971	0	2294
PC2	350	179	895	971	2.1	2294
PC3	350	179	895	971	4.2	2294

Table 1 - Concrete mixing plan used to make samples of reinforced concrete beams.

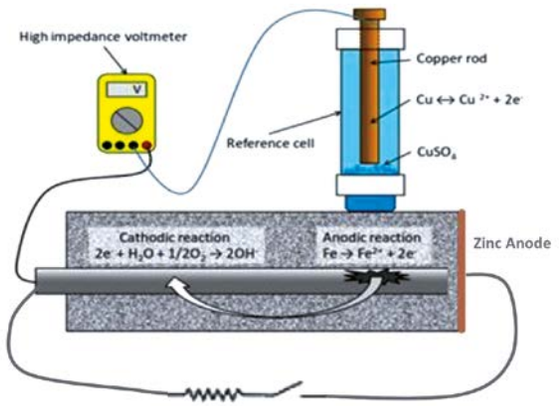

Figure 2 - Schematic of how to measure corrosion potential and read CP parameters on samples.

Name	Temp (°C)	R.H. (%)	Native Potential (mV)	Distance (mm)	ON Potential (mV)	Ins. OFF Potential (mV)	Polarization (mV)
PC1	32	27	-88	50	-471	-345	257
				140	-368	-320	232
				230	-336	-305	217
				320	-291	-280	192
				410	-234	-230	142
PC2	29	30	-206	50	-512	-390	184
				140	-411	-355	149
				230	-387	-335	129
				320	-339	-310	104
				410	-291	-275	69
PC3	30	32	-262	50	-522	-405	153
				140	-432	-380	118
				230	-391	-365	103
				320	-325	-315	53
				410	-309	-305	43

Table 2 - Potential readings of the samples.

3. Polarization Calculation:

The polarization was calculated by subtracting the base potential from the instant off potential using the following formula:

$$V_P = V_{instant\ off} - V_{native}$$

Where:

- $V_{instant\ off}$ is the potential measured immediately after the sacrificial anodes are disconnected.
- V_{native} is the natural potential of the steel reinforcement without the sacrificial anodes connected.

Samples without chloride (PC1), with 0.6% chloride (PC2), and with 1.2% chloride (PC3) by weight of cement showed varying levels of protection. According to the measurements, samples with 0%, 0.6%, and 1.2% chloride by weight of cement could meet the cathodic protection criteria up to distances of 410, 320, and 230 mm, respectively, from the zinc anode applied on the concrete surface. Concrete containing chloride ions exhibits a more negative overall potential compared to chloride-free concrete. This increase in negativity can be attributed to the influence of chloride ions, which reduce the resistivity of the concrete. Additionally, the presence of chloride ions leads to the breakdown of the passive layer on the steel bars, causing corrosion and instability.

Conclusion

In summary, this study demonstrates the significant impact of chloride ions on the corrosion behaviour of steel in concrete and the effectiveness of cathodic protection. The results show that the addition of chloride ions increases the negative potential of steel and reduces the effectiveness of cathodic protection as the distance from the anode increases. Areas with higher chloride content exhibit less polarization than required for adequate protection, leading to insufficient protection of the rebar. Adhering to established CP criteria, such as those outlined in NACE SP0216, is crucial for ensuring the longevity and durability of reinforced concrete structures. The findings emphasize the importance of considering chloride content in the design and implementation of cathodic protection systems to maintain the structural integrity of concrete infrastructures.

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AROUND THE WORLD

FERN HOLLOW BRIDGE COLLAPSE

by **ROB HAKIMIAN**

EMAP Publishing Limited, London – United Kingdom

This article was first published on the "New Civil Engineer" website[1] *and it is republished here courtesy of the author.*

The invaluable damages caused by corrosion become evident when striking events occur, such as the collapse of a building or a bridge. The article by Rob Hakimian, which we present in full below, analyses the causes that led to the collapse of the Fern Hollow Bridge near Pittsburgh in January 2022, fortunately without any fatalities.

Years of neglect led to the corrosion of the weathering steel legs of Pennsylvania's Fern Hollow Bridge in the lead up to its collapse, new details from USA's National Transportation Safety Board (NTSB) reveal. The Fern Hollow Bridge near Pittsburgh, which carried two lanes in each direction on the east-west Forbes Avenue over Frick Park, collapsed on 28 January 2022. Four vehicles – including a public bus – were on it at the time and another car drove off the east abutment shortly after the collapse plummeting 30 m to the ground below. Ten people were injured and four taken to hospital, but fortunately there were no fatalities.

The NTSB has now provided detail into how the bridge – which was 136 m long and opened in 1973 – was displaying signs of distress for many years in the lead up to the collapse.

[1] www.newcivilengineer.com/latest/fern-hollow-bridge-collapse-details-emerge-on-years-of-neglect-leading-to-leg-corrosion-23-02-2024/

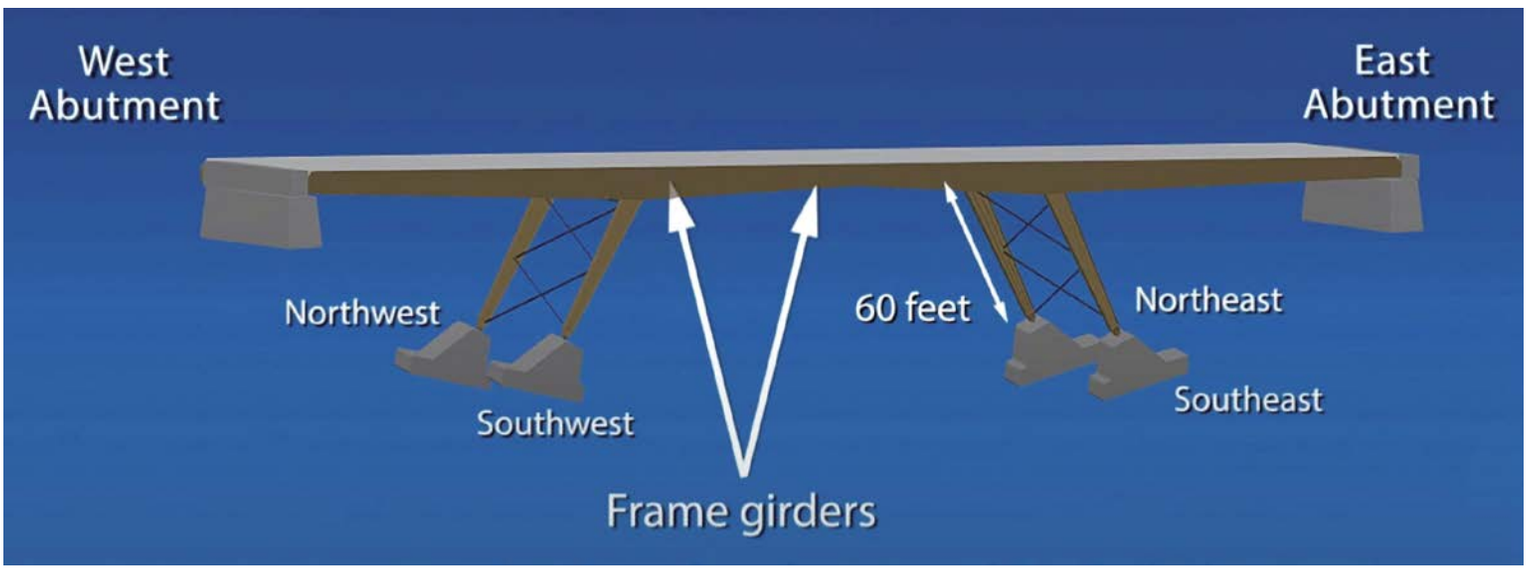

PORT AUTHORITY

Bridge design

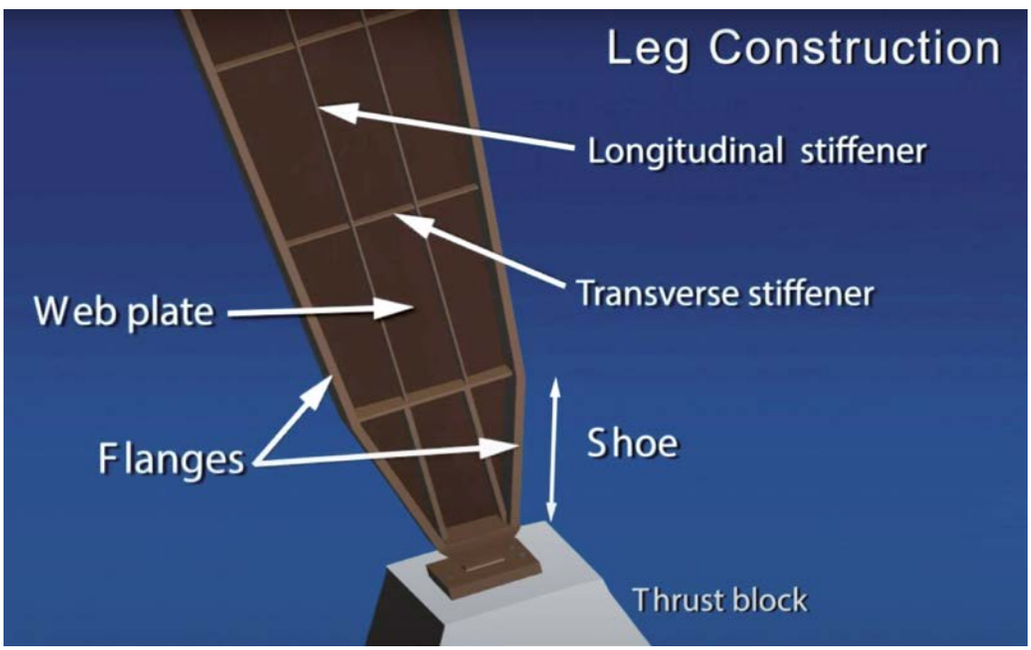
The main structure of the Fern Hollow Bridge consisted of two large frame girders running east and west, supported by four rigidly connected legs and abutments. The legs were about 18 m long and oriented with the frame girders to create a K-frame. Each pair of legs was connected by cross bracing.

The legs were formed of welded steel plates forming an I-shape cross section. The two flanges were the load-carrying parts of the legs. The legs narrowed from top to bottom, tapering to a shoe at the bottom, which sat on a reinforced concrete thrust block.

On the inside of each leg, longitudinal and transverse stiffeners were welded to the web and flanges to resist buckling. The outside of the legs did not have stiffeners but did include a transverse tie plate and longitudinal bearing stiffeners running the length of the shoe. The tapered legs caused compression forces in the flanges to push outwards. This outward push was resisted by the transverse tie plate and the web at the top of the shoe, which placed the transverse tie plates in tension. By design, the transverse tie plates were thicker than the transverse like stiffeners to carry the forces at this critical location in the leg.



Overview of Fern Hollow Bridge structure.



Overview of Fern Hollow Bridge leg design.

The bridge was constructed of uncoated weathering steel, an alloy designed to form a protective surface layer of rust – the patina. This patina develops over time through repeated wet and dry cycles. Because a properly formed patina resists corrosion, using this material eliminated the need for painting or coating.

Maintenance failures

The Fern Hollow Bridge was inspected every two years in compliance with USA's National Bridge Inspection Standards and from 2014 the Pennsylvania Department of Transportation (PennDOT) required the bridge to be inspected annually due to its condition rating and 26 t weight restriction.

Inspection reports over the years repeatedly documented clogged drains in areas where leaves or other debris collected. This allowed water and road salts to run down the bridge legs and accumulate on the legs near the transverse tie plates.

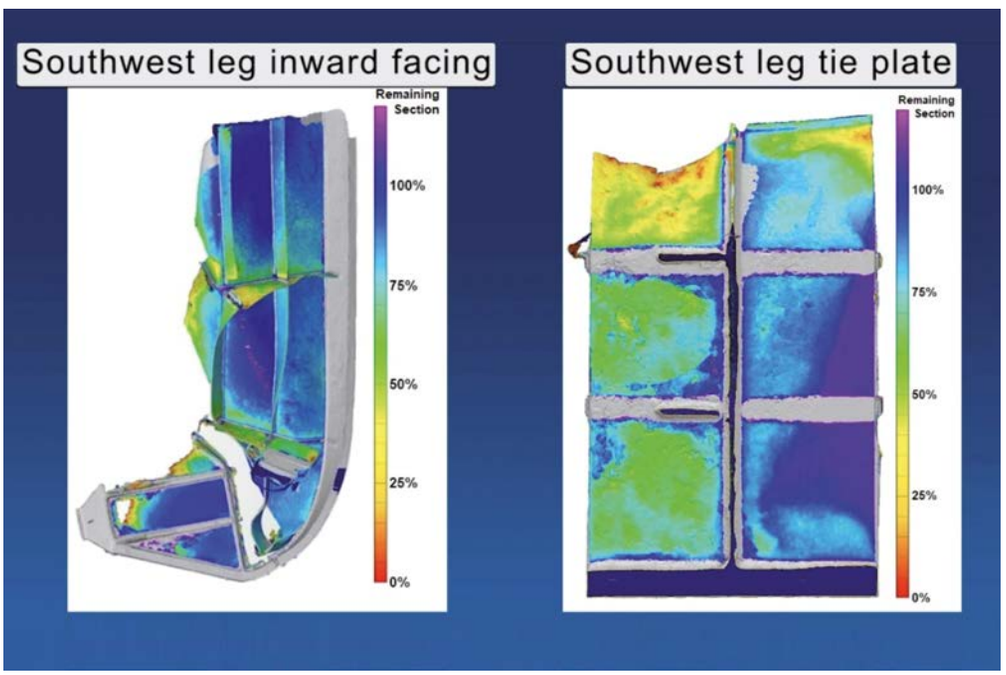
This accumulation of water and debris prevented these lower areas of the bridge legs from drying, which in turn prevented the protective patina from forming on the uncoated weathering steel.

This lack of patina and continued accumulation of water and debris ultimately led to extensive corrosion damage and loss of material or section loss on critical areas of the bridge legs, including the transverse tie plates.

THE MAIN STRUCTURE OF THE FERN HOLLOW BRIDGE CONSISTED OF TWO LARGE FRAME GIRDERS RUNNING EAST AND WEST, SUPPORTED BY FOUR RIGIDLY CONNECTED LEGS AND ABUTMENTS. THE LEGS WERE ABOUT 18 M LONG AND ORIENTED WITH THE FRAME GIRDERS TO CREATE A K-FRAME. EACH PAIR OF LEGS WAS CONNECTED BY CROSS BRACING.

Leg corrosion documented by inspector in 2015, 2017 and 2021 – the year before collapse.

Damage to all four legs, documented after collapse.



3D imaging of southwest leg after collapse, showing areas where steel thickness had worn down.

The inspection reports documented some of this section loss, which progressed to the point that there was thinning of material and holes through numerous structural elements on all four legs.

In 2009, due to corrosion of the legs' cross-steel bracing, steel cables were added to both sides of the bridge legs connecting the top of one leg with the bottom of the other leg, forming an X. The cables were intended to be used as a temporary measure until the rigid cross bracing could be replaced with new cross bracing of the same kind. This was never completed.
Similarly, a rust-inhibiting coating was to be applied to the bridge legs and lower bracing members, but this was also not completed.

Post-collapse examination

The post-collapse examination revealed that all four legs sustained damage.
The southwest leg sustained the most damage, including significant fracturing and deformation. On this leg, both the web and transverse tie plate were severely corroded. The thickness of the transverse tie plate was substantially reduced near the hole in the web. Three dimensional scanning was used to document section loss on the legs of the bridge. The thickness of the steel on some areas of the southwest leg was only 25% of its original thickness. During the collapse, the bottom flange of the southwest leg separated from the web and the transverse tie plate. The flange curled back onto itself. The bottom of the leg also bent approximately 90°, changing the orientation of the shoe. All of the data collected, including video taken from the bus, confirm that the collapse began when the transverse tie plate in the southwest bridge leg failed due to extensive corrosion and section loss.

New Fern Hollow Bridge elevation view.

New Fern Hollow Bridge aerial view.

Replacement bridge

In 2022, after the collapse, NCE spoke to PennDOT about how a replacement bridge was constructed and opened within 10 months of the incident. Officials said that collaboration and supply chain focus enabled the delivery to happen in a much shorter timescale than the usual three years. It was also aided by president Joe Biden signing off the $1.2 trillion (£1 trillion) Infrastructure Investment Bill shortly before the collapse.

Scan the QR Code to watch the video or read a summary of the NTSB's findings

THE POST-COLLAPSE EXAMINATION REVEALED THAT ALL FOUR LEGS SUSTAINED DAMAGE. THE SOUTHWEST LEG SUSTAINED THE MOST DAMAGE, INCLUDING SIGNIFICANT FRACTURING AND DEFORMATION. ON THIS LEG, BOTH THE WEB AND TRANSVERSE TIE PLATE WERE SEVERELY CORRODED.

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COVER STORY

A cross-linking oven with two independent tiers doubles the output of Fimeur's innovative DDS protective coating application plant

by **Gabriele Lazzari**, ipcm®

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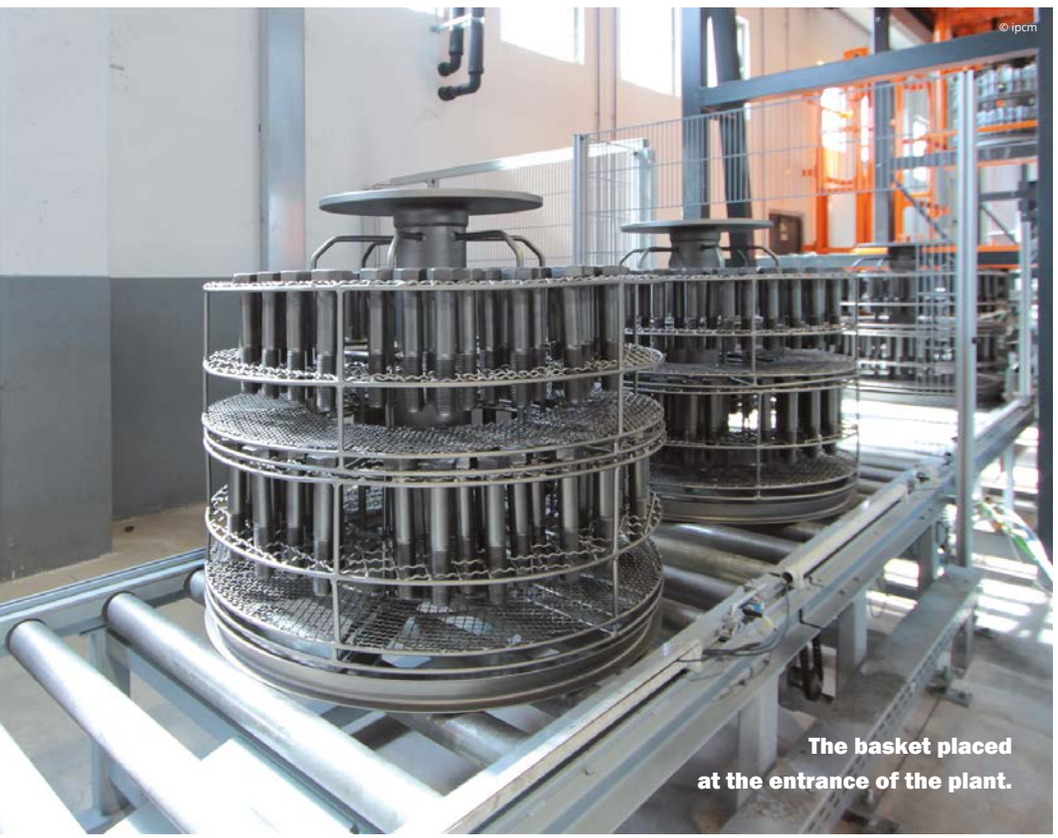
For over forty years, Fimeur has pursued a philosophy of improvement and growth, focusing on developing new solutions for the corrosion protection industry. That is why it has recently expanded its offer with the application of anti-corrosion zinc flake coatings through a new modular plant with DDS technology and an O.M.SA two-tier oven, which has doubled its production capacity and its treatments' quality.

Corrosion is a complex, multifaceted issue that negatively affects the durability and performance of metal components in numerous industries, from automotive to aerospace and from infrastructure to defence. Companies must constantly be at the forefront in the development of new technologies and treatment processes to effectively meet increasingly sophisticated customer requirements and more and more stringent environmental regulations. In the anti-corrosion treatment sector, innovation and flexibility are therefore fundamental to guarantee competitiveness and high quality in the services offered.

Innovating means investing in research and development, adopting environmentally friendly and sustainable solutions, and continuously improving production processes to obtain more resistant and durable coatings. On the other hand, being flexible enables a business to adapt quickly to market changes and customise treatments according to specific requirements, thus offering a tailor-made service that also optimises delivery times and reduces operating costs. In this context, Fimeur Group (Cazzago S. Martino, Brescia, Italy) stands out as a virtuous example of a company that has combined innovation and flexibility to excel in the corrosion protection sector. Collaborating with O.M.SA. Srl (Besana in Brianza, Monza e Brianza, Italy) has been vital to do so, as it supplied a two-tier oven designed to bake different parts simultaneously but at different temperatures, thus increasing the company's production capacity.

Some of the components treated by Fimeur.

The customised racks to handle the parts.



The basket placed at the entrance of the plant.

It also provided Fimeur with a paint stripping machine, essential for keeping the frames used in its coating processes clean, preventing contamination of the process tanks, and protecting the company's assets.

Fimeur: innovation and growth in corrosion protection

Founded in 1996 by Gianpietro Ambrosini following the acquisition of T.S.M., a leading metal treatment business since 1979, Fimeur integrated its expertise and expanded its production capability by specialising in phosphating and chemical surface treatments. "For over forty years, Fimeur has stood for continuous improvement, growth, and technological development. In the mid-1980s, my father and two other partners started T.S.M., which was a machine shop at the time. The company grew steadily, so much so that in 1987 it had to move to a larger plant in Cazzago San Martino, where the phosphating operations still take place today," says Gianluca Ambrosini, the current owner of Fimeur Group together with his brother Federico Ambrosini. Following the takeover in the mid-1990s, T.S.M. moved to another plant devoted to the treatment of engine screws and bolts, whereas Fimeur specialised in burnishing and phosphating operation, serving a variety of sectors including infrastructure, ACE, wind power, electromechanical, automotive, motor vehicles, and defence. "This has been our core business for many years – so much so that, thanks to our proprietary technologies and proven processes, we have also helped draw up OEM standards for phosphate materials. In 2009, we took over all the shares of T.S.M., making Fimeur an entirely family-owned company with a solid orientation towards innovation, differentiation, and growth. That is why, over the past three years, we have decided to finalise a significant investment aimed at expanding our service range with the application of GEOMET® water-based zinc flake protective coatings from NOF

Metal Coatings Europe, a leading manufacturer of anti-corrosion products," explains Ambrosini.

Phosphating and zinc flake coating for the most diverse components, from small screws to platform tie-rods

Fimeur stands out for its attention to detail, ability to meet deadlines, and highly efficient service tailored to each customer's needs. Through innovative technologies and modern equipment for phosphating and other chemical treatments of metals, the company's 70 employees process over 60,000 tonnes of material per year. The company operates with a carriage system with rotating barrels, static stations, and four automatic lines devoted to phosphating bolts. Recently, it also expanded its range of treatments to include the application of GEOMET® zinc flake protective coatings, using a technology based on the DDS (Dip-Drain-Spin) process and occurring in a newly built factory adjacent to its headquarters with 8 operators.

"We handle many types of small and large components. For example, we phosphate around 15% of the world market for engine heads, connecting rods, and flywheels for the light and heavy vehicle sector, and we process 30,000 tonnes of screws every year. We also process powertrains, joints, and bevel gears for trucks, tie rods for the petrochemical sector, and components that weigh more than 450 kilograms. Consequently, our equipment must be able to apply different treatments to various workpieces effectively and consistently, covering their entire surfaces," Ambrosini emphasises. "Racks and baskets must also be adapted to the specific components they accommodate. We can usually use standardised tools for the phosphating operations, but the DDS technology requires that the parts are stable inside the racks while, of course, leaving their surfaces exposed to the treatments."

"We phosphate around 15% of the world market for engine heads, connecting rods, and flywheels for the light and heavy vehicle sector, and we process 30,000 tonnes of screws every year."

The chemical pre-treatment tanks and the two Capri-type cluster shot blasting machines from OMSG.

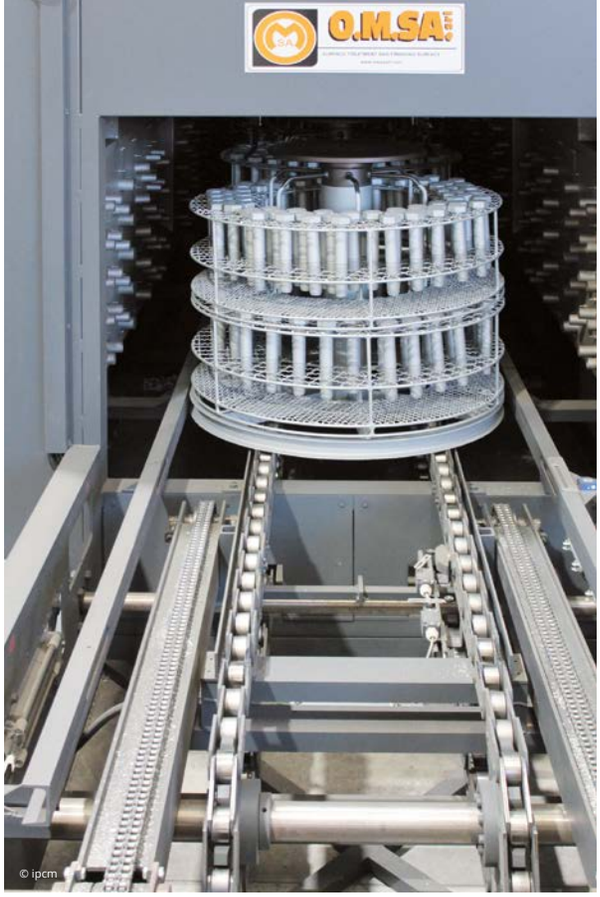
The DDS – Dip-Drain-Spin application system

Fimeur receives the blanks to be treated from its customers. After alkaline degreasing and shot blasting, it subjects them to phosphating or applies an inorganic coating based on zinc and aluminium flakes in its new, innovative plant with DDS (Dip-Drain-Spin) technology, which has been operational since 2022. The process begins with loading the parts to be coated onto customised racks, which are specifically designed to separate the parts, thus minimising contact points among them and ensuring uniform coating. “These racks can hold up to 600 parts at a time with a maximum total weight of 500 kg, and they are developed with the shape and size of specific components in mind to ensure that each of them is correctly positioned on the frame. We always ask our customers for drawings of the parts to be treated in order to identify the most suitable arrangement,” adds Ambrosini.
Once loaded onto the racks, which in turn are positioned on a roller conveyor equipped with an overhead crane to raise and lower the baskets near the treatment tanks, the parts undergo a chemical-physical pre-treatment phase consisting of several stages. The components are first immersed in a degreasing solution to remove oils, grease, and other surface contaminants to ensure good paint adhesion. Then, the basket is removed from the first tank and taken to two rinsing tanks to remove any degreasing residues. After drying through a hot air blow-off phase, the parts are treated with spherical stainless steel grit – capable of treating any material, even the softest ones such as aluminium – inside two Capri-type cluster shot blasting machines from OMSG - Officine Meccaniche San Giorgio S.p.A. to remove any surface oxides and slightly roughening them to promote paint adhesion. Finally, prior to immersion in the coating tanks, the components are dedusted through another blow-off phase to prevent dust from contaminating the immersion tanks.
After that, the workpieces are taken to the inlet of one of the plant’s two centrifuge units, where they undergo the DDS treatment, which combines dipping, dripping, and spinning to effectively apply five to twenty microns of coating:

- Dipping – The parts are immersed in the tank containing the GEOMET® product, which also adheres to the surfaces of parts with cavities, holes, or particularly complex shapes; the immersion time is adjusted according to the specific requirements of the parts and the expected coating results.
- Dripping – After immersion, the components are lifted and allowed to drip to remove excess coating, which is then recovered from the tank.
- Spinning – The racks are then subjected to high-speed centrifugation (up to 300 rpm) to even out the coating’s thickness across the entire surface of the parts.

The flexibility guaranteed by O.M.SA.’s two-tier oven

After coating, the parts are transferred to a two-tier oven for the cross-linking phase, which can take place from a minimum of 80 °C to a maximum of 350 °C. The plant is equipped with a pre-baking chamber at 70 °C and a chain system with an overhead crane that lifts and lowers the racks, placing them on one of the



From the left:

The booth for the DDS process.

The tank for the application of zinc flake coatings.

The two-tier oven supplied by O.M.SA.

A rack at the entrance to the cross-linking oven.

two tiers and extracting them at the end of the process to take them to the cooling tunnel. “The oven was specifically designed to optimise productivity. Indeed, it is possible to use the two tiers with the same temperature and cycle time or with two different temperatures, for example, to cross-link a base coat and a top coat at the same time, which often requires very different temperature values,” says Diego Cazzaniga, the technical engineer of O.M.SA. who developed this plant. “In addition, since the process entails the application of at least two layers of GEOMET® water-based zinc flake coating, we placed the oven and the tunnel within a loop that allows the conveyor to pick up the baskets and automatically take them either to the unloading area or back to the entrance of the DDS treatment area depending on the recipe.”
“This new plant’s design enables us to easily apply multiple coats while reducing downtime and increasing production efficiency. Its current configuration includes a base coat application tank matched with the first tier of the oven and a top coat application tank linked directly to the second tier, but we can always change this setting quickly if we need to modify our production flow. NOF METAL COATINGS GROUP’s specifications call for at least two layers of basecoat, but our customers usually also need a topcoat (for example, for controlled friction coefficient or higher chemical resistance), with some requiring up to five coats,” illustrates Gianluca Ambrosini. “At the beginning of June, we had some parts sampled that are going to be installed on offshore oil platforms in a C5 corrosive environment. We treated them with four coats of basecoat and a silicate-based topcoat for high chemical

The oven from O.M.SA. was specifically designed to optimise productivity. Indeed, it is possible to use the two tiers with the same temperature and cycle time or with two different temperatures, for example, to cross-link a base coat and a top coat at the same time, which often requires very different temperature values.

resistance. They passed 2,400 hours of resistance in salt spray test. The flexibility offered by O.M.SA.'s plant and oven was crucial in achieving this result without sacrificing productivity."

The need to paint strip the racks

However, the cycle does not end when Fimeur's operators remove the workpieces from the baskets, as the latter must also be paint-stripped. The DDS process applies the GEOMET® zinc flake coating on the cylindrical frames that make up the racks as well. "It is necessary to completely remove the coating from the frames because it could detach during the following cycle and pollute the pre-treatment or application tanks, thus degrading the quality of our entire coating process," notes Ambrosini. "As a consequence, we integrated an O.M.SA paint stripper into the new plant to keep the coating cycle efficient, protect the operators, and safeguard our assets."

This machine is equipped with a hermetically sealed, electrically powered, pneumatic door and consists of a continuously operating chamber. This houses two tanks and a mechanism to rotate the baskets to expose their entire surfaces to treatment. Inside it, spray nozzles apply an alkaline cleaning product that completely removes the coating.

Long-standing collaboration

O.M.SA.'s contribution was not limited to the supply of these two systems. "In 2021, when NOF Metal Coatings Europe approached us to become one of their licensees, we turned to O.M.SA. and OMSG, two of our long-standing suppliers, to analyse the project's feasibility. The former has been a partner of ours for more than twenty-five years, ever since we commissioned it with the first augers for a screw phosphating plant, and it has helped us choose the best technologies to adopt on several occasions. It was therefore natural to involve them in this new challenge. We also took part in a study on these coatings with the University of Trento: there are no other plants of this type in Italy and there were only four in Europe at the time, so we had

The paint stripping machine from O.M.SA.

some legitimate concerns. Thanks to their expertise, however, we could correctly assess this market's potential and design a highly flexible system. This DDS technology combines the advantages of spray application with those of traditional mass centrifuge treatment, providing a sustainable and highly efficient solution for applying zinc flake coatings. Water-based products also reduce the emission of volatile organic compounds (VOCs) and other harmful substances, contributing to a more environmentally friendly coating process. The hybrid technology of dipping and spinning ensures homogeneous thicknesses and complete coverage, even in areas that are difficult to reach with conventional spraying methods. The two-tier oven enables us to cross-link paint products at both low (80 °C) and high temperatures (350 °C), giving us maximum operational flexibility. In brief, our DDS plant not only improves our degree of coating quality but also the productivity and sustainability of our process, giving us a significant competitive advantage in the protective coating sector," Ambrosini summarises with satisfaction.

This DDS technology combines the advantages of spray application with those of traditional mass centrifuge treatment, providing a sustainable and highly efficient solution for applying zinc flake coatings.

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SCIENCE OUTLOOK

CorrSen monitoring system for coating and inhibitor testing

By **Kateryna Popova, Tomáš Prošek and Václav Šefl,**
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Department of Metals and Corrosion Engineering, University of Chemistry and Technology Prague, Prague, Czech Republic

The CorrSen corrosion monitoring system is the result of four-year cooperation between Gema Ltd. and the University of Chemistry and Technology (UCT) in Prague, Czech Republic. The system consists of resistometric sensors, small wireless loggers (**Figure 1**), a data transmission solution realized via a gateway or a mobile application, and a simple and user-friendly web interface for online data processing and presenting, as schematically shown in **Figure 2**.

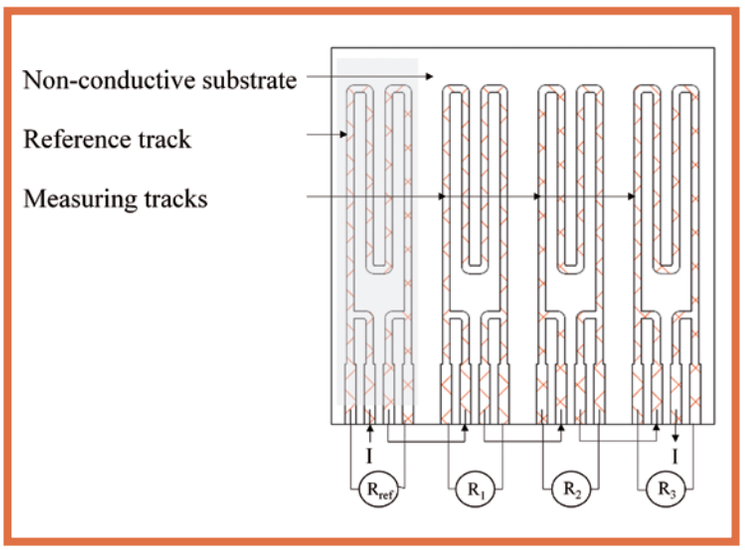
The operating principle of the system is based on the resistometric technique which involves applying a small current to a thin metal sensor exposed to a corrosive environment and measuring its electrical resistance [1, 2]. Corrosion of the sensing track leads to a reduction in its thickness, resulting in an increase of electrical resistance. CorrSen sensors consist of four metal tracks (**Figure 3**) [3]. One track is protected during the measurement and acts as a reference to compensate for the effect of temperature variations on the electrical resistance. Knowing the initial and reference resistance values, the cumulative thickness loss over time and the actual corrosion rate of the three measuring tracks can be calculated.

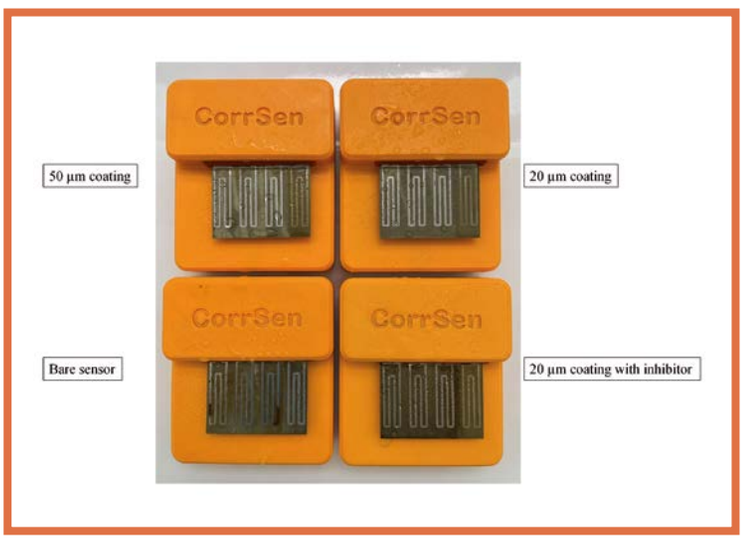
Gema Ltd. and the University of Chemistry and Technology (UCT) in Prague developed a new compact wireless device for real-time corrosion monitoring of coated metallic materials. The device's principle is based on the resistometric technique which involves applying a small current to a thin metal sensor exposed to a corrosive environment and measuring its electrical resistance.

The use of three sensing elements increases accuracy. Plotting the thickness loss data over time allows to follow changes in the corrosion rate in time. Ambient temperature and relative humidity (RH) are recorded simultaneously, allowing to assess the effect of climatic conditions on the corrosion response of the monitored material. The measurement is in principle not limited by the environmental electrical conductivity and can be carried out in both atmospheres and electrolytes, allowing to test materials in the actual operating conditions. The sensors are manufactured from a wide range of pure metals and alloys including carbon and stainless steel, zinc, aluminium, copper, silver and lead.

Figure 1 - CorrSen logger.

Figure 2 - CorrSen monitoring system.





Sensors of different thicknesses were designed to find the best compromise between high sensitivity and long life in the environments of varying corrosion aggressiveness. Continuous data transmission and displaying the real-time corrosion rate on the web interface provides operators opportunity of timely action eliminating the negative impact and cost of corrosion. Simplicity of the device set-up, installation and maintenance is particularly advantageous for industrial applications.

While originally developed to monitor corrosion of bare metal surfaces, the application of CorrSen has recently been extended to pre-corroded, pre-treated and coated materials. Research on coating and inhibitor efficiency testing is currently being carried out in collaboration between UCT Prague and Instituto Superior Técnico in Lisbon, Portugal. The aqueous acid-modified polyolefin dispersion CANVERA 1110 was chosen as a protective coating for the experiments. The coating, in two different thicknesses of 20 and 50 µm, was applied to a sensitive carbon steel sensor Fe-25µm with the track thickness of 25 µm to perform measurements in static and dynamic atmospheric conditions and in immersion. Along with the as-manufactured polyolefin coating, a coating modified with 1 wt.% tannic acid, selected as an environmentally-friendly corrosion inhibitor, is tested. The static atmospheric test is carried out under condensation conditions. The cyclic atmospheric corrosion test includes periodic phases of sodium chloride deposition, wetting at 77 % RH and drying in laboratory atmosphere with average RH of 45%. Sodium chloride solution with 0.5 wt.% concentration and natural pH is used as the medium for sensor immersion. The CorrSen loggers after an exposure in the cyclic atmospheric test and immersed in NaCl solution are shown in **Figure 4** and **Figure 5**, respectively.

Figure 3 - Resistometric sensor.

Figure 4 - CorrSen loggers exposed to the cyclic atmospheric corrosion test after the first chloride solution application and wet/dry cycle. Steel sensors protected by the coating appear intact, while the bare reference sensor is partially corroded.

Figure 5 - CorrSen sensors immersed in chloride solution. Using the cables to connect the sensors to the loggers allows corrosion monitoring in immersion and aggressive environments without damaging the measuring electronics.

Figure 6 - EIS measurement on resistometric sensors to ensure data comparability.

Exposure conditions	Coating	Total corrosion depth after 2 weeks of exposure [nm]
Immersion	50 µm	0*
	20 µm	260
	20 µm + inhibitor	0*
	Bare surface	10 970
Static atmospheric test	50 µm	2
	20 µm	2
	20 µm + inhibitor	0*
	Bare surface	> 25 000**
Cyclic atmospheric test	50 µm	< 1
	20 µm	16
	20 µm + inhibitor	< 1
	Bare surface	> 25 000**

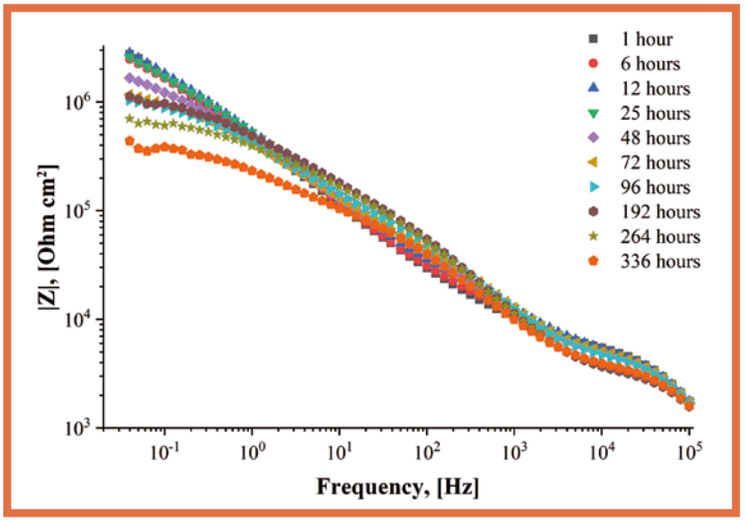
*below the detection limit
**sensor fully corroded in less than 2 weeks

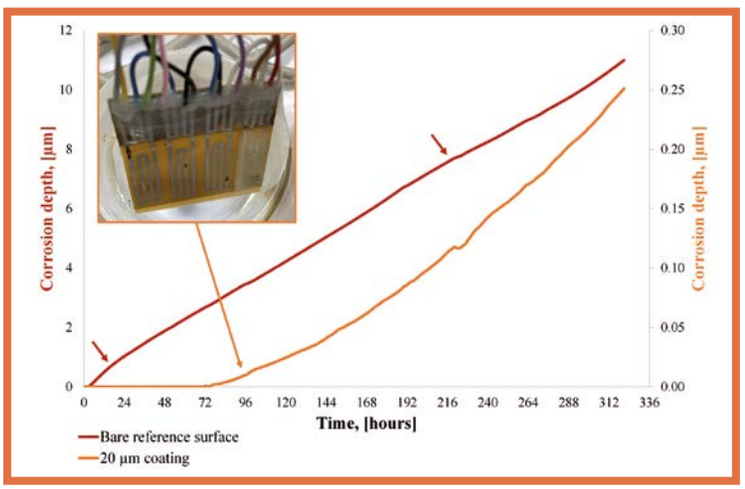
Table 1 - Total corrosion depth of 25 µm steel resistometric sensors as recorded after 2 weeks of exposure.

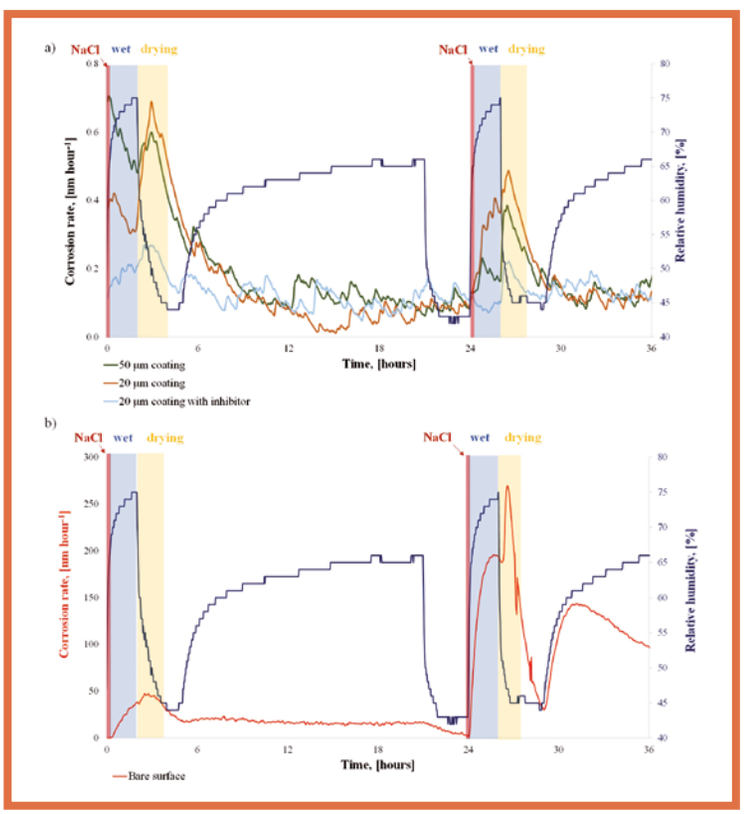
The main focus of the experiment is to detect the onset of coating degradation and to assess critical conditions leading to coating failure by analysing real-time corrosion rate data and climatic parameters. Electrochemical Impedance Spectroscopy (EIS) measurements are performed on the same substrates immersed in the salt solution as illustrated in **Figure 6** to compare the resistometric results with the traditional coating characterisation technique. **Table 1** gives a total average corrosion depth detected by the resistometric sensors after two weeks of exposure.

The results show that only very low or even non-detectable corrosion degradation has been recorded by the sensors covered with the thicker coating and the coating with inhibitor. **Figure 7** illustrates Bode plots of the sensor covered with 50 µm coating measured during the first two weeks of immersion in sodium chloride solution. Despite the slow decay of the low-frequency impedance modulus |Z| values, the coating still provides sufficient barrier protection to the steel substrate.

More significant thickness loss occurred on the sensors covered with the thinner coating without the inhibitor exposed in immersion and cyclic atmospheric test. For the non-coated reference sensors, the corrosion loss of the immersed sensor was almost half of its original thickness, whereas the two sensors exposed in static and cyclic atmospheric conditions totally corroded in less than two weeks.
The real-time corrosion depth curves measured during the immersion of the bare reference sensor and sensor covered with the 20 µm coating without the inhibitor are illustrated in **Figure 8**. Bare reference surface activated after 2 hours of immersion and continually corroded throughout the exposure reaching the total thickness loss of 10.9 µm after two weeks. During this time, slight decreases in the slope of the corrosion depth curve over time corresponding to the corrosion rate can be observed after 1 day (24 hours) and 9 days (216 hours) of exposure as marked with the red arrows, most likely correlating with the formation of corrosion product layer serving as a weak barrier and partly also to changes







in the electrolyte chemistry, especially in terms of the metal ion concentration. The sensor covered with the 20 µm coating was activated after 3 days (72 hours) of exposure indicating the beginning of coating deterioration and corroded gradually throughout the experiment reaching the total corrosion depth of 0.26 µm after two weeks of immersion.
The corrosion process of the coated sensors in static atmospheric conditions was very slow and steady and is thus not presented here. In contrast, cyclic atmospheric conditions of alternating wetting and drying resulted in short periods of significant corrosion rate increases illustrated in **Figure 9**.

The real-time corrosion rate record of the coated sensors shows that despite the sensors visually appeared intact (see Figure 4), short-term corrosion activation can be observed on Figure 9a during the first chloride application (time 0) and during drying after the sodium chloride application at 3rd and 27th hour. The corrosion activation during drying was also detected by the bare reference sensor with the effect being particularly pronounced during drying at 27th hour. This phenomenon can be explained by the formation of a thin, concentrated, highly corrosive surface electrolyte layer which allows unlimited supply of atmospheric oxygen and creates an extremely corrosive environment [2, 4, 5]. The absolute values of the detected corrosion rates correspond with the trends observed for the immersed sensors with the thicker coating and coating with inhibitor showing better protective ability. Moreover, an increase in corrosion rate of the sensor coated with the thinner 20 µm coating without the inhibitor during the wet cyclic test phases was observed starting from 4th day of exposure resulting in the higher corrosion depth (Table 1).

Figure 7 - EIS Bode plots for Fe-25µm sensor coated with 50 µm coating during the first two weeks of immersion in 0.5 % NaCl.

Figure 8 - Corrosion depth of bare reference sensor and sensor covered with 20 µm coating in immersion. The detail illustrates visual appearance of the covered sensor after 4 days of exposure, where corroded areas can already be observed in agreement with the detected increase in corrosion depth.

Figure 9 - Real-time corrosion rate curve of the a) coated sensors and b) bare reference sensor exposed in the cyclic atmospheric corrosion test during the first 36 hours of exposure. Red, blue and yellow rectangles mark NaCl application, wet and drying phases, respectively.

It is also worth noting that the curves measured with the coated sensors appear to be noisier compared to the one measured with the bare reference sensor. However, the difference is given by the extremely low corrosion rates measured for the coated samples, in order of Ångströms per hour, at the detection limit of the technique.

The ongoing results show the importance of testing the protective properties of coatings and inhibitors in cyclic atmospheric conditions which often better reflect the real operation environment of the coated structures, together with the well-established experiments in immersion. CorrSen real-time corrosion monitoring system allows for the highly sensitive measurement in both atmosphere and electrolytes providing an important information on the coating behaviour in dynamic exposure conditions. It is an interesting supplementary method to traditional testing techniques. The system has a great potential for scientific and technical applications during coating development, testing and operation.

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SUCCESS STORY

New hangar floors reflect owner's commitment to quality

Sherwin-Williams provided its coatings to protect flooring of two new hangars at Atlantic Aviation's airport in Scottsdale, Arizona (United States).

When Atlantic Aviation was planning the construction of two new hangars for its Scottsdale (Arizona) location, the company knew its choice of hangar flooring was important.

Having the right hangar floor coating system plays an essential role in creating a beautiful, safe and functional space where clients can feel confident housing and servicing their prized aircraft.

As one of the industry's largest aeronautical ground support companies, or "fixed-base operators" (FBOs), Atlantic Aviation operates at more than 100 airports around the United States. Fuelling, tie-down and parking, and aircraft storage and maintenance, as well as myriad pilot, crew and passenger amenities are among the services offered.

Long-term performance and enduring aesthetics are crucial considerations when selecting a hangar flooring system. The coatings must protect the concrete slab from exposure to harsh aircraft fluids such as jet fuel, Skydrol® and maintenance chemicals, as well as ongoing foot and wheel traffic. Concrete moisture and moisture vapor transmission are among the many other factors at play. New moisture barrier primer technology can alleviate concerns of coating system damage caused by slab moisture.

Sherwin-Williams Resuflor™ Performance HPS with Resuprime™ MVB moisture vapour barrier meets these requirements and more. As explained by Arizona Epoxy Systems owner, Steve Durgarian, the concrete coating system has long been Atlantic Aviation's hangar flooring of choice due to its durability, ease of maintenance and slip-resistant technology. The decades-long track record of success in untold numbers of air hangars throughout North America, combined with the Sherwin-Williams team of aviation industry experts, technical service professionals and a network of highly experienced hangar floor installation contractors contribute to the exceptional value that Resuflor Performance HPS delivers to aviation facility owners.

In addition, the Light Gray colour and glossy finish selected by Atlantic increase the floor's ability to reflect overhead lighting, thus helping enhance room illumination, visibility and safety.

Thanks to the skilled installation by Arizona Epoxy Systems using Sherwin-Williams industry-leading coatings, Atlantic Aviation is extremely satisfied with its beautiful new hangar floors, which are in keeping with the FBO's reputation for quality and attention to detail. Along with Sherwin-Williams High Performance Flooring, the manufacturer's Pro Industrial™ coatings were also utilized during the hangars' construction. Rick Wielebski, Atlantic Aviation General Manager, stated, "Sherwin-Williams offers a premium product portfolio for all surfaces within an aviation hangar, making them the total coatings solutions for this industry."

PROJECT HIGHLIGHTS

CUSTOMER: Atlantic Aviation
LOCATION: Scottsdale airport in Arizona
SCOPE: Coat two 30,000-square-foot (about 2,787 m2) hangar floors, new construction
INSTALLER: Arizona Epoxy Systems, Tempe, AZ
GENERAL CONTRACTOR: JE Dunn Construction, Kansas City, MO
DESIGNER: DWL Architects, Phoenix, AZ
SYSTEM INSTALLED: Resuflor™ Performance HPS in Light Gray with moisture vapour barrier
SURFACE PREP: Shot blasted to meet ICRI CSP 4, as required for the selected primer
PRIMER: Resuprime™ MVB Moisture Vapor Barrier Epoxy at 17 mils (0.43 mm) — 640 gals (about 2,422 litres)
MIDCOAT: Resuflor MPE Ultra-High Solids Epoxy at 20 mils (0.58 mm) — 600 gals (about 2,271 litres)
TOPCOAT: Resutile™ HPS Chemical Resistant Urethane w/glass bead slip-resistant aggregate at 3 mils (about 0.076 mm) — 120 gals (about 454 litres)
ADDITIONAL PRODUCTS: Sherwin-Williams Pro Industrial™ High-Performance Coatings for concrete walls and metal panels.

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COVER STORY

An innovative side extraction system in a new coating booth for SBB's rolling stock

by **Monica Fumagalli, ipcm®**

The main workshops of the SBB (Swiss Federal Railways) in Bellinzona, responsible for the maintenance of the company's fleet, recently pioneered a significant innovation in the field of booth air treatment. In collaboration with Eurotherm, the Italian plant engineering company that won the tender to supply SBB's three maintenance sites with new coating systems, they installed a booth with a side extraction system that not only guarantees flexibility and energy savings but also avoids the need for excavations to build a floor system, thus also speeding up delivery and meeting the tight deadlines.

"L'arrivée d'un Train en Gare de La Ciotat" by the Lumière Brothers, one of the very first films screened in public in 1896, is a 45-second short showing the arrival of a train pulled by a steam locomotive at the railway station of the coastal town of La Ciotat, near Marseille, in France. Legend has it that some spectators in the auditorium, attending a film screening for the first time, ran away because they were frightened by the illusion of a moving train seemingly about to come out of the screen.
It was with these early experiments that the history of cinema began. But why did the Lumière Brothers choose a train as the subject of their first cinematographic endeavours? Because the train was, and still is today, synonymous with movement, speed, and... innovation.

The construction of railway networks travelled by freight trains and passenger carriages in the first half of the 19th century changed the economic and social face of the industrialised world of the time, speeding up connections and expanding geographical horizons. Today, the country that holds the record for train travel in Europe is Switzerland. According to one of its latest press releases[1], Schweizerische Bundesbahnen AG (SBB), the public company controlled by the Federal Council that acts as the infrastructure manager and principal operator of this nation's rail network, ended 2023 in the black for the first time since 2019, in the pre-Covid period, thanks to a new record number of travellers.

The rolling stock owned by SBB, which includes electric multiple units, freight wagons, and special-purpose infrastructure vehicles, reflects the diversity of an integrated railway company. "The train," the statement reads, "is a climate- and land-friendly means of transport and will continue to play a central role in the global mobility of the future. At the same time, due to increasing demand, the capacity of railway nodes and the complexity of the system are reaching their limits. In order to meet these challenges, based on the RAIL 2050 perspective formulated by the Federal Council, SBB is developing a long-term strategy for its railways, which will ensure more flexible, frequent, and fast connections."

To ensure such growth, however, the light and heavy maintenance of rolling stock calls for enhanced technologies and structures to guarantee the resistance of components against corrosion and wear and prolong their use as much as possible. Railway rolling stocks and their components are exposed to the atmospheric agents of the environment in which they operate, temperature changes, and humidity: therefore, if not adequately protected, they are subject to corrosion that can cause damage and, in the worst cases, even serious accidents. To avoid this risk, rolling stock must be protected with specific treatments enabling it to withstand corrosive stress throughout its entire nominal service life. Therefore, appropriate design and maintenance solutions must be chosen to achieve effective corrosion protection.

[1] https://news.sbb.ch/it/media/articolo/127444/ffs-di-nuovo-in-attivo-grazie-al-record-di-viaggiatori

"Most of the work we do here, at the Bellinzona SBB workshops," says Marco Siccardi, Project Manager of SBB (the German acronym by which the Swiss Federal Railways are identified), "relates to the heavy maintenance of railway vehicles. That means carriages and components must wait here for months for the maintenance activities to be completed as planned, in contrast to light maintenance, where partial intervention is possible each time a convoy reaches the station until completion." When a train reaches the workshop, it is disassembled, and the wagons and other components are subjected to various repairs, including recoating. "One of our most recent investments was for a new liquid paint application and drying booth. Our company put out a public tender, which was won by Eurotherm Spa (Volpiano, Turin, Italy). This Italian company thus supplied us with a flexible plant with a totally innovative side extraction system."

The Swiss Federal Railways' fleet

In 2023, the rolling stock owned by SBB amounted to 691 electric trains, 219 shunting locomotives, and 172 self-propelled special-purpose infrastructure vehicles, totalling 1,916 passenger carriages and 4,518 freight wagons[2]. "SBB has three train maintenance industrial hubs in Olten (one of the most important railway hubs in Switzerland, where mainly passenger trains are maintained), Yverdon-les-Bains (in the canton of Vaud), and here in Bellinzona, where maintenance work is carried out on passenger trains," explains Siccardi.

[2] https://reporting.sbb.ch/en/rolling-stock?highlighted=&scroll=700&sv_lang=3&sv_lang_change=true&years=1%2C4%2C5%2C6%2C7

From top left clockwise:
The exterior of the coating booth with the side air treatment system designed and installed by Eurotherm.

The booth can accommodate one carriage at a time.

The shutter at the entrance to the booth.

The liquid application chamber.


PaintingAREA


PaintingAREA

The Eurotherm booth's side extraction system enabled to avoid excavations for the construction of a floor system, as is typical with this type of booth, thus speeding up delivery times.

"Our rolling stock maintenance department is located underneath the railway station, from where convoys of a minimum of 7 and a maximum of 11 carriages travel directly to the underground floor along a track built especially for this purpose. We perform maintenance on all kinds of internal and external components." After the total dismantling of the wagons, the required restoration work mainly related to corrosion issues and any modifications are carried out, followed by shot blasting, recoating with water-based paints, and drying, before final reassembly.

The future of the Bellinzona SBB workshops

"The Bellinzona SBB workshops," Siccardi notes, "will be soon relocated from this long-standing site to a new area. After more than 135 years of activity in the heart of Bellinzona, the need has arisen to relocate the structure, which is no longer suited to meet the new requirements of the transport sector in the long term. After careful consideration, the choice of the new location fell on an area in the municipality of Arbedo-Castione, located a short distance from Bellinzona. That will free up a large area of around 120,000 m^2, where around 500 people are currently employed,

A carriage ready for paint application and a stage in the application of the white primer.

offering the chance to build a model district from scratch that will transform the surface currently occupied by the SBB workshops into a driver for the city's urban development. At the same time, the new premises in Arbedo-Castione will allow a wide range of work to be carried out, with a focus on light and heavy maintenance of rolling stock, especially in the passenger train sector. With this project, SBB intends to build a new industrial hub that is socially, environmentally, and economically sustainable."

SBB's plan for new coating plants

SBB had put out a tender for installing new coating booths in Olten and Yverdon-les-Bains and building two coating plants on the new site in Arbedo-Castione. Siccardi confirms: "No new booth was intended to be acquired for the Bellinzona workshops because, with the site expected to be decommissioned, it would have made no sense to invest in a new system at the moment. However, since the beginning of 2023, we have been working on a renovation project for the Astoro fleet, a group of electric trains undergoing a wide-ranging renovation, upgrading, and recoating process whose completion is scheduled for 2027, and we needed to upgrade our paint shop to do this with excellent results. We had initially considered installing an inexpensive booth with essential features precisely because of the temporary nature of the plant, but we soon realised that we could not have achieved the required level of quality and, therefore, opted for a more professional system."

The new Eurotherm booths were to be installed first in the workshops in Olten, then in Yverdon-les-Bains, and finally in the new plant in Arbedo-Castione. However, as Siccardi illustrates, "the workshops in Bellinzona urgently needed one, so we required it before the other maintenance sites: we started working with Eurotherm in October 2023, and on 1 May 2024, the booth was already installed at our premises." That was also possible thanks to an innovative feature designed by this Italian plant engineering company: the booth's side extraction system enabled to avoid excavations for the construction of a floor system, as is typical with this type of booth, thus speeding up delivery times.

The new coating booth

"The liquid paint application and drying booth we designed and installed at the Bellinzona industrial workshops," states Eng. Davide Quartana, Project Manager at Eurotherm, "was conceived specifically for the railway sector and can accommodate both components and actual carriages. The challenge the customer presented us with was twofold: it required a flexible solution to coat different types of rolling stock, and it wanted to avoid building work for its construction, since it is a booth for an existing plant.

The control display for automatic management of booth parameters.

Our technical team, therefore, customised the line by equipping it with a side extraction system partitioned into three distinct sectors: a series of extraction walls with a total length of 34 metres on both sides virtually divides the booth into three segments, each managed by an air handling unit (AHU) to guarantee recirculation over the three zones with the possibility of managing each zone independently. During coating, the operation of the extraction system is constrained by the operator platform's positioning, which means that only two of the three available air handling units are active at the same time. Moreover, in addition to the 60 °C-drying function, the booth has a controlled temperature and humidity management system."

A completely independent extraction system

"After preparing each wagon for the coating stage by cleaning its surfaces and shot blasting them if required," emphasises Quartana, "the customer applies three colours (white in two coats, blue, or red) and two lacquered layers. Thanks to the extraction system's advanced 4.0 software, the operators can adjust different parameters to manage the temperature-controlled surface preparation and application phases. Air supply comes from the roof through a plenum space that is also accessible from the platforms to facilitate maintenance work. With this system, air is taken directly from outside the factory, poured into the plenum space via an extractor fan, and introduced by high pressure. The air thus enters the coating chamber and, after being filtered, heated or cooled, and humidified at constant values, it is always

Three colours can be applied on the wagons' exteriors: white, blue, and red. The booth is designed to flexibly coat rolling stock in any size.

expelled outside, creating a cycle that is totally independent of the factory's internal environment."

Each of the three AHUs is equipped with an automatic water system to cool or heat the air according to the seasonal outdoor temperatures, so that the booth maintains a constant temperature range throughout the year. "The operator simply enters the parameters from the touch panel of the control PLC to automatically set the required temperature," indicates Quartana. "The water chiller was designed and manufactured by Eurotherm, whereas hot water is supplied directly by the SBB workshops and distributed to the various batteries via servo-controlled valves." Each of the three AHUs is also equipped with a system for controlling the humidity level through an osmosis water plant, which prepares the water to be atomised inside the unit, whereas humidity sensors are placed directly in the plenum space.

"Another interesting aspect of this air treatment plant is that, due to its enormous size, we had to resort to a helicopter to place its chimneys outside our building, a procedure that is quite common in a factory with oversized equipment such as the Bellinzona workshops."

The advantages of the new solution

"In addition to the flexibility of the plant, which enables us to coat any type of rolling stock, from entire wagons to the smallest components, there are two aspects that we particularly appreciated in the design of this booth," says Siccardi. "One, as already mentioned, is the innovative side extraction system that eliminated the need for excavations to install a floor system – which in an already existing factory is a complex operation and can lead to long production stoppages – thus reducing costs and simplifying maintenance, which can take place at the floor level. The other relates to energy savings: partitioning the booth into three zones with three independent AHUs means that only two out of three air handling units are activated at the same time, i.e. those in the area where operations are actually taking place, ensuring significant savings in terms of energy consumption."

Innovation that breaks new ground

"Eurotherm's team," adds Quartana, "is going to inaugurate the construction site for the paint shop at the Olten site in October. It will include a shot blasting booth and two coating booths similar to the one installed in Bellinzona but with a floor extraction system. Finally, the Arbedo-Castione plant will have a shot blasting booth, booths for preparing the wagons and components, and two coating booths. The work carried out so far has been challenging due to the tight schedule, and we would not have been able to

meet the deadlines and complete the job in the best possible way without the invaluable cooperation of the specialised train maintenance technicians of the Bellinzona workshops."
"SBB is mobilising to purchase new rolling stock and renew its fleet," says Siccardi. "The number of passengers and goods handled by our railway network is constantly increasing. For example, this is borne out by the fact that not long ago, we had to carry out major maintenance work on some old carriages that had to be put back on the tracks to cover the morning and evening rush hours at Zurich station. Our work is essential not only to bring these worn-out vehicles back to life but also to ensure their excellent durability. That is why we must be put in a position to work with the best plant engineering and technological solutions, as was done here in Bellinzona. This project was an important turning point because SBB now knows it can take into consideration booths with similar characteristics to the one built here for future investments. This system's performance is such that we will keep some parts of it in the new premises in Arbedo-Castione: we plan to move the booth's external structure there and adapt the machine's equipment to the new spaces, also to recover a part of our investment."
More and more people are choosing the train as a means of transport because it is considered more sustainable and convenient for covering long distances than cars or planes. That is why it is safe to predict that the number of travellers and the amount of goods transported by these vehicles is going to increase exponentially in the coming years – and, with them, the required rolling stock. Therefore, its maintenance, upgrading, and recoating will play an increasingly strategic and decisive role, making innovative solutions that can facilitate these interventions indispensable for the sector.

The number of passengers and goods handled by Swiss railway network is constantly increasing. Recoating operations are essential not only to bring worn-out vehicles back to life but also to ensure their excellent durability.

A door coated red.

From the left, Alessia Venturi from ipcm®, Marco Siccardi from SBB and Davide Quartana from Eurotherm.

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ASSESSMENT OF CORROSION BEHAVIOUR OF SOME ALUMINIUM ALLOYS VIA ELECTROCHEMICAL AND FREE CORROSION TESTS IN ACIDIC AND NEUTRAL ENVIRONMENTS

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The corrosion behaviour of four commercial aluminium alloys, extensively employed in engineering applications, was evaluated by means of electrochemical and free corrosion tests in order to compare their performances in both acidic and neutral environments. The electrochemical parameters obtained via cyclic potentiodynamic polarisation were compared with the corrosion features observed on these alloys after free corrosion tests. Different morphologies and damage extents were identified on these samples and upon the aggressive environment and the results were related to the chemical composition of the alloy and the corrosion and passivation mechanisms.

The reduced availability of primary mineral resources as well as the growing environmental concerns about mining and disposal of metal commodities make unavoidable the embracement of more sustainable consumption practices. In this optic the use of non-scarce mineral resources and the prevention of corrosion effects which extend the working life, is highly desired. For such reason, the use of aluminium alloys is currently experiencing a continuous increase for widespread applications. In some of them aluminium made items could be in contact with human skin such as robotic surgery, rehabilitation equipment, watchmaking etc. Therefore, for these applications, the corrosion behaviour in acidic complex environments such as human sweat is of paramount importance. Corrosion behaviour is currently assessed by means of accelerated and/or electrochemical-based tests [1-4] which can provide, in a very short time, evidence about the corrosion tendencies [4-11].

Cyclic potentiodynamic polarisation (CPP) technique, is one of these techniques and probably the most suitable to investigate materials with active/passive behaviour and, more in general, localised corrosion phenomena [12,13]. Despite the high versatility, results of CPP are affected by several experimental parameters [14-17] needing an appropriate experimental set-up, as described in the ASTM G61 test [5].

In principle, by means of CPP, it is possible to detect the potential value at which the passive layer become unstable and undergoes severe damage [18], but it also can give mechanistic information about the corrosion phenomena [19]. That may be used to rank the corrosion tendency of metallic materials [4,19-22]. In CPP the potential scan usually starts near the open circuit potential (OCP) value and reaches an anodic potential than, the scan is reversed and stopped close to the cathodic potential at which the current changes sign from anodic to cathodic [19]. The current values at which the scan is reversed (i_{rev}) may be dependent on the nature of the analysed material and generally, 5mAcm^{-1} is considered a suitable value [21]. It is well known that discrepancies between free corrosion and electrochemical tests can be present in case of passive materials. That is related to the stability and recovery capability of the passive layer. Indeed, the backward or reverse scan, may present some peculiar features that are directly connected to the tendency of a material to undergo pitting or SCC corrosion [14,24,25]. Previous studies have investigated the processes taking place during the reverse scan aiming to rationalise the experimental data [14,21-26]. However, even if many electrochemical parameters are easily achievable, their physical meaning is not always straightforward. Just to say one, the sign of the hysteresis loop was proposed as related to surface acidification [16] or to the incipit of localised corrosion [27]. Regarding the pit transition potential (E_{ptp}) it was found to be practically unaffected by environment conditions [15] while, the difference between pitting potential (E_{pit}) and E_{ptp} is dependent to the pit micro chemical environment, and it could be used as an indicator of pitting susceptibility [21]. Some studies have compared the data obtained from CPP with the data from free corrosion tests [22] but, to the best of our experience, these are limited to neutral saline environments and no data are available for artificial sweat. In this work we compare corrosion behaviour of aluminium alloys in neutral and artificial sweat environments using both electrochemical and free corrosion approaches.

Experimental procedures

Samples preparation and inspection

Samples consisting of 1 mm thick 25x25 mm tokens of commercially available aluminium alloys (chemical composition as determined by XRF-WDS (Rigaku ZSX Primus II) is depicted in **Table 1**) were polished with emery paper down to 1200 grit, rinsed in distilled water, acetone and then air dried.

Alloy designation	Composition (w%)									
	Si	Fe	Mn	Mg	Cu	Zn	Cr	Ti	V	Al
AA1200A	0.46	0.29	n.d.	0.25	n.d.	n.d.	n.d.	n.d.	n.d.	99%
AA5182-O	0.13	0.26	0.39	4.4	0.06	0.01	0.01	0.02	0.01	balance
AA6008	0.64	0.2	0.12	0.47	0.18	n.d.	n.d.	n.d.	0.07	balance
AA6351 - T6	0.85	0.27	0.71	0.45	0.04	0.07	n.d.	n.d.	n.d.	balance

Table 1. Designation, chemical composition (Wt%) and hardness of the 4 commercial alloys tested.

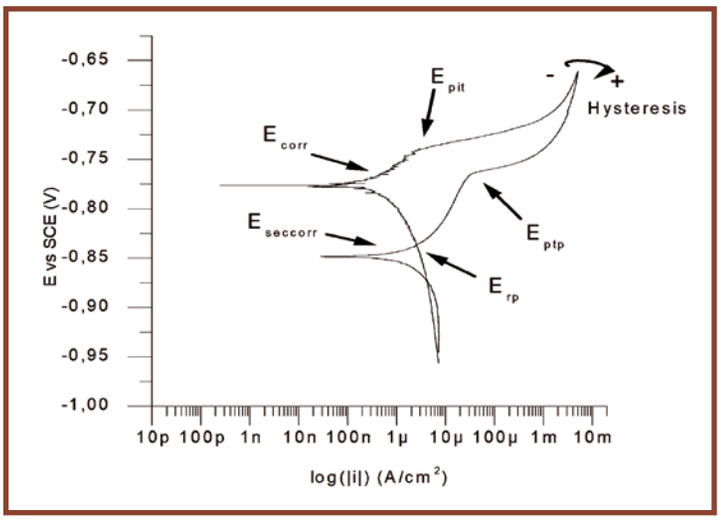


Figure 1 - Typical CPP curve with indication of the parameters taken into consideration in this work. E_{corr} is corrosion potential, E_{pit} is pitting potential, E_{ptp} is pit transition potential or the change in slope during the backward scan, E_{rp} is the repassivation potential or the potential at which inward and backward scan crosses, $E_{seccorr}$ identified at the current's change in sign during the backward scan.

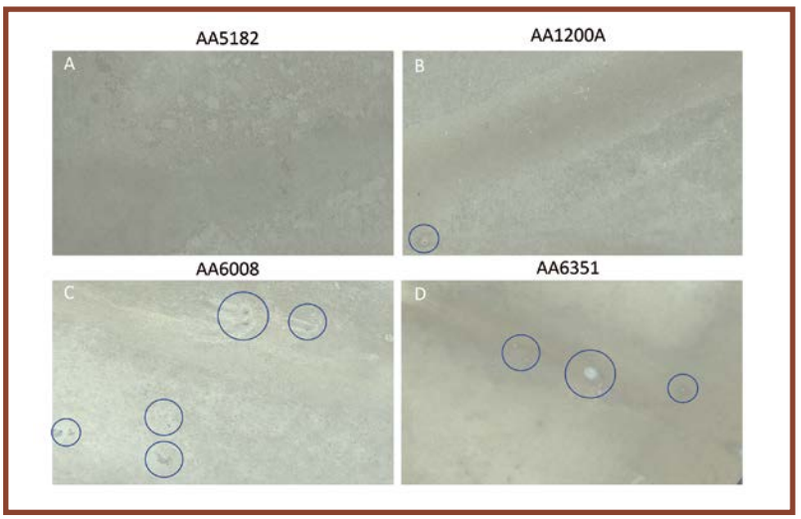


Figure 2 - Digital macro images of sample surface after salt spray test for 28 days. Blue circles identify the main corrosion features detectable.

After exposure to aggressive environments, the samples were washed with demineralized water, air dried and investigated by means of digital magnifier (OCULUX Macro Zoom, Microconsult), optical microscope (Nikon eclipse LV 150 NL) and scanning electron microscope (SEM, HITACHI 2300).

Free corrosion tests

Free corrosion tests were carried out in triplicate (three samples for each alloy) via both salt spray and contact modes. Salt spray test was achieved using a spray cabinet (Angelantoni model DCTC600) employing a 1L/h flux of nearly neutral saline solution containing 5% w/w NaCl at 35 °C. The control was performed at 24h, 48h, 96h and 7, 14, 21, 28 days (end of the test). Contact tests were performed in artificial sweat obtained by dissolving 5g/L of Urea, 20g/NaCl, 17.5g/L NH_4Cl, 2.5mL/L acetic acid, 15mL/L (S)-lactic acid in deionized water and the pH is adjusted to the value of 4.7 with a solution of 80 g/L of NaOH (analaR Normapur). The tests were realised in a home-built climatic chamber capable of maintaining 50 °C (±2 °C) and 100% relative humidity, by placing the samples on a cotton swab soaked with artificial sweat and located in a Petri dish. One of the two surfaces was exposed to the condensing vapours while the other was in contact with the cotton swab. The corrosion features check was done at 24 and 48 hours (end of the test).

Electrochemical tests

A computer controlled potentiostat (Autolab, Metrohm) controlled via Nova electrochemical software (2.1) and a three-electrode corrosion cell (EG&G Parr Flat cell) constituted the electrochemical set-up. Samples alloy constitute the working electrode, 1 cm^2 exposed area, while a platinum grid and a saturated calomel electrode (SCE) constituted counter and reference electrodes, respectively. All the tested samples reached stable potential with a variation smaller than 5mV/min within 600 seconds and cyclic polarisation curves (CPPs) were recorded at a scan rate of 0.1667mV/s from -0.2V vs OCP up to the potential's value corresponding to a current of 5 mA/cm^2 were the scan was reversed. In artificial sweat solution, the CPP curves were performed from -0.2V vs OCP toward an anodic direction until 15 mA current is reached, then the scan is reversed. The experimental parameters obtained from such experiments are schematized in **Figure 1**.

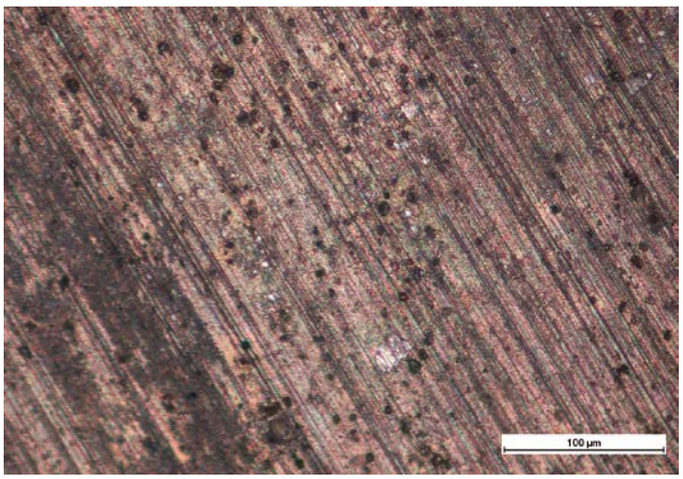
Results

Salt spray free corrosion tests

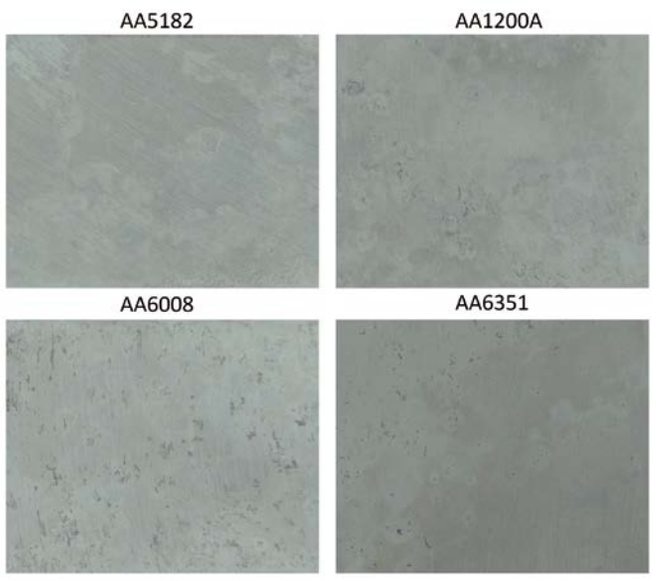
Representative images of the sample surface after 28 days of exposure are depicted in **Figure 2**. All the samples but AA5182 showed a rapid onset of corrosion pits whose number increases as a function of the exposure time, leading to a marked change in surface's appearance. There are significant differences among the tested alloys, from which the following rank AA6008 > AA6351 > AA1200A > AA5182 can be defined. The most performing alloy (AA5182) displays only few small pits compared to the other alloys, as evidenced in Figure 2 and **Figure 3**.

Artificial sweat solution

As expected, in artificial sweat, the corrosion features become more evident than in the neutral environment. Just after 48 hours the samples present large areas macroscopically stained and visibly damaged (**Figure 4**).



3 - Optical microscope images comparing the surfaces of AA5182 (left) and AA6008 (right) samples after 4 weeks of NSS. Ruler size, 200 µm.



4 - Optical examination of samples surface after 48h exposure to artificial sweat. AA5182 alloy resulted the less affected by corrosion phenomena.

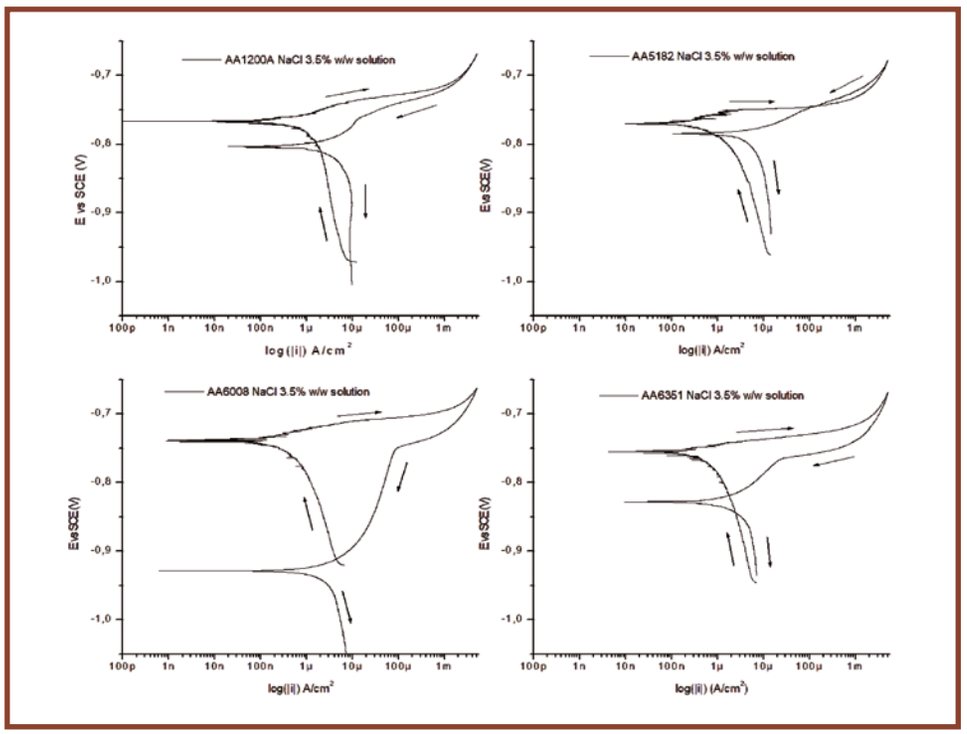


Figure 5 - Tafel plot of the data collected from CPP in aerated 3.5% NaCl solution. Arrows indicate the potential scan direction.

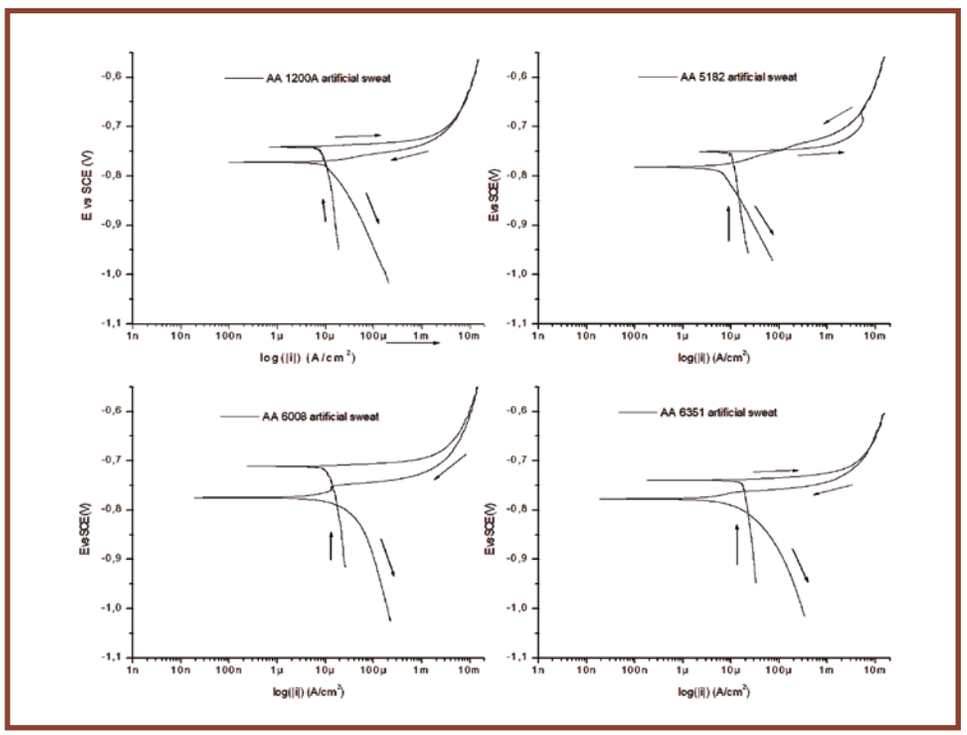


Figure 6 - Tafel plot of the data collected from CPP in artificial sweat solution. Arrows indicate the potential scan direction.

However, also in this environment, AA5182 alloy resulted the less affected by corrosion phenomena.

Cyclic potentiodynamic polarisation tests

The cyclic potentiodynamic polarisation curves performed in the neutral saline environment are depicted in **Figure 5**, while the ones collected in artificial sweat are represented in **Figure 6**. It is worth noting that, among the tested alloys, there are significant differences in the backward scan. In saline neutral environment repassivation and pit transition potentials are located some tenth of mV far from each other, while in artificial sweat solution their value is almost coincident. Going into more detail, the forward scan of the cycled polarisations depicted in figure 5 show modest differences among the tested alloys. The E_{corr} and E_{pit} values fall within a 30mV range, giving poor information about the alloy's stability in this environment. The value of pit transition, passivation and the secondary corrosion potentials were similar, but despite this closeness, their relative position confers to the entire scan a well differentiated shape. Regarding the hysteresis, all the tested alloys but AA5182 presented a positive loop.

The shape of the CPP curves registered in artificial sweat present peculiarities respect the curves collected in neutral saline environment as highlighted by the example depicted in **Figure 7** which, for the same alloy (AA6008) the CPP curves are compared. It is evident as in artificial sweat pitting and corrosion potentials coincides (see Figures 6 and 7). Moreover, the curves collected in artificial sweat presented a well differentiated reverse scan, showing values that are close only for pit transition potential and for the hysteresis sign. E_{rp} and E_{ptp} are relatively close each other except in the case of AA5182, and the corrosion phenomena take place at more cathodic values that, albeit different, are closer to the repassivation potential with respect to the ones determined in neutral saline solution.

SEM and optical investigation of corroded samples

During exposure tests in the neutral saline environment, corrosion byproducts tend to accumulate on the surface leading to the formation of deposits which can occlude the pits (**Figure 8**). AA6351 behaves similarly to AA6008, while AA1200A is characterised by a larger number of surface cracks with only small pits. AA5182 presents an almost undamaged surface.

Vice versa, in acidic environment, the amount of saline byproducts was dramatically reduced. AA6008 displayed the largest corrosion degree characterised by the presence of two distinct corrosion features: a) highly fractured layer and b) deeply eroded portions of the surface (**Figure 9**). Similar features were displayed by AA6351, while the AA1200A alloy presents tiny pits and the AA5182 results mostly unaffected by corrosion phenomena.

Discussion and conclusions

As evidenced in the previous paragraph the complex behaviour of the passive layer makes the use of $E_{corr,}$ E_{pit} and OCP alone insufficient to correctly predict the alloy sensitivity to localised corrosion susceptibility. To overcome this issue, delta potentials values, which are achievable from CPP tests, have been extensively studied in the last 50 years. In particular we focus on a serie of deltas as defined in the following: a) $\Delta E_{ps} = (E_{bd(pit)} - E_{ptp})$ [21] (we named it pitting stable (ps)), that represent the potential range from the pitting outbreak until the point of repassivation due to the occlusion of the pits via accumulation of corrosion byproducts; b) $\Delta E_{pp}=(E_{bd(pit)} - E_{rp})$ [23] (we named it pit progression (pp)), that is the potential span from the pitting outbeak to the point of surface repassivation; c) $\Delta E_{corr} = (E_{corr}$ and $E_{seccorr})$[28] (we named it corrosion's delta), determined as the difference between the corrosion potentials in the forward and the backward scan; d) $\Delta E_{pspe} = (E_{corr}$ and $E_{rp})$ (we named it pitting start - pitting end (pspe)),

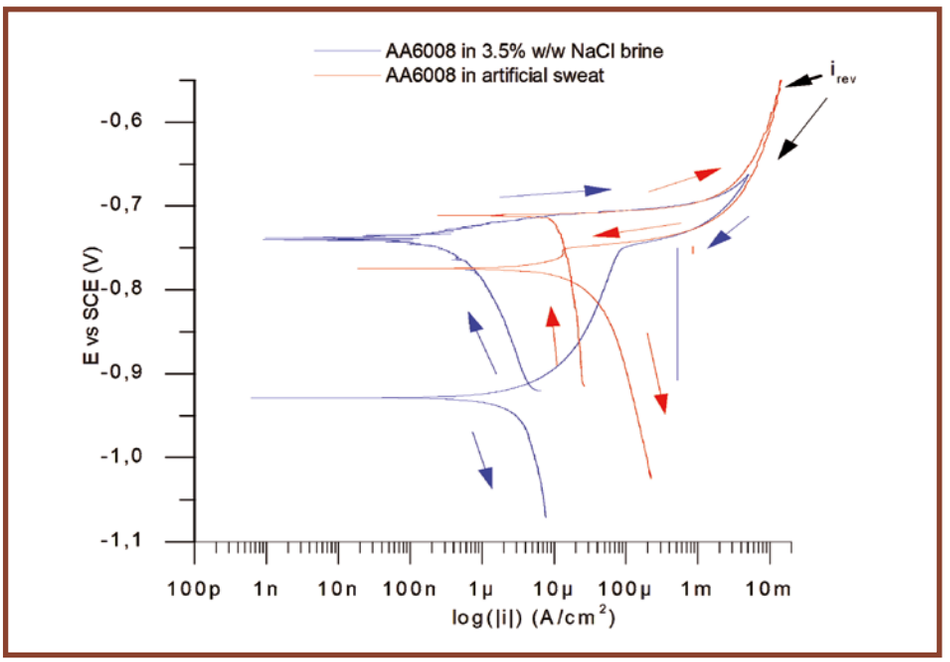


Figure 7 - CPP of AA6008 performed in neutral NaCl solution (blue line) and artificial sweat (red line). Moving from neutral to acidic environment makes the pitting and corrosion potentials to coincide and the entire curve shifts to higher current's values.

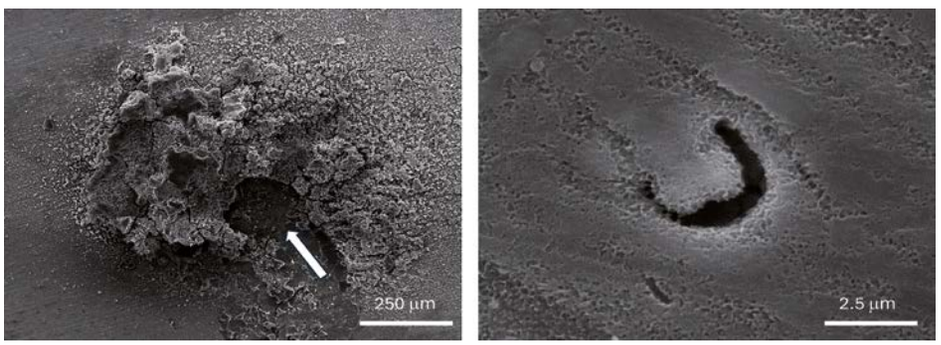


Figure 8 - Corrosion pit on AA6008 after 4 weeks of exposure to salt spray test. (left) The pit is not completely occluded by the corrosion by products (ruler 250 µm). (right) A small open pit free of deposits (ruler 2.5 µm).

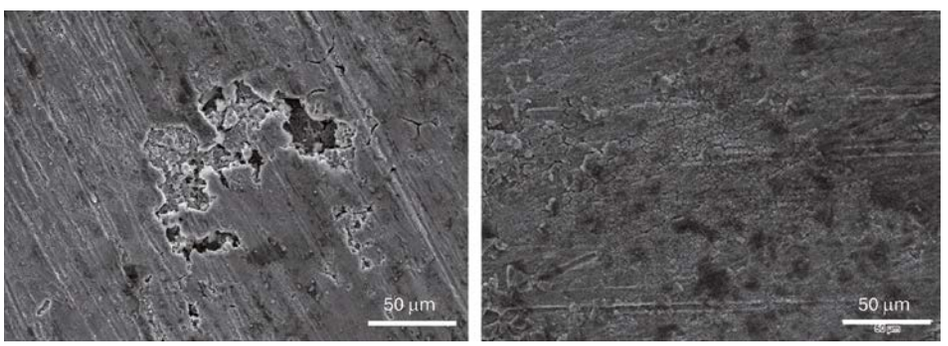


Figure 9 - SEM Images of different parts of AA6008 surface showing IGC features (left), and cracked oxide layers (right). Ruler = 50 µm.

Alloy	ΔE_{ps} NaCl (mV)	ΔE_{ps} a.s. (mV)	ΔE_{pp} NaCl (mV)	ΔE_{pp} a.s. (mV)	ΔE_{pspe} NaCl (mV)	ΔE_{corr} NaCl (mV)	ΔE_{corr} a.s. (mV)	Hysteresis sign
AA1200A	+16 ± 2	+15 ± 1	+57 ± 2	+29 ± 1	+42 ± 2	+51 ± 2	+30 ± 1	+
AA5182	-9 ± 1	-15 ± 2	-8 ± 1	-10 ± 3	-27 ± 2	+31 ± 2	+30 ± 3	-
AA6008	+32 ± 2	+41 ± 1	+198 ± 8	+46 ± 5	+188 ± 4	+211 ± 7	+63 ± 2	+
AA6351	+26 ± 3	+28 ± 2	+84 ± 8	+27 ± 3	+74 ± 2	+81 ± 2	+39 ± 2	+

Table 2: Delta values determined via CPP in the two test solutions. $\Delta E_{ps} = (E_{bd(pit)} - E_{ptp})$, $\Delta E_{pp} = (E_{bd(pit)} - E_{rp})$, $\Delta E_{corr} = (E_{corr}$ and $E_{seccorr})$, $\Delta E_{pspe} = (E_{corr} - E_{rp})$, NaCl stands for 3.5% sodium chloride, a.s. stands for artificial sweat.

the range of potentials from pitting from onset as a metastable phenomenon until the surface repassivation potential.
The experimental value of these parameters are summarized in **Table 2**.
We also account the hysteresis sign as positive the one formed after current's increase following the scan reversal (see Figure 6A for a positive sign and Figure 6B for a negative one). The positive sign has been interpreted as associated to the localised corrosion attack and the negative one as the substantial protection against this phenomenon. The identified ΔE trace back their meaning to a physical interpretation, some are identified by the mixed potential theory (corrosion and secondary corrosion potentials), others are more related to the corrosion mechanism (pitting, breakdown, pit transition etc) or surface passive layer restoration (E_{rp}). Pitting potential is dependent on the state of the passivating layer with little regard to its thickness [30] but it is strictly dependent upon chemical stability in such an environment as assessed by Galvele's equation [31]. Since pitting may initiate via a metastable mechanism above the E_{corr}, the E_{pit} is the value beyond which pitting becomes a self-sustaining mechanism. On the other hand, E_{ptp} is the potential at which, during the reverse scan, an abrupt slope's change can be detected in the semilogarithmic plot that is reasonably related to the inhibition of the charge transfer mechanism, taking place inside the sites of localised attack and expressed by the potential in Newman's equation [13]. In this interpretation, at potential below than E_{ptp} the pits cannot form but, if already present, they can propagate, until reaching the repassivation potential (E_{rp}) where pits cannot growth.
Indeed, the superior corrosion resistance displayed by AA5182 in neutral NaCl solution is also well represented by the sign of the hysteresis loop. Moving from neutral to acidic, and more complex solutions, AA5182 still remains the most performing alloys but the number of truthful parameters dramatically decrease; only the ΔE_{ps} still correlates to the observed corrosion damage. Regarding the superior performance displayed by AA5182 respect to local corrosion, it can reasonably be related to its relatively high magnesium content (see table 1). The possible formation of more stable magnesium hydroxide can account for the occurrence of pit transition and repassivation at potentials that are higher than the breakdown potential one. It is possible to propose an acid base reaction between magnesium oxide/hydroxide during the recording of the cyclic potentiodynamic polarisation after current reversal in the portion of the scan that is characterised by the hysteresis loop. This reaction may stop the acidification of the surface that several authors identified as the responsible for the hysteresis loop [26] reducing the sensitivity of the AA5182 alloy even in acidic environment.
Electrochemical and free corrosion tests in acidic and neutral saline environments on four different aluminium alloys evidenced that the relative stability of the "as formed" passive layer is not the key point in guarantee the protection of the material but, vice versa, the capability of the layer to repassivate become a pivotal attribute. That can be accounted via both, pores occlusion or the formation of a new passive layer. Noteworthy, and in accordance with previous work [32], E_{ptp} value is almost unaffected by the environment, letting to assess that it is mainly related to the composition of the alloy and the peculiar chemistry of the cavities microenvironment [33].

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VENTHERM'S NEW GANTRY PAINT ROBOT: THE TECHNOLOGY THAT TRANSFORMS INDUSTRIAL PAINTING

By **Ventherm A/S**
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Ventherm A/S was founded in 1984. In 1986, the company moved to its current location on Kastanievej in Broby (Denmark), where the company has approximately 3400 m² of production and administration. Over the years, Ventherm has gained a market-leading position in spray booths and painting systems, among other things by focusing on customised turnkey solutions for the industry.

The Ventherm team works on the fundamental principle that its sole justification for existence is to provide added value for customers. Based on this, Ventherm has defined a Plug-and-Paint philosophy, which outlines its main objectives and the criteria for its future success. This philosophy is founded on knowledge, market-leading innovation, quality, sustainability and low energy consumption, compliance, turn-key solutions, on-time delivery, and competitive pricing under all circumstances.

Another significant aspect of this philosophy is building long-term relationships with business partners and the broader community. Therefore, Ventherm dedicates significant resources to maintaining the following:

- **Highest creditworthiness**
- **ISO 9001 quality management system**
- **HSE (rating by Danish authorities)**
- **UN's Sustainable Development Goals.**

The company serves customers worldwide.

VENTHERM, A LEADING EUROPEAN COMPANY IN SPRAY BOOTHS AND PAINTING SYSTEMS, DEVELOPED A NEW GANTRY PAINT ROBOT DESIGNED TO REVOLUTIONIZE INDUSTRIAL PAINTING PROCESSES, PARTICULARLY FOR STEEL COMPONENTS USED IN OFFSHORE WIND APPLICATIONS.

The Ventherm's team has started painting with its latest innovation, the gantry paint robot. The robot is designed to revolutionize industrial painting processes with its advanced technology, enhanced efficiency, and commitment to environmental sustainability. In this article, we will explore the technical workings of the gantry paint robot, its contributions to efficiency and sustainability, and the broader implications for the industry.

Technical description

Structure and design

The Ventherm gantry paint robot features a robust gantry framework, allowing it to cover extensive work areas with high precision. The gantry system comprises two parallel rails mounted on the walls, supporting

The robot's gantry system comprises two parallel rails mounted on the walls, supporting a crossbeam that moves horizontally along the X-axis.

a crossbeam that moves horizontally along the X-axis. This crossbeam carries a vertical axis, which holds the paint robot, enabling movement along the Y and Z axes. This three-axis system ensures comprehensive coverage and precise application, even on complex surfaces. Constructed from high-strength steel, the gantry frame offers durability and stable properties. The rails and crossbeam are equipped with precision linear guides, and racks and pinions, ensuring smooth and accurate movements which are essential for high-quality painting.

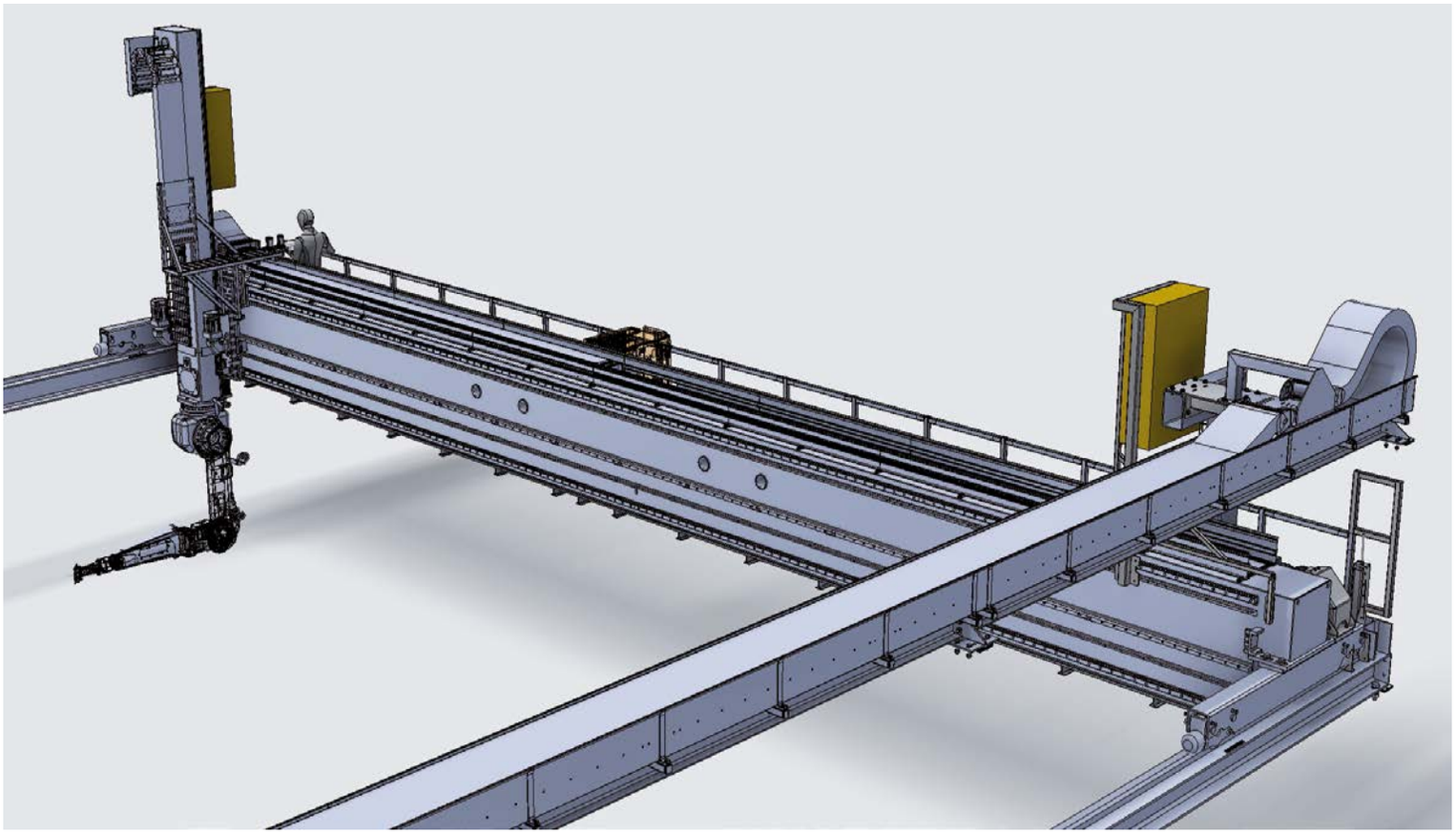
Motion control system

At the heart of the gantry paint robot is its motion control system, which includes servo motors, encoders, and a central control unit, that integrates the robot axes with the external axes that have to do with the gantry. Servo motors positioned on each axis drive the gantry and paint robot, while high-resolution encoders provide real-time feedback on the robot's position. This feedback allows for precise control, ensuring consistent paint application.

The central control unit integrates advanced algorithms to manage the robot's trajectory, speed, and acceleration. This ensures uniform paint application regardless of the workpiece's shape and size. The control system can be programmed with various painting patterns and sequences, providing customization for different applications.

Paint application technology

The gantry paint robot excels in applying paint with exceptional precision. It utilizes a high-performance paint applicator, which can be an airless spray gun, electrostatic sprayer, or an air mix spray gun, depending on the application requirements.



Technical drawing illustrating the Ventherm gantry paint robot's gantry system.

The intelligent paint delivery system maintains a constant flow rate and pressure, ensuring uniform application. Sensors monitor the paint's viscosity, temperature, and pressure, adjusting real-time parameters to maintain consistency. This reduces the risk of defects like runs, sags, or orange peel, ensuring a high-quality finish.

Vision and sensing

A key feature of the Ventherm gantry paint robot is its integrated vision system. Laser scanners and cameras map the object's surface, generating a 3D model used to plan the painting path. This vision system allows the robot to detect and compensate for deviations in workpiece position or orientation, ensuring accurate application. The vision system also identifies surface defects or irregularities, adjusting painting parameters to address these issues. This adaptability enhances the robot's efficiency and effectiveness across various painting tasks.

Enhanced efficiency

The Ventherm gantry paint robot significantly enhances efficiency in industrial painting processes. By automating the painting

THE GANTRY PAINT ROBOT EXCELS IN APPLYING PAINT WITH EXCEPTIONAL PRECISION. IT UTILIZES A HIGH-PERFORMANCE PAINT APPLICATOR, WHICH CAN BE AN AIRLESS SPRAY GUN, ELECTROSTATIC SPRAYER, OR AN AIR MIX SPRAY GUN, DEPENDING ON THE APPLICATION REQUIREMENTS.

The gantry paint robot utilizes a high-performance paint applicator, which can be an airless spray gun, electrostatic sprayer, or an air mix spray gun, depending on the application requirements.

process, the robot reduces the time required to complete jobs, allowing for continuous operation without fatigue. This results in faster turnaround times, which is essential for industries facing tight production schedules. The robot's precision and consistency minimize the need for rework, reducing downtime and increasing overall productivity. Its programmable control system allows for quick setup and changeover between different painting tasks, further enhancing operational efficiency.

Environmental sustainability

Ventherm's commitment to environmental sustainability is evident in the design and operation of the gantry paint robot. The robot's precise control over paint application reduces overspray and waste, leading to more efficient use of materials. This not only lowers costs but also minimizes the environmental impact associated with paint production and disposal.

The robot's intelligent paint delivery system ensures consistent application, reducing the need for excessive coats and further minimizing waste. Additionally, the use of electrostatic sprayers can enhance paint transfer efficiency, reducing the amount of paint required to achieve the desired coverage.

By automating the painting process, the gantry paint robot reduces the exposure of human workers to hazardous chemicals and volatile organic compounds (VOCs). This contributes to workplace safety and a healthier environment for employees.

Implications for the industry

The introduction of the Ventherm gantry paint robot has far-reaching implications for the industrial painting industry. Its advanced technology and capabilities set a new standard for efficiency, quality, and sustainability, prompting other manufacturers to adopt similar innovations.

Improved quality and consistency

The gantry paint robot's precision and consistency result in superior finish quality, which is difficult to achieve with manual painting. This quality

improvement can enhance the durability and aesthetics of painted products, leading to greater customer satisfaction and reduced warranty claims.

Cost savings

The automation of the painting process leads to significant cost savings. Reduced labour costs, decreased paint wastage, and minimized rework contribute to lower overall expenses. Higher production rates and faster turnaround times also improve profitability, making companies more competitive in the market.

Environmental regulations and compliance

With increasing emphasis on environmental sustainability, industries are under pressure to reduce their environmental impact. The Ventherm gantry paint robot's ability to minimize waste and improve material efficiency aligns with these regulatory trends.

Companies adopting this technology can better comply with environmental regulations and reduce their carbon footprint.

Conclusion

Ventherm's new gantry paint robot is revolutionizing industrial painting. With its advanced design, precision control, and integrated vision system, it delivers unmatched performance in terms of efficiency, quality, and sustainability. Automating the painting process, this robot boosts productivity, enhances safety, and supports environmental sustainability. As industries seek to optimize their operations, the Ventherm gantry paint robot emerges as a transformative solution that meets the demands of modern manufacturing while paving the way for a more sustainable future.

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Cost effective corrosion control on SSC's launch ranges

By **Lisa Sodders,**

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The US Space Launch Ranges are situated near the sea, leading to a high rate of corrosion of the metal structures – such as towers and radomes - due to the elevated salinity levels, necessitating maintenance every two years. In this article, costs and management of operations to maintain the safety of launch structures, which are gradually intensifying their activity, are well detailed.

Over the past five years, Space Systems Command's (SSC)[1] Launch and Test Range System (LTRS) Product Support has saved $4.8 million in program funds by partnering with Hill Air Force Base and the Air Force Materiel Command's Ogden Air Logistics Complex to support corrosion control and maintenance at both the Eastern and Western Space Launch Ranges.

Both the Eastern and Western Space Launch Ranges are located near oceans: if a launch goes awry, it is safer to have the rockets launch over water. But proximity to the ocean comes at a price: the salt air is extremely corrosive to metal.

"It's one of the most corrosive environments because we sit right on the ocean and the salt-water air comes in and just corrodes everything in its path – if it's metal, it'll eat it up," said Ralph Greenleaf, logistic management specialist with SSC Range Management (RM).

So relentless is the corrosion, mitigation measures must be repeated every two years, Greenleaf said. At stake is $6.45 million worth of mission-critical equipment, including eight tactical shelters; 29 towers; 22 radomes – weather-proof domes that protect radar antennas from the elements; two Advanced Tactical Optical Tracking System vans; and two Multiple Object Tracking Radars that house Prime Mission Equipment (PME).

"Corrosion ate through one of the legs on one of our towers and we were afraid it might fall over if they had a bad tropical storm come through," Greenleaf said. "However, our corrosion team partnered with SLD45/CE[2] and the Tower and Equipment building is being replaced to ensure our PME is protected."

"At Patrick Space Force Base (PSFB), we had two telemetry radomes that had water intrusion, and with the electrical equipment housed there, that was a safety hazard," Greenleaf added. "We requested an Emergency Depot Level Maintenance (EDLM) with SSC/A4 approval, and Ogden ALC sent their Mobile Depot Maintenance (MDM) team to repair the radomes in record time."

Both the Eastern and Western Space Launch Ranges are the gateways to space for a host of space customers, including the U.S. Space Force, the U.S. Air Force, the U.S Department of Defense, the National Aeronautics and Space Administration (NASA), and other commercial programs. Maintaining operational availability for the equipment on the ranges is of particular concern, given the rapidly increasing pace of space launches.

"The 45th Space Launch Delta's Civil Engineering (CE) Squadron was maintaining our towers that had critical PME in support of space launches and major corrosion issues," Greenleaf said. "In partnership with SLD45/CE, we transferred 29 towers for Ogden support of corrosion control and maintenance to not only support our space launch mission but help CE with a limited budget to perform all the maintenance at Cape Canaveral and Kennedy Space Center."

The SSC/LTRS started researching a source to acquire better maintenance support. Initially, they looked for an independent contractor to do the work but received a quote of more than $1 million a year, Greenleaf said. The corrosion control team eventually discovered that the Ogden Air Logistics Complex[3] at Hill AFB could support the requirement and started the partnership with Ogden in 2019 by attending the Communication Electronic Schedule Review (CESR) that ensured Ogden support for SSC's tactical shelters, radomes, and towers (TSRT) equipment.

[1] Space Systems Command (SSC) is the United States Space Force's space development, acquisition, launch, and logistics field command. It is headquartered at Los Angeles Air Force Base, California, and manages the United States' space launch ranges. Source: Wikipedia.

[2] The Space Launch Delta 45 (SLD 45) is a unit of the United States Space Force. The Space Launch Delta 45 is assigned to Space Systems Command and headquartered at Patrick Space Force Base, Florida. Source: Wikipedia.

[3] The Ogden Air Logistics Complex (OO-ALC) performs programmed depot maintenance on a number of US Air Force weapon systems. Source: Wikipedia.

It is critical to keep these systems 'Green and Go for Launch' with the dramatically growing space launch pace. There is an annual corrosion control program focusing on critical sustainment projects that will build the Spaceport of the Future next-generation technologies.

Ogden ALC also supports a host of Eastern Range shelters that protects equipment vital to the operation of the mission support equipment. Ogden also helped modernize and replace condemned shelters with new ones, saving the LTRS program $110,000.00. These new shelters provide support for critical doppler radar weather systems that support all launches on the Eastern Range.

The Ogden Air Logistics Complex provides worldwide engineering and logistics management for such aircraft as the F-35 Lightning II, F-16 Fighting Falcon, A-10 Thunderbolt II, and Minuteman III Intercontinental Ballistic Missile system. Ogden maintains radomes, shelters, and towers all over the world.

Because Ogden is funded through the U.S. Department of Defense, partnering with Ogden means SSC has saved $4.8 million in program funding, while at the same time having access to Ogden's expertise. Last year, SSC/LTRS saw a $403,965.00 cost savings for corrosion control and maintenance on the 13 Western Range radomes alone, Greenleaf said.

Ogden also supports Emergency and Urgent Depot Level Maintenance for all tactical shelters, radomes, and towers (TSRT) equipment on both ranges, including recent work on the Advanced Tactical Optics Tracking System at Kennedy Space Center for severe corrosion. The Odgen team completed corrosion control in 7 days.

"Our tactical shelters, radomes, and towers are the front line of protection for our mission critical space systems in our launch range's most corrosive environment," said John Wilkinson, product support manager for the Launch and Test Range Systems. "It is critical that we keep these systems 'Green and Go for Launch' with our dramatically growing space launch pace. We now have an annual corrosion control program focusing on critical sustainment projects that will build the Spaceport of the Future next-generation technologies."

"Establishing our Ogden ALC corrosion control partnership is one of the smartest programs we have created," Wilkinson said. "Without a doubt, the Ogden ALC Team will continue as one of our crucial space launch partners as we evolve our current ranges into our Nation's Spaceports of the Future."

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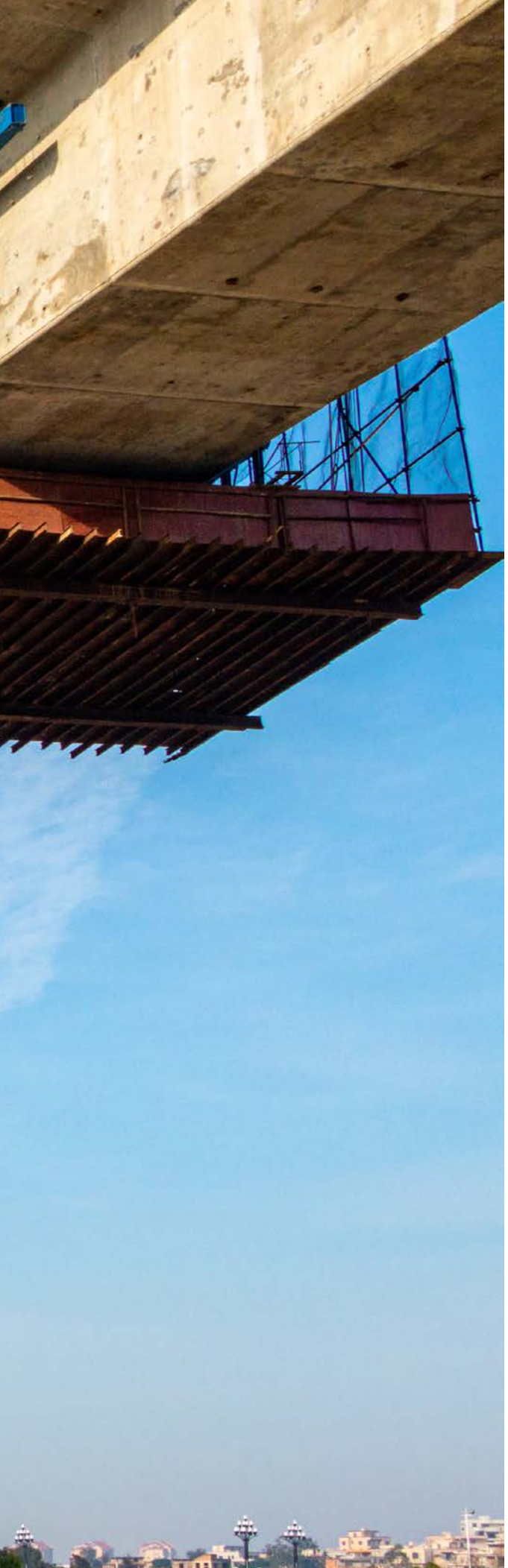

Fighting the danger of overprotection on concrete repairs

Edited by **Cortec® Corporation,**

St. Paul (MN), United States
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Is it possible to give concrete too much protection against reinforcement corrosion? Research[1] indicates that this is so, although no consensus exists on the exact mechanisms and how to avoid it. However, following logical reasoning, Cortec® recommends applying Migrating Corrosion Inhibitors to mitigate the problem.

What is overprotection?

Overprotection occurs when metal reinforcement in one part of the concrete is more protected than in another. This can happen when a new concrete patch is laid, replacing contaminated or carbonated concrete with uncontaminated concrete that has a high pH and therefore a naturally protective alkaline environment. The resulting difference in corrosion potential between the patch and the adjacent concrete eventually leads to corrosion in surrounding areas, thus transferring the original problem elsewhere. This is known as the ring anode / halo effect.

Examples of overprotection

Overprotection can also happen in a variety of other ways. One is through the common practice of cathodic protection (CP). The challenge of calculating the appropriate number of anodes for an area and removing concrete to install them is compounded by the fact that it is not possible to gain access to and treat all parts of the rebar equally. This leaves some portions of the metal reinforcement with more protection than others, an imbalance that could show itself over time by corrosion in areas with less protection.

[1] https://www.sciencedirect.com/science/article/abs/pii/S0950061818308572

A similar effect may happen with the application of an epoxy coating to one part of a rebar and not to another.
Using other corrosion protection measures may cause a similar imbalance when over-applied.

Even out the corrosion potential

The use of MCI® Surface Applied Corrosion Inhibitors (SACIs) makes it easier to balance out the corrosion potential. Rather than leaving a well-protected patch surrounded by chloride-contaminated concrete, contractors can apply MCI® SACIs to the undisturbed concrete in an effort to reduce the difference in corrosion potential between two portions. Fortunately, MCI® SACIs are easy to apply by spraying onto the concrete like a standard surface treatment. As time progresses, Migrating Corrosion Inhibitors in the MCI® SACI work their way deeper in through the concrete pores toward the metal reinforcement. Their affinity to metal allows them to form a protective molecular layer on the embedded rebar when they encounter it.

MCI® SACI options

MCI®-2020 contains the highest concentration of surface applied Migrating Corrosion Inhibitors on the market and is therefore the number one recommended SACI for this purpose. Typically, a coating or water repellent should be applied on top of this to keep moisture out and MCI® in. Two-in-one MCI®/ water repellents are also available for greater convenience, albeit with smaller doses of Migrating Corrosion Inhibitors (MCI®-2018 combines MCI® with a 100% silane water repellent, and MCI®-2019 combines MCI® with a 40% silane water repellent).

Take a balanced approach to corrosion protection

Concrete repairs are too labor-intensive to make the mistake of overprotection. By being sure to protect the concrete around the patch area with Migrating Corrosion Inhibitors, contractors can take one step ahead of the chain reaction of corrosion that is common in less protected areas.

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THE INDUSTRY COMING TOGETHER: COMBATTING THE HIDDEN CUI THREAT IN THE ENERGY SECTOR

Edited by **Jotun Performance Coatings**

Sandefjord, Norway

THE FIGHT AGAINST CORROSION, PARTICULARLY CORROSION UNDER INSULATION (CUI), IS INCREASINGLY BECOMING A MAIN FOCUS FOR THE ENERGY SECTOR. HOW IS THE INDUSTRY ADDRESSING THIS ISSUE AND HOW CAN RISK BE REDUCED? A NEW STANDARD TEST PROCEDURE THAT ADDRESSES THIS CRITICAL INDUSTRY CHALLENGE MIGHT PAVE THE WAY, SO THAT THE ENERGY SECTOR BETTER CAN MAINTAIN STEEL INTEGRITY.

CUI is a serious issue for energy facilities - and has been for as long as there has been insulation on steel equipment. Moisture gets into the insulation material due to condensation or external sources. Combined with high or cyclic temperatures, this creates optimal conditions for rapid corrosion development.

According to the Norwegian Petroleum Safety Authority, more than 20% of the major oil and gas accidents reported within the EU since 1984 have been associated with CUI. Furthermore, about 50% of the reported hydrocarbon leaks at onshore plants in that study are caused by CUI*. Thus, there is no doubt that CUI represents a major challenge for facilities that continuously focus on reducing risks and hazards.

Explaining the issue from a technical perspective Svein Jacob Kaspersen, R&D Manager Speciality Temp and Tank at Jotun Performance Coatings says "standard carbon steel can be affected when moisture can infiltrate the insulation from sources such as precipitation or condensation in cyclical processes or when more stable systems are shut down for maintenance. Stainless steels can suffer external chloride-induced stress corrosion if contaminates, such as chlorides from the atmosphere and or the insulation, are present at the steel surface. Therefore, steel structures under insulation are normally protected with coatings to prevent corrosion-related damage during the operational life required of the equipment".

But CUI is not something that has just been discovered, although the focus on the topic has increased rapidly during the last 50 years.

"One of the main reasons that it has grown in importance is because operators now have more focus on energy efficiency and that can be a driving factor for insulating elements of the plant," Kaspersen continues. Insulation is also needed to maintain a steady temperature in some of the different processes that take place in refineries. "This can require cool or cryogenic temperatures, as well as high temperature".

A hidden threat

Despite the growing focus on CUI in the industry there does not appear to be a quick fix. One of the major problems is that discovering CUI is extremely difficult because of the various components involved. During the processes, the steel will expand and contract when exposed to temperature changes, but the coating protecting the steel may expand and contract at a different rate. This puts stress on the coating and could lead to cracking and flaking leaving the steel unprotected, and at high temperatures the coating itself could break down.

"For an uninsulated pipe this degradation of the coating would be visible during routine inspections. However, once a layer of insulation is placed around the pipe any such damage becomes invisible. There may be some signs in extreme cases such as staining or lifting of the insulation, but this cannot be relied upon. Furthermore, the insulation itself requires protection from the elements in exposed situations and there will be an outer jacket or casing covering it," Kaspersen points out.

Although the manufacturers of the various components, such as piping, coating, insulation, and casing may have

© Jotun

worked and developed products aimed at reducing the incidence of CUI, they have mostly been doing so on a separate basis. Part of the challenge is therefore down to the fact that there has been less than ideal collaboration between the different parties.

Working together to solve the problem

This state of affairs existed until 2018 when an ISO standard for testing coatings was published. "ISO 19277 Qualification testing and acceptance criteria for protective coating systems under insulation"[1] was considered a step in the right direction but the mandatory elements of it did not actually test the coating together with insulation.

[1] www.iso.org

That same year, a Joint Industry Project (JIP) was started up in the US, and phase 1 was finalised in 2023. The work was coordinated and carried out by Southwest Research Institute (SwRI) in San Antonio, Texas. The initial aim was to determine the durability of various coatings and insulation types applicable to CUI. Among those taking part were eight oil and gas operators, five coating manufacturers including Jotun and a number of insulation suppliers.

"I'm delighted that, after years of collaboration, we finally established a new and improved test method coating and insulation systems. Although CUI has gained increased focus over the last years, in-depth research on this topic has been limited, and that is why our joint industry project (JIP) is a major asset for the whole industry," states Leonardo Caseres, Principal Engineer, Materials Engineering Department at Southwest Research Institute.

He continues: "This project took a systematic approach, examining how different coatings and insulation systems perform together - reflecting real-world scenarios where various coatings are used with different insulation types. Insights from both coating manufacturers and insulation manufacturers were invaluable in enhancing our understanding. Additionally, end users provided valuable perspectives from how these systems have performed in real life over the years. Collaborations like this are essential for deepening knowledge on complex topics like CUI. This advancement will greatly facilitate the development of new coatings and insulation products."

The new standard test procedure is published by the Association for Materials Protection and Performance (AMPP) as "AMPP TM21442 Test Method for Evaluation of Protective Coatings For Use Under Insulation"[2].

The AMPP document states the rationale behind it as, "CUI test methods currently available in industry do not mimic field conditions and are based on a pass-fail criterion conducted for a fixed exposure time and are unsuitable for estimating coating service life and performance. This AMPP standard provides a comprehensive test methodology to simulate field conditions under insulation in order to establish the performance of a coating in service."

During the SwRI JIP, coated pipe spools with different types of insulation were exposed to wet and dry testing at temperature cycles ranging from 21 °C to 80 °C through to 21 °C to 315 °C.

[2] https://store.ampp.org/ampp-tm21442-2023-test-method-for-evaluation-of-protective-coatings-for-use-under-insulation

INSIGHTS FROM BOTH COATING MANUFACTURERS AND INSULATION MANUFACTURERS WERE INVALUABLE IN ENHANCING UNDERSTANDING. ADDITIONALLY, END USERS PROVIDED VALUABLE PERSPECTIVES FROM HOW PROTECTIVE COATING SYSTEMS UNDER INSULATION HAVE PERFORMED IN REAL LIFE OVER THE YEARS. COLLABORATIONS LIKE THIS ARE ESSENTIAL FOR DEEPENING KNOWLEDGE ON COMPLEX TOPICS LIKE CUI.

Among the coatings tested were products from Jotun's Jotatemp range which showed an overall very good performance.
Commenting on Jotun's participation in the SwRI JIP, Ingrid Vee, Global Category Manager -Heat Resistance at Jotun says, "We are proud to have been an active contributor to the development of this new industry standard by providing support and information, and sharing our research expertise and experience."
As the 2021 study by DNV for the Norwegian Petroleum Institute found that operators consider CUI as "the biggest threat to the mechanical integrity of oil and gas industry facilities"[3], It Is understandable why this topic now Is a hot topic in the industry. A failure of any steel component in an energy plant would likely pose a threat to those in the immediate vicinity and could affect a wide area beyond the plant itself.
At the end of the day, it all comes down to how you protect your assets and properties.

[3] https://www.havtil.no/contentassets/9ec16fd263fc4a25a5b8e4fc20de33d3/maintenance-management---corrosion-under-ins

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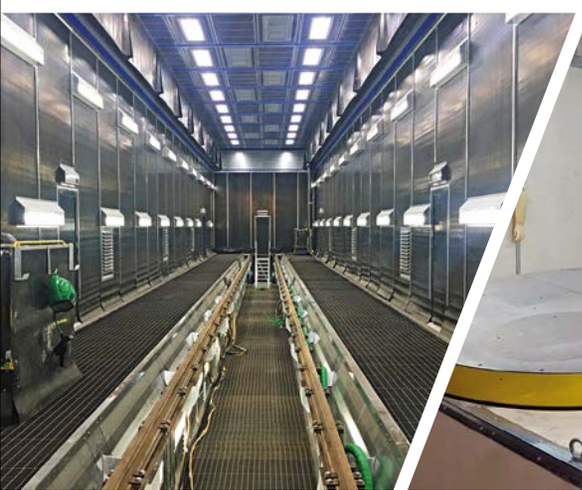

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RESEARCH
BREAKTHROUGH

Building better infrastructure for climate resilience

Edited by **The UBC - University of British Columbia**, Okanagan, British Columbia – Canada

Stretching 543 kilometres from Hope to Kamloops (BC - British Columbia, Canada), the Coquihalla Highway is a vital corridor linking Canada's west coast with the rest of the country. However, in November 2021, unprecedented flooding washed out more than 20 sites along 130 km of highway, including seven bridges.

The shortest and most critical link between the BC interior and the coast was severed for weeks, negatively affecting supply chains and ultimately costing the government more than $1 billion in repairs.

"What happened to the Coquihalla Highway was a perfect example of how unprepared Canada is in response to climate change hazards," says Dr. Shahria Alam, a Professor of Civil Engineering at UBC Okanagan.

"We've designed our structures to bear loads based on historic data, but with climate change, everything is different. We're dealing with unknown hazards and unknown natural load combinations, so as researchers, we must find a statistical balance of how the future might play out."

In Dr. Alam's Applied Laboratory for Advanced Materials and Structures (ALAMS) , his team of undergraduate and graduate students is doing just that: exploring advanced materials through extensive applied experimental work.

By subjecting ultra-high-performance concrete and high-strength/super-elastic reinforcements to various tests simulating potential real-world conditions, Dr. Alam aims to build modern resilient structures with lifespans upwards of 200 years.

Sustainably retrofitting for climate resilience

Catastrophic events like what happened on the Coquihalla Highway only stand to increase as climate change conflicts with vulnerable road structures and higher traffic volumes.

Dr. Shahria Alam, a Professor of Civil Engineering at UBC Okanagan (Canada), and his team of researchers are exploring sustainable solutions for more resilient buildings and bridges.

From top:
Dr. Shahria Alam (left) and Dr. Sherif Osman examine the crack propagation of a damaged concrete bridge pier following a simulated earthquake load. An example of sustainable engineering in action, the concrete bridge pier is reinforced with stainless steel rebars, which is expected to increase the corrosion resistance and service life of bridges.

A bridge located at Juliet, 53 kilometres south of Merritt, collapsed and has since been rebuilt to be more climate-resilient. *Photo courtesy of BC Ministry of Transportation and Infrastructure.*

Killam doctoral student Rubaiya Rumman performs tests to find the optimum replacement level of cement with wood fly ash to produce green concrete.

The mixture is then put into cement mortar cubes cast in moulds.

Meraj Rubayat Kamal, a civil engineering doctoral student at ALAMS, tests the compressive strength of mortar cubes made of wood fly ash.

The result is incredible pressure on Canada's aging roads and bridges—further exacerbated in BC by the ever-present threat of earthquakes along the west coast's Cascadia Subduction Zone. "Retrofitting existing infrastructure will help protect it against future disasters, but we have to explore more sustainable ways of doing that by considering life cycle costs," Dr. Alam explains. "At the same time, we have the opportunity to use different—and more advanced materials—to make our structures more resilient."

Some unique alternative materials being explored in Dr. Alam's lab include the combination of wood fly ash—a byproduct of burning sawdust—and cement to produce green concrete. Wood fly ash has been found to have great potential as a substitute for coal fly ash, a green cement supplement that is becoming obsolete as coal power plants shut down around the globe.

His research team is also exploring the use of advanced materials like super elastic Nitinol bars, fibre-reinforced plastic bars and high-strength-steel reinforcing bars; the incorporation of green concrete developed from industrial waste and substances like demolished concrete from old buildings and bridges; and recycled rubber from old tires.

Many of Dr. Alam's projects are collaborations with other professors in the School of Engineering, enabling him to broaden the scope and influence of his research.

"UBC Okanagan attracts top talent from around the world, and when they join my research group, they enrich our work with diverse insights and expertise. I believe this is key to opening doors to the kinds of innovative projects and perspectives we're working on." He adds: "Everyone in my lab has a similar motive; we don't want to just study about sustainable construction and then publish our findings in a journal. We want to create the most change possible in the real world."

Climate-proofing BC's highways and bridges

Considering the climate change and seismic challenges facing sections of BC's roads, Dr. Alam and his team have partnered with the BC Ministry of Transportation and Infrastructure and various private companies to help address the province's urgent needs. "British Columbia has more than 2,500 highway bridges; many are old and require different retrofitting schemes. "Given the funding available, how do we prioritize which bridges are retrofitted and the level of functionality you want the bridge to have?"

In a previous project, Dr. Alam assisted the ministry in expanding its knowledge about the current condition of the province's bridges—documenting everything from construction materials and bridge length to foundation type, structural health rating, and construction period.

The cubes are tested after 28 days of curing under standard curing conditions.

Dr. Ahmad Rahmzadeh, a Postdoctoral Fellow at ALAMS, applies simulated earthquake loads to test the effectiveness of energy-dissipating devices. Such sustainable engineering devices can help reduce damage to buildings and bridges during an earthquake.

"This comprehensive information is crucial for proper infrastructure management and rehabilitation in an increasingly climate-prone world," Dr. Alam says.

Furthering this provincial work, Dr. Alam and industry partners are now developing a way to identify and prioritize bridges in BC that need to be evaluated for seismic retrofitting following lifecycle costs.

A second aspect of the study aims to introduce innovative cost-effective bridge retrofit and repair measures using any of the high-strength or sustainable advanced materials currently being tested in Dr. Alam's lab. "Take the example of high-strength steel reinforcing bars, which could have a lower carbon footprint than traditional steel. But we can't use this material to its full potential in seismic zones because of design code restrictions, since there's a lack of research," Dr. Alam says.

His research team aims to assess and document the performance of high-strength steel reinforcing bars in bridge columns and, hopefully, develop recommendations on how to incorporate this material into future design codes.

For Dr. Alam, this kind of applied research work is vital; by addressing local problems, his work has global influence. He is already collaborating with numerous institutions, including Abu Dhabi University, UAE University, Nagoya Institute of Technology and Tongji University in separate sustainable engineering projects.

"The legacy of the Coquihalla Highway disaster is that it illustrated how infrastructure resiliency affects day-to-day life, emergency response and economic development in a region. "My team is working on developing and testing alternative materials to see if they can be valuable to various industries or community partners—and if they can serve the greater good, then why shouldn't we explore this?" Dr. Alam asks.

"Most countries are working toward the common goal of tackling climate change, so if there is anything the team and I can do to resonate with the wider world and create solutions, we're going to try."

MEETING
THE INDUSTRY

IVS 2024 ends with record numbers: 15,000 visitors from over 69 Countries

The fifth edition of IVS Industrial Valve Summit, the most important international event dedicated to industrial valve technologies and flow control solutions, closed with record numbers. The event, promoted by Confindustria Bergamo and Promoberg, was held at the Bergamo Exhibition Centre from 14th to 16th May 2024.

The fifth edition of the Summit closed with a final influx of 15,000 visitors from 69 countries. Attendance, representing all five continents, was 25% higher than during the Summit's fourth edition, when the city of Bergamo attracted 12,000 guests.

The protagonists of IVS 2024 were the 325 exhibitors (+13% compared to the 2022 edition) from 14 countries: besides Italy, the companies represented the sectors of Germany, Great Britain, the United States of America, France, Denmark, Spain, the Netherlands, Norway, the United Arab Emirates, South Africa, Turkey, Niger, and the Czech Republic. The international element proved to be in great turmoil, with foreign companies doubling in number compared to the fourth edition and reaching 20% of the total number of exhibitors.

The extensive IVS scientific programme is also undergoing great development. A space that has proved over the years to be an agora where to interpret change and delve into the latest technological innovations, identifying and analysing the challenges of the industry. IVS 2024 offered 52 events including conferences, roundtables, workshops, case studies and laboratories, constituting a plan more than 50% larger than the 34 in-depth technical events of IVS 2022. To support the increased schedule, the Summit organisers built two additional conference rooms in Pavilion C.

The event also consolidated the exhibition areas, covering more than 15,000 square metres in three pavilions. These numbers tell how IVS has established itself as an essential showcase for the entire global supply chain connected to industrial valves and flow control.

On the occasion of the 2024 edition, the organisers boosted the qualitative growth of the event, increased the number of appointments in the exhibition programme and enriched the side events, leading the Industrial Valve Summit to grow from a two-day exhibition to a full-fledged valve week.

The Summit kicked off on 14th May with the opening conference, during which the IVS-Prometeia Observatory "The Oil&Gas Valve Industry in Italy" 2024 was presented, providing a snapshot of the current state of the Italian sector of reference, a sector of excellence of Made in Italy and a leader in Europe. In parallel, the organisers opened the doors of the pavilions to IVS exhibitors: a première introduced to generate a valuable opportunity for dialogue between the protagonists of the Summit.

The IVS-Prometeia Observatory "The Oil&Gas Valve Industry in Italy" 2024 has confirmed the supremacy of the Italian industrial valve sector in the European competitive context. In 2022, almost 4 out of every 10 oil & gas valves produced in Europe were manufactured in Italy, where the sector's production value was close to EUR 3 billion. The 2022 turnover of the domestic industry rose by 12% compared to 2021 but has not yet recovered to pre-pandemic levels. The numbers are achieved within an ecosystem of 139 companies (more than 90% of the turnover is generated within a 100 km radius of the province of Bergamo), employing over 10,000 people (up from 9,300 in 2021). In 2023, exports of Italian valves for the Oil&Gas industry started to grow again at a fast pace (+5.7% in value over 2022), driven by the Middle Eastern and Asian markets. Investments in the energy sector, upstream, downstream and transportation services are growing.

A positive trend that, along with the development of 'green' investments, offers positive effects that may also be evident beyond 2023. There are opportunities for growth in traditional as well as renewable and innovative sectors, such as Carbon Capture Utilisation and Storage (CCUS) and hydrogen.
The exhibition got into full swing on 15th and 16th May, and the pavilions welcomed the international valve audience. On Friday 17th May, a further opportunity was available to the foreign delegations attending the exhibition to meet the players in the extended oil and gas supply chain, thanks to targeted matchmaking operations. The synergies with ICE (the Agency for the promotion abroad and internationalisation of Italian companies), AVR ANIMA (the industrial trade association representing Italian companies in the valves and fittings sector) are of great stimulus to the increase in high-level international attendance, Confindustria Assafrica & Mediterraneo (the international representation of Confindustria that supports Italian companies in their growth path in Africa and the Middle East) and SACE (an insurance-financial group directly controlled by the Ministry of Economy and Finance, specialised in supporting companies and the national economic fabric).
The partnerships gathered international delegations consisting of institutional representatives, entrepreneurs, decision makers, speakers, and specialised operators at the fair. The organisers invited over 100 qualified end-user buyers of primary standing and international EPCs. A parterre that can interface with operators from the entire energy sector, giving rise to moments of exchange and comparison. Moreover, through the operational collaboration with UNIDO ITPO Italy (the Italian Office for the Promotion of Technology and Investment of the United Nations Industrial Development Organisation), IVS confirms the participation of a delegation of entrepreneurs and representatives of Iraqi institutions.
The organisers of the event announced that the sixth edition of IVS will be held at the Fiera di Bergamo from 19th to 21st May 2026.

https://industrialvalvesummit.com

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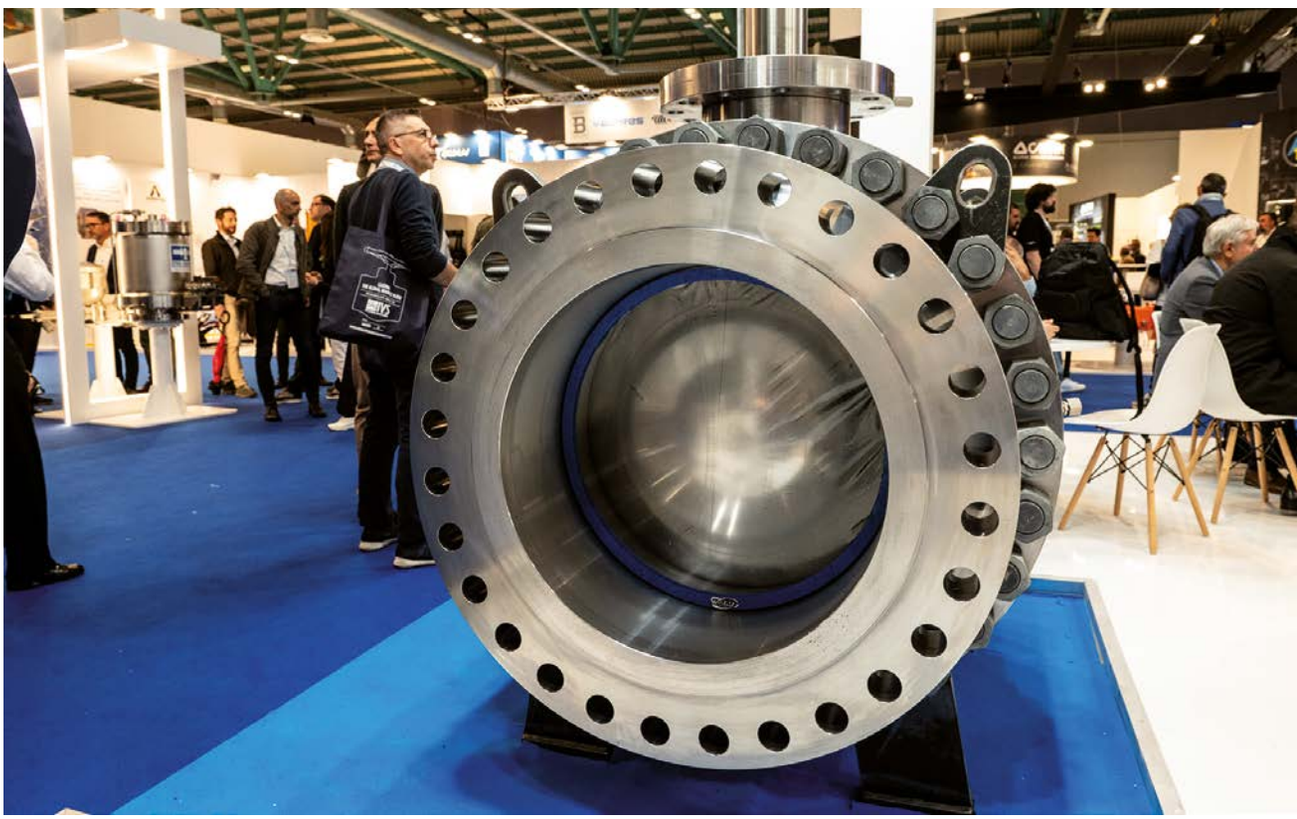

Successful conclusion of the AMPP Italy Chapter 3rd Conference & Expo on Corrosion Prevention

The highly anticipated Conference & Expo 2024 successfully concluded in Genoa (Italy), spanning three impactful days from June 9 to 11, 2024. The international event focused on corrosion prevention and was marked by a series of engaging activities and sessions.

Key highlights of the event

The event offered a variety of activities that captured the interest of the participants. The conference included six parallel sessions, 180 insightful oral presentations, compelling keynote lectures, and a student poster session.

Global participation was remarkable, with 450 attendees from all corners of the world, including Africa, Asia, Australia, Europe, and both North and South America. Countries such as the United States, the United Kingdom, Japan, and Italy, among many others, were well represented, reflecting the international scope of the event.

A significant aspect was the strong industry involvement. A total of 28 sponsors and 51 exhibitors took part in the event, underscoring its importance. In total, 240 companies actively participated, showcasing their latest innovations and solutions in corrosion prevention.

The conference's theme, "Sharing knowledge, the way to go!", was fully embraced, creating a collaborative environment for the exchange of ideas and advancements in the field of corrosion prevention. This spirit of sharing enriched all participants, fostering constructive dialogue and mutual learning.

The success of the AMPP Italy Chapter 3rd Conference & Expo 2024 in Genoa has set a high benchmark for future events.

The organizers extend their heartfelt gratitude to all attendees, sponsors, exhibitors, and participants who contributed to making this event a memorable and impactful gathering.

www.amppitaly.org/genoa/2024

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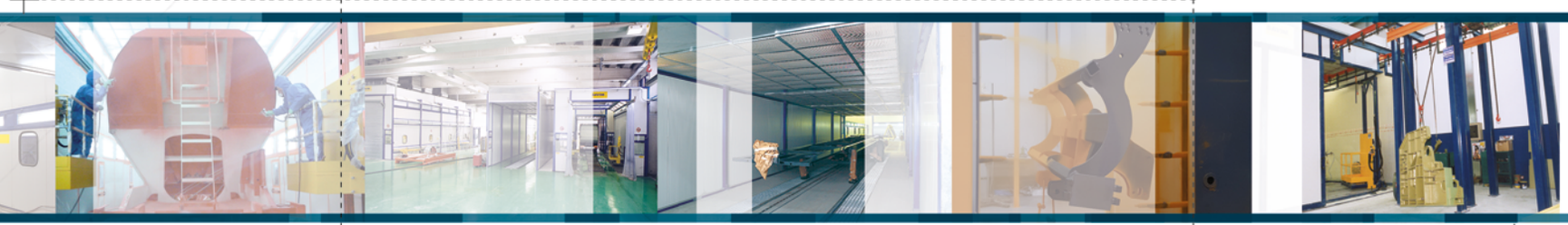

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