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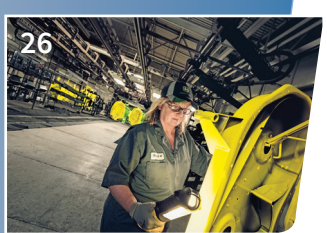
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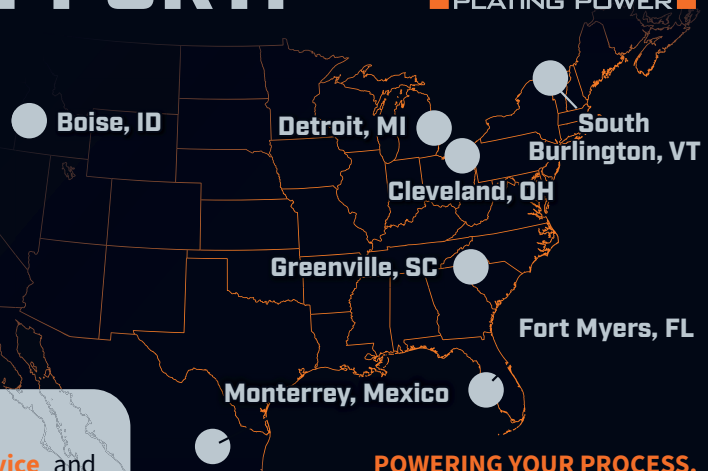
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EDITORIAL STAFF

EDITOR-IN-CHIEF	Scott Francis *sfrancis@gardner.media*
SENIOR EDITOR	Brian Budzynski *bbudzynski@gardner.media*
ASSOCIATE EDITOR	Jessica Pompili *jpompili@gardner.media*
SENIOR MANAGING EDITOR	Grace Stubbins *gstubbins@@gardner.media*
SENIOR ART DIRECTOR	Claudean Wheeler *cwheeler@gardner.media*
CUSTOMER SUCCESS COORDINATOR	Chris Larkins *clarkins@gardner.media*

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How Top Finishers Protect Agriculture and Construction Equipment

From exacting paint specs to strategies for avoiding powder coating edge failures, this issue of* Products Finishing *explores how suppliers and OEMs are engineering finishes tough enough to survive the harshest jobsite and field conditions.



SCOTT FRANCIS / EDITOR-IN-CHIEF
sfrancis@gardner.media

For agriculture and construction machinery, there are no easy days. A combine spends harvest season chewing through dust and chaff, gets hosed down at midnight and sits out in sun, rain and frost between uses. An excavator on a highway job gets sprayed with road salt, knocked around and scraped up by debris. This equipment is constantly facing harsh conditions and unique problems for coatings and finishes — and this latest issue of *Products Finishing* (*PF*) explores the way finishers rise to meet those challenges.

In this month's first feature, "Efficacious Agricultural Machinery Surfacing Starts With Suppliers," *PF* senior editor Brian Budzynski explores the corrosive and environmental



conditions that constantly put farm equipment to the test, from fertilizers and acidic herbicide and pesticide mixes, to organic acids, diesel exhaust byproducts, hydraulic fluid, manure, and constant UV exposure and moisture cycling. Not to mention the corrosive power of deicing salts for anything that travels a road in winter.

What strikes me about this article is how the interviewed suppliers — including Surventis, Henkel, PPG, Gema and Parker Ionics — kept coming back to the same point, which is that every stage of the finishing process plays an important role. In fact, many coating failures trace back to preparation, cleaning and pretreatment.

That view of finishing as a *system*, rather than just its individual parts, is built into how the industry's largest OEMs partner with finishers. Another feature, "Inside John Deere's Paint Specs and Supplier Success," offers a great example of how exacting construction-agricultural specifications can be. Deere has roughly 80 coating operations worldwide, and outside suppliers paint about half of its components; the company has to be able to trust shops it doesn't run. Its answer is a tiered spec covering hidden components, primary agriculture equipment and riding lawn equipment. Approval means meeting material qualifications and then approval for the specific process lines — and the bar is high.

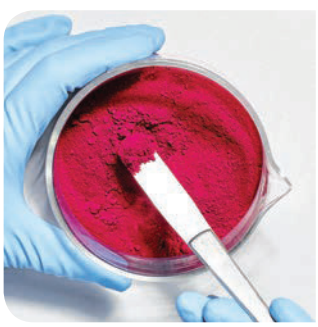
Another feature highlighted in this issue, contributed by AkzoNobel's Dr. Sunil Kulkarni on "Advancing Powder Coating Technologies for Enhanced Corrosion, Edge Protection," also addresses unique problems and conditions related to finishing equipment, but more specifically in how these processes can go wrong. Some of the most stubborn weak points on heavy equipment are sharp edges, Kulkarni points out, as this is where the electric field concentrates during electrostatic coatings application. This means powder films in these areas can be diminished to 30-70% of nominal thickness. And on a laser-cut bracket headed for a loader or a tillage tool, that's where rust starts. Kulkarni walks through the fixes from edge-optimized formulation to tuning gun parameters and more.

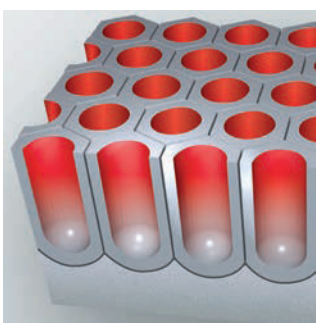
In addition, an Ask the Expert column, "Is Your Coating System Holding Your Operation Back?," contributed by Aaron Wagner, global director of Sherwin-Williams General Industrial, speaks directly to smaller equipment manufacturers running lean. His point is that a system doesn't have to fail outright to cost you. Creeping scrap rates, low transfer efficiency, recurring rework, long cure times and inconsistent results from operators are all signs that a once-adequate system is falling behind and may require a reassessment. Together, these stories and others present in this issue carry a lesson for anyone coating equipment that works in fields, quarries and job sites: durability comes from clean metal, the right pretreatment chemistry, a coating matched to its exposure, an application process that respects part geometry and supplier partnerships built on testing. These are the machines that feed us and build our infrastructure. Their finishes deserve the same engineering rigor as their engines and hydraulics. I hope these stories gives you a few ideas to optimize your own processes.

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Industry Champion's Curiosity Paves the Way for Success

_PF_ Champion of the Industry and Electroless Nickel Conference technical director Brad Durkin's curiosity has resulted in a 43-year-long career. Now, he's preserving and sharing what he's learned for future generations.

BY JESSICA POMPILI, ASSOCIATE EDITOR



_PF_ Champion of the Industry Brad Durkin has served as the technical director of the Electroless Nickel Conference (ENC) since 2007. _Source_ | Products Finishing

Industry veteran and _Products Finishing_ (_PF_) Champion of the Industry Brad Durkin is a chemistry-trained technologist with MBA-level business expertise and more than four decades of experience in the surface finishing industry. Durkin's career, however, began in a high school chemistry classroom, where a particularly engaging instructor motivated him to study chemistry at the college level.

Durkin's chemistry teacher was the first of many mentors who have enriched his career of 43 years, instilling in him a lifelong passion for learning.

"Adapted from a classic Walt Disney philosophy, I have always believed in moving forward, opening new doors and exploring new paths," says Durkin. "I believe curiosity naturally leads us toward new experiences and knowledge. I have been incredibly fortunate in my career; whenever one door closed, another always seemed to open for me."

Durkin earned his bachelor's degree in chemistry from Bowling Green State University and soon entered the world of electrochemistry as a plant chemist at a facility in northwestern Ohio. The plant served automotive and appliance customers, manufacturing zinc die castings and electroplating them on a large, automatic copper-nickel-chromium line. There, Durkin's supervisor at the time acknowledged that Durkin did not have the traditional qualifications for the role, but was impressive based on his curiosity and willingness to learn.

"That experience taught me something fundamental: formal education may open a door, but practical experience, trial and error, curiosity and the willingness to listen are what create real value," Durkin says.

He was then hired by Allied Kelite, a leader in plating technology at the time, who specialized in electroless deposition systems. There, Durkin worked alongside, and was mentored by, several pioneers of electroless nickel deposition, sparking his interest in the technology. He attended his first Electroless Nickel Conference (ENC) in 1985, which connected him with many of his peers in the industry. In his pursuit of continuous education, Durkin made sure to ask questions of his peers, learn from them and collaborate whenever possible.

"I wanted to get my hands dirty. I wanted to learn," says Durkin. "The best way to learn is to get in the lab. So, people threw projects at me. Many of them were failures, but you can learn from failure."

Learning as he went

Further along in his career, Durkin eventually brought his curiosity and expertise to global suppliers like MacDermid and Conventya. In these roles, he had the opportunity to travel the world. Durkin says his travels meaningfully



BRAD DURKIN

Associations: NASF, NASF TAC (six years), ASTM, EN Steering Committee, ENC committee

Awards/Certifications: NASF Fellowship, NASF August P. Munning Award, Certified Electro Finisher (CEF)

Advice for future generations: "I have learned from line operators, technicians and experienced practitioners who did not necessarily have advanced formal education, but who understood their processes deeply and could make plating lines perform day after day. Their knowledge deserves respect. Young professionals entering the industry should seek out these people, listen carefully and ask questions.

"My advice to the next generation is therefore fairly simple: Align yourself with people who know something you do not. Be curious, stay engaged and participate in industry associations. Listen to practical experience, even when it comes from someone whose background is different from your own. Challenge your assumptions and never stop learning."

contributed to his lifelong education, especially in the aesthetic sense."Surface finishing is a science, but a lot of that knowledge can be related to art. It is technology-based, yes, but it is also about knowing what to do and what not to do," he says. "I've seen a lot of different things, met a lot of people and learned a lot. It's been very satisfying to be able to realize that there are other ways to do things outside of the way that we think here in North America."

Traveling for over 25 years enabled Durkin to establish long-term relationships with international surface finishers, offering him insight into how surface finishing operations are conducted around the world.

Sharing and preserving industry knowledge

Alongside travel, collaboration with industry peers has been a constant source of education throughout Durkin's career. He has since spoken at several global conferences and events, invented and co-invented several industry patents covering electroless deposition and electrolytic plating technology, and authored, co-authored and contributed to a variety of industry publications, including the Electroless Deposition chapter of the "Kirk-Othmer Encyclopedia of Chemical Technology." Durkin's exposure to a variety of different perspectives in the industry encouraged his success but also posed a new challenge: sharing this information with future generations.

"My early desire to discover and educate myself associated with metal surface finishing technologies, however, created a problem. I have always maintained that knowledge is powerful but, sometimes, recalling specific details can be challenging due to the vastness of information that exists, especially for many plating technology platforms," says Durkin.

With the goal of making this vast supply of information accessible for years to come, Durkin has been curating a personal technical library over the past four decades. This library includes many seminal publications, conference papers and hard-to-find resources from industry pioneers that can offer insights and answers to today's questions. While he views AI as a useful tool for organizing, cross-referencing and calculating information, Durkin encourages current and future industry professionals to also incorporate institutional knowledge and hands-on experience into their decision-making.

"The issue is not whether modern technology is useful. It is whether the underlying knowledge is actually accessible. A decades-old paper written by an experienced plating chemist may contain exactly the practical observation needed to solve a difficult process problem, while that paper may not be indexed or digitized in a way a modern system can retrieve," says Durkin. "That is why I believe technology should augment human expertise, not replace the need for source quality, traceability, fundamentals and validation against actual plating results. That's where hands-on experience also becomes important."

He adds, "In surface finishing, experience still matters. The industry has always relied on people who know how a line behaves at two o'clock in the morning, how a deposit changes when a process drifts or how a particular defect looks before the laboratory data is available. Much of that knowledge is what people sometimes call tribal knowledge. I prefer to think of it as accumulated expertise — knowledge earned over years that deserves to be captured, respected and passed forward."

Contributing through industry associations

Participating in industry organizations like the National Association for Surface Finishing (NASF) has also

advanced Durkin's goal of sharing knowledge with future generations. He has served nine years on the NASF's committee and served as the chair of its Technology Advisory Committee (TAC) for six years, where he was responsible for developing content for the SUR/FIN exposition. Durkin was also selected by his peers as a NASF Fellow and received the August P. Munning Award in 2020, celebrating his contributions to the future and well-being of the organization. With the NASF, Durkin has had the opportunity to develop numerous training technology modules and supported the redevelopment of the Electroless Nickel CEF training program.

Additionally, Durkin has been an active member of the American Society for Testing and Materials (ASTM) for more than 35 years, particularly serving the metallic and inorganic coatings, aerospace and corrosion sectors. He has also been involved with the ENC since 1993, where he was nominated to the EN Steering Committee to support the Orlando, Florida, conference. Since then, he has been part of the conference's committee. He has served as the technical director for all EN conferences since 2007.

"My career has also reinforced the importance of developing people. One accomplishment I value was helping create a technical career ladder that gave employees a visible path for development and mobility," says Durkin. "Organizations sustain knowledge when people can see a future for themselves inside the organization and understand how education, experience and performance can lead to greater responsibility."

Looking forward

These days Durkin describes himself as "semi-retired." He has been providing his own industry consulting services since 2021, and runs a woodworking business out of his own home. Woodworking has enabled Durkin to employ the aesthetic knowledge he gained through his travels and transfer his metal finishing experience to wood finishing.

Additionally, he is constantly expanding his personal technical library and encouraging current and future industry professionals to join organizations, get involved and ask questions.

"Receiving recognition as a Champion of the Industry is very gratifying, but it also prompts a more important question: what does it really mean to be a champion of the plating and surface finishing industry?" Durkin says. "For me, the answer is not simply a list of titles, technologies or years of experience. It is a lifelong commitment to learning, asking questions, solving problems, building relationships, advancing technology and, perhaps most importantly, sharing what I have learned so that others can build on it."

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An Interview With … DR. MICHAEL FLÄMMICH, FiT

In this installment of On the Line, *Products Finishing* (*PF*) looks at industrial parts cleaning with Dr. Michael Flämmich, general manager of VACOM Montana (Lewistown, Montana) and president of FiT, the German Parts Cleaning Association (Fachverband industrielle Teilereinigung, Neuffen). Fresh off his presentation at this year's Parts Cleaning Conference in Columbus, Ohio, Flämmich talks about what drew him to high-purity cleaning, the forces reshaping the industry and FiT's plans to open its expert network to U.S. participants.





Scan the QR code to listen to the complete interview.

▶ ***Products Finishing* (*PF*): What led you to take on a leadership role at FiT in addition to your work with VACOM?**

Michael Flämmich (MF): VACOM has been a FiT member since about 2013, and I became active in 2015, chairing the Measurement, Testing and Control technical committee until 2021. In that committee, we gathered a great crew of experts on molecular and filmic contamination. We felt there was a lack of available information and knowledge on the topic in the parts cleaning industry, so we developed the FiT guideline on filmic contamination and its control.

I served as FiT vice president from 2019-2021 and have been president since 2021. For me, it's interesting, challenging, meaningful and a pleasure to make a strong impact on FiT and the parts cleaning community in general.

***PF:* Tell me about FiT's mission, current initiatives and how companies can get involved.**

MF: FiT is a cross-industry expert network. We bring together technology suppliers, chemical companies, service providers, industrial users, research institutes and universities. We develop high-quality training programs, and we make fundamental knowledge for quality-assured process control easily and digitally accessible. We generate new knowledge in our technical committees and spread those building blocks for process solutions as widely as we can. And we provide expert support for developments in industrial parts cleaning, which helps set the direction for the industry.

More recently, our technical committees and working groups have published a guideline on drying in parts cleaning; a guideline on technical terms, to standardize the industry's terminology; and FiT papers on filmic contamination and its impact on cleaning equipment, on media treatment in industrial parts cleaning, and on manufacturing process planning and optimization — all so that cleanliness gets attention at the planning stage.

We currently have 15 working groups. Highlights include low-temperature cleaning and its possibilities and limitations; cleanability, which gathers and describes all the factors affecting the cleanliness of a part; a guide to measurement, testing and analysis techniques to help users better understand the existing methods; and plastic compatibility with cleaning agents, where we connect known empirical data with experiments and measured values.

Companies can get involved by sending their parts cleaning experts to work in our network, technical committees and working groups.

***PF:* Looking ahead to the next few years, what's on the horizon for FiT and the parts cleaning industry?**

MF: Most important is our aim to open FiT to international participation and create a stronger cross-border network for industrial parts cleaning between Europe and the U.S. FiT deliberately chose the U.S. as an important test market, and we presented the concept at the Parts Cleaning Conference in Columbus. The response was very positive, with participants immediately expressing interest in contributing.

For the U.S. industry, the potential benefit is access to FiT's established technical network and its expertise in areas where we are strong, such as cleaning chemistry, equipment, process control, technical cleanliness and filmic contamination. At the same time, FiT can benefit from U.S. expertise in aerospace, semiconductor manufacturing, medical technology and the rapidly changing requirements associated with reshoring and advanced manufacturing. The objective is a two-way knowledge transfer, so experts from both sides of the Atlantic can jointly address emerging challenges, develop technical guidelines and exchange best practices more systematically.

Next, we are preparing for the FiT General Assembly, our member summit in October, where we plan to pave the way for FiT to open up to international players. The next step here in the U.S. will be an international roundtable, where interested participants will help define requirements, expectations and possible forms of cooperation between FiT and the U.S. before the concept is finalized.

IFS Coatings Expands U.S. Production With Elkhart Facility

IFS Coatings acquires a 100,000-square-foot production facility in Indiana, which will increase its powder coating and bonded metallic capacity to serve customers nationwide.

Performance powder coating provider IFS Coatings Inc. (Gainsville, Texas) has acquired a new 100,000-square-foot production facility in Elkhart, Indiana. The multi-million-dollar investment marks a significant step in the company's continued growth and reinforces its commitment to support customers across the U.S.



The facility will focus on the manufacture of powder coatings and metallic finishes, expanding IFS' production and bonding capabilities and increasing its capacity to provide a broad range of colors and finishes. The Elkhart location will also serve as a key hub for production efficiency and regional support, improving service for customers nationwide while creating multiple local jobs.

"We are strengthening our manufacturing capabilities and significantly increasing our bonded metallic capacity, while expanding our reach and continuing to deliver the quality and service our customers rely on every day," says Rob Sole, president of IFS Coatings. "Elkhart is an excellent location for IFS, and we are excited by the manufacturing talent and expertise available in the area."

The expansion builds on the company's existing manufacturing footprint in Texas and Oklahoma and further strengthens its U.S.-based production capabilities, positioning the company for continued growth in the years ahead.

PCI Opens Call for Powder Coating 2027 Presentations

The Powder Coating Institute (PCI, Albany, New York) is accepting abstracts for its Powder Coating 2027 technical conference, which takes place April 12-14 at the Renaissance Orlando at SeaWorld in Orlando, Florida. The submission deadline is **Jan. 15, 2027**.

The technical conference is the centerpiece of PCI's Powder Coating Week. PCI says it wants new, interactive sessions that help attendees produce high-quality powder coated products.

The organization is seeking presentations on the following topics:

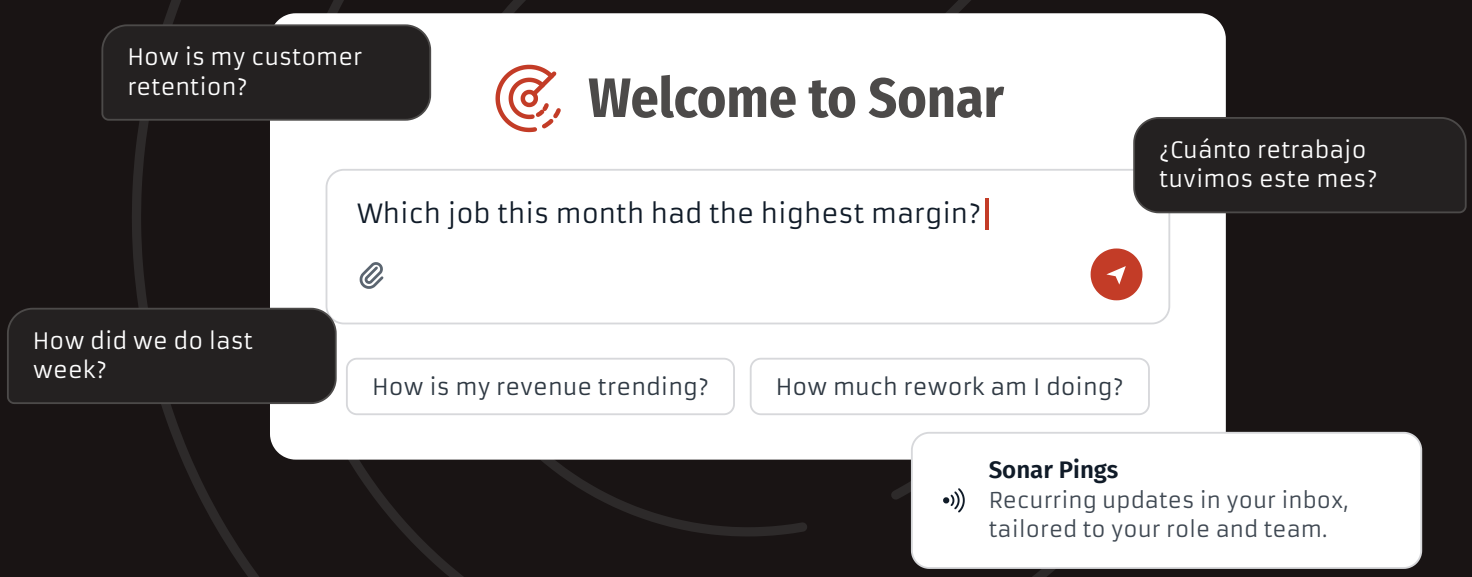
- Conversion from liquid to powder coating.
- Powder technology advancements.
- Process improvement, including part window, racking, labor, powder and chemical use, line speed, grounding and automation.
- Sustainability, including waste reduction and carbon footprint reduction.
- Labor, including finding, training and retaining workers and developing trainers.
- Media blasting, including process selection to maximize performance and efficiency.
- Pretreatment advancements, including dealing with tough soils, preventing flash rust and temp requirements.
- Quality, including specifications and expectations for incoming and outgoing parts, troubleshooting and correcting process defects, selecting tools and training personnel to identify issues.
- Case studies showing industry improvement trends.
- Professional development.
- New technologies. These are 15-minute presentations on technologies introduced, or scheduled to be introduced, after Jan. 1, 2026.

All abstracts must be submitted through PCI's website. Abstracts sent by email will not be accepted. The submission portal and additional details are accessible at **powdercoating.org/page/topicdetails**.



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Kyle Walker

Reliant Aluminum Product LLC (Highpoint, North Carolina) announces the appointment of **Kyle Walker** to the position of national sales manager. Walker has more than 30 years of experience in industrial and manufacturing environments, including over 20 years of leadership experience managing teams and driving business performance.



Mike Thies

Gema USA Inc. (Indianapolis, Indiana), a Graco Inc. company, announces that **Mike Thies**, general manager for Gema North America, is celebrating 40 years of service with the company.

A graduate of ITT Technical Institute with a degree in electrical technology, Thies entered the finishing industry in 1986, joining Gema as an electrical assembler. Over the next four decades, he steadily advanced through the company, moving from field service into sales and engineering, then to director of sales and engineering, before being named general manager for Gema North America in 2023.



Marcos Scuccuglia

Hubbard-Hall (Waterbury, Connecticut) announced the promotion of **Marcos Scuccuglia** from director of operations to vice president (VP) of operations, expanding Scuccuglia's role to operations leadership across all Hubbard-Hall locations.

Since joining Hubbard-Hall, Scuccuglia has led initiatives that improved efficiency, expanded capacity and enhanced operational visibility. Now, Scuccuglia will oversee capital projects and companywide Lean initiatives focused on expanding capacity, improving processes and supporting evolving customer needs.

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UltiCoat Unites Wisconsin, Arizona Industrial Finishing Operations Under One Brand

UltiCoat is a single brand uniting Scott's Industrial Coatings and Perfection Industrial Finishing's operations in Green Bay, Wisconsin, and Phoenix and Tucson, Arizona. The new platform combines Scott's high-volume Midwest coating capacity with Perfection's aerospace- and defense-qualified Southwest finishing under one CEO and point of contact.



Combined capabilities include powder coating, liquid paint, chemical processing (anodizing and conversion coatings), media blasting and Cerakote application. Facilities are AS9100D-, ISO 9001:2015- and Nadcap-certified, and ITAR-registered. UltiCoat lists itself as an approved supplier to defense primes including BAE Systems, Lockheed Martin, Northrop Grumman and Honeywell Aerospace, and to commercial customers including Caterpillar and Oshkosh Corp.

"Bringing these two companies together under UltiCoat gives our customers something neither of us could offer alone," explains Joaquin "JQ" Salas, CEO of UltiCoat. He notes that a manufacturer needing both powder coating and anodizing previously had to manage two separate vendor relationships and qualification processes. Now, these capabilities are consolidated into one.

UltiCoat operates 64,000 square feet in Green Bay, 32,000 square feet in Phoenix and 15,000 square feet in Tucson. The company serves aerospace, defense, marine, transportation, energy, fire/rescue, construction and industrial fabrication customers.



NASF Technical Papers

Edited by Dr. James Lindsay, NASF Technical Editor

Electroless Nickel Blackening Processes and Coating Effects

Jacob Weingart, Ph.D., CAF-MSF, Columbia Chemical Co., Brunswick, Ohio, USA

This paper is based on a presentation originally given at SUR/FIN 2026 in Rosemont, Illinois, on June 2, 2026, in Session 3: Automotive Surface Finishing. Blackening processes for nickel plating have been pursued and employed in decorative and functional metal surface finishes. For nickel electroplating, in-process additives have been used to produce black deposits as well as matte/dull nickel plating post-treatments that darken and etch the metal surface.



For applications where dimensional uniformity of metal deposit is required, electroless nickel (EN) is chosen. To darken the EN coating, an oxidizing acid etchant solution is employed. The darkening effect results from the formation of a thin nickel oxide layer and an underlying porous morphology of the EN coating. Black-finished EN metal coatings offer stability against light compared to other surface treatments, maintain electrical conductivity and have good wear resistance. Depending on the end application, heat treatment may be employed to enhance the coating's wear resistance. However, heat treatment alters the surface morphology of the blackened EN coating.

In this study, a proprietary blackening solution was employed and the effects of immersion time and subsequent heat treatment on the morphology, darkening effect and physical properties of a blackened low-phosphorus EN coating were investigated. The full presentation can be accessed and printed at **short.pfonline.com/NASF26-Nov1**.

Navigating the Shift: Trivalent Chromium Plating in the Automotive Steel Market

Ryan McBath, MKS Atotech, Anderson, South Carolina, USA

This paper is based on a presentation originally given at SUR/FIN 2026 in Rosemont, Illinois, on June 2, 2026, in Session 3: Automotive Surface Finishing. Decorative trivalent plating processes have been available for several decades, yet widespread adoption has faced significant industry hurdles. Debates regarding chloride-based chemistries versus sulfate-based chemistries, coupled with rigorous requirements for interior and exterior performance, have created a complex landscape for suppliers, applicators and OEMs alike.



This article reviews the strategic transition of automotive steel into the trivalent chromium market. By examining barriers to entry and the technical evolution of these processes, it outlines how the industry is successfully navigating regulatory and performance demands to implement sustainable, high-quality plating solutions. The full presentation can be accessed and printed at **short.pfonline.com/NASF26-Nov2**.

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AkzoNobel Opens New Powder Coatings Innovation Lab

AkzoNobel (Amsterdam, Netherlands) opened a new €7.5 million innovation lab at its Sassenheim site in the Netherlands, which holds the company's largest global R&D center.

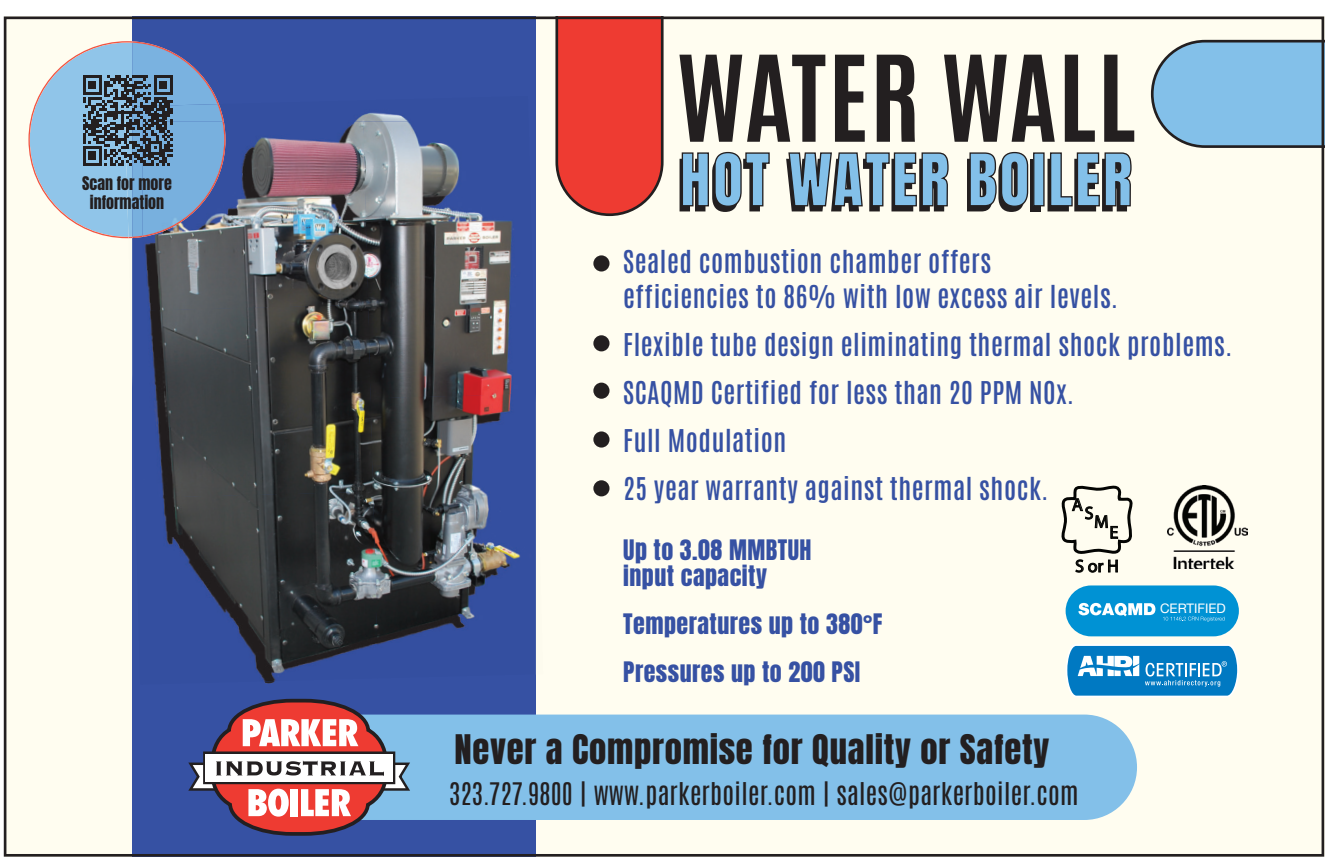
The lab will mainly focus on accelerating the development of next-generation powder coatings — including lower-temperature curing technologies that can further reduce energy use — as well as solutions designed to support customer productivity improvements. In-depth research will be carried out to identify new opportunities, such as extending product lifetimes and reducing maintenance and material use.

AkzoNobel aims to improve its ability to cut carbon emissions across its value chain. The company has already reduced CO_2 emissions in its own operations (Scopes 1 and 2, baseline 2018) by 50%, which is four years ahead of schedule.



"As well as strengthening our leadership in powder coating technologies, this investment will also expand the company's wider innovation capabilities in coating performance, application and advanced particle analysis," says Frank Vergeer, R&D director of AkzoNobel's Powder Coatings business.

"The name of my ministry — Climate and Green Growth — is no coincidence," adds Dutch Minister of Climate and Green Growth Stientje van Veldhoven, who was on hand to officially open the facility. "We don't just want to reduce emissions; we want to make sure the Netherlands stays at the forefront of clean technologies. This lab fits that ambition. It shows that sustainability and economic opportunity go hand in hand."



Efficacious Agricultural Machinery Surfacing Starts With Suppliers



Finishing shops, coating equipment manufacturers and pretreatment specialists are a crucial aspect of agricultural OEM supply chain and market success.

BY BRIAN BUDZYNSKI SENIOR EDITOR

The scope of environmental aggressors that prey on agricultural equipment might surprise you.

There are the usual suspects: fertilizers, including phosphate, potash and nitrogen-based urea and ammonium nitrate, which are highly corrosive to sprayer booms, tanks and framework; pesticides and herbicides, many of which contain acidic mixes and salts that degrade coatings; organic acids from fermented silage and feed that corrode bunks and mixers; and wash chemicals, which — notably in food-grade operations — can be aggressive detergents. Add to these road salt and deicing chemicals, which can affect equipment on farmsteads near roadways; diesel exhaust and engine byproducts like sulfur compounds and soot that build up near exhaust components; and hydraulic fluid and lubricants, which can soften or degrade coating chemistries, and you've got an insidious mix of elements to defend against.

Then there are aggressors that wouldn't seem to be aggressors at all. Soil and mud on undercarriages, wheels and lower

LEFT: Agricultural machinery, like this Case Axial Flow 7160 combine harvester, are subjected to all manner of environmental and mechanical aggressors. *Source | CNH Case*

frame components accelerates rust, especially where coatings become abraded. Manure and animal waste, which are really just hydrogen sulfide and ammonia byproducts, are corrosive to metal on livestock equipment, manure spreaders and barn-adjacent machinery, as are bird and insect droppings, which tend to be overlooked on stored equipment. Persistent dust and grit from splintered husks and tough foliage can wear coatings thin and, when combined with condensation produced by wet-dry cycling and the chalking effects of UV radiation from direct sunlight, accelerate electrochemical corrosion in enclosed cavities and on exposed surfaces.

In the face of all this, coatings and finishing suppliers are a crucial element of operations for large agriculture (ag) and forestry machinery manufacturers such as John Deere, Caterpillar, Case and New Holland.

The right prep

While the OEM will set the spec for a specific part's coating profile, it is often left to the supplier to present a viable regimen for achieving it. Partnership is the name of the game, and while suppliers each have their own ways of working, the keystone in any collaboration is asking the right questions in order to find the right prep for the part.

"It's a coordination between the design engineer [OEM], the paint company and what the pretreatment company can do to enhance that layered system, depending on the specific component," says Ronald M. Sattler, global marketing manager for agriculture, construction, earthmoving and industry at Surventis (Southfield, Michigan). "For something you're dragging behind a tractor, for example, the ground contact is going to demand something significantly different than what the cab needs, where you want a more automotive-quality performance."

"You also have to look at your incoming metal quality," Surventis key industry manager, special products, Jon Flikkema adds. "If you've got bad or rusted metal coming in, that can't be fixed by a liquid topcoat or powder coat alone. A good pretreatment — a neutral pickle or acid pickle — helps get the material back to where it should be, and then a good thin-film, zinc phosphate or iron phosphate pretreatment gets you better corrosion protection and more consistent quality."

Ag equipment doesn't just run all the time; it sits outdoors, gets pressure-washed and is passively exposed to many of the aggressors previously listed. It's also subject to thermal expansion. Experience among supplier partners helps steer an OEM toward pretreatment chemistries that perform best under such circumstances.

"In general, zinc phosphate performs above zirconium, which performs above iron phosphate," says Joseph Caiozzo, senior application engineer and coatings specialist at Henkel (Madison Heights, Michigan). "However, paint quality and substrate quality will have significant impact on performance as well. When we focus on pretreatment, zinc phosphate has the biggest advantage due to the significantly heavier coating that is applied. There is more physical barrier between the substrate and the outside environment when compared to zirconium and iron phosphate. That said, we evaluate customer parts in our lab case by case through an agreed-upon test plan to determine optimal cleaning, pretreatment chemistry and conditions."

When it comes to pretreatment strategies, liquid versus powder coating tends to have a minimal effect on recommendations; ecoat, however, is another story.

"Ecoat systems will limit the type of post-treatment that can be used due to chemical compatibility issues and the lack of a drying step prior to paint application," Caiozzo points out. "Of the main types of pretreatment, zinc phosphate will suffer most from impact and flexing. The thicker crystalline nature of the



An agriculture (ag) OEM's supplier partners will troubleshoot pretreatment and coating recommendations based on the OEM's spec to create the best holistic finishing process for their equipment. *Source | Andy Sacks/Getty*

coating can cause coating system failures from sharp acute impacts, whereas zirconium and iron phosphate coatings are amorphous in nature and can withstand impacts and flexing without adhesion or cohesion loss."

Failure analysis in the pretreatment world is very challenging to track after the fact, which makes documentation and full disclosure key elements of customer support. "We actively document all work with our customers," Caiozzo notes. "This allows us to track past issues and solutions, changes to the process or production and keep track of past recommendations. By having a strong case history, we often know what we need to look for or try to identify. There is no CSI-like database where a part can be analyzed. If we suspect a cleaning issue is the root cause, we compare the known contaminants to what is present on the failed part, and that analysis guides the team to what is contributing to the failures."

At the end of the day, efficacious coating is impossible without diligent cleaning and pretreatment, and those prefatory steps provide long-term damage control under the surface of whatever coating choice is determined to be right for the part.

"If cleaning is compromised, it doesn't matter how good the quality of the coating is, whether it's powder, liquid or ecoat," Surventis key industry manager Suresh Patel says. "If cleaning is compromised, you might as well not have any conversion coating or other coating on there."

"It's a system," Sattler adds. "Pretreatment isn't independent of the paint, and it's not independent of the cleaning, either. It all has to operate as a unified system."

The equipment impact

While liquid coatings are appropriate in certain circumstances for ag machine parts, for those too large to heat and cool efficiently for other applications, powder coating or ecoat are the predominantly preferred modes of surface finishing. And while the immersive nature of ecoat addresses many of the challenges faced by powder coaters, one challenge powder coating equipment providers have is how to put just enough on the part to meet the spec without overcoating the product and creating another problem.

"The agricultural side does struggle with putting too much powder on, which can create an inappropriate appearance," says Jeff Hale, director of marketing for powder coating equipment manufacturer Gema USA Inc. (Indianapolis, Indiana). "You might get back-ionization or some orange peel, which gives you a less attractive finish. The other issue you might have is fitment problems if the coating gets too thick. There are a lot of complex geometries in the parts they're [customers] looking to get powder coating applied to, not only for decorative purposes but for corrosion protection."

"A lot of ag parts have nooks and crannies, you might say," says Parker Ionics (Westland, Michigan) president John Cole. "Basically, Faraday cages, where you've got to get powder to flow into a corner or inner cavity, and there are multiple ways to attack it. There is hot flocking, where you actually heat up the part before you powder coat it. The problem there is any powder particle that makes it onto the part melts right away, so it doesn't have a chance to penetrate that Faraday cage and get powder to stick deep in the corner, not just around it."

One solution where powder spray technology providers have found success, however, is balancing voltage.

"Getting powder into tight recesses comes down to managing charge, not just aiming the gun," Cole says. "High voltage builds up a cloud of charged ions that grab onto powder particles and pull them toward grounded metal — but that same voltage repels particles away from sharp edges and corners. The trick is balancing enough voltage to charge the powder without overcharging the surface, since too thick a film lets the charge reverse itself [back-ionization], pushing powder away and leaving craters that bake into orange peel."

Gema's Hale points to dynamic contouring as a means of addressing "complex geometries" and other nooks and crannies common to ag machine parts. In fact, dynamic contouring technology is at



Evolving powder coating technology in the booth, which can contour around complex part geometries and reclaim powder for reapplication, is helping ag manufacturers, notably with parts unsuited to liquid or ecoat applications. *Source | Parker Ionics*



From large-scale harvesters and seeders to smaller vehicles like this lawn tractor, John Deere has one of the most robust coating specs in the ag industry. *Source | John Deere*

the heart of new developments for Gema as a way to help ag OEMs achieve the desired coverage.

"On a vertical overhead line where products are coming down on an overhead conveyor, a scanner looks at what's being presented in the booths and records the geometry," Hale says. "The spray guns contour around those shapes as they pass by. So, instead of guns all moving together in a single vertical plane, we can reciprocate up and down while at the same time moving in and out, perpendicular to the conveyor. That's where the dynamic contouring is occurring. OEM manufacturers, and even peer suppliers that supply to these OEMs, are getting coating uniformity and consistency, less powder consumed and less labor involved. That's been a big improvement within the ag market space."

Powder's not smart

Paint and powder manufacturers' relationship with their ag OEM customers extends the quality control line. The strongest partnerships are holistic, rather than being focused solely on the powder or liquid alone.

"When we do audits and line surveys for customers, we look at the whole process, from hanging the part all the way through baking the powder," says Julia Haponski, powder and liquid coatings expert at PPG (Pittsburgh, Pennsylvania). "We look for clogged nozzles and check the pressure of the water and chemicals coming out. Those really are the big things — customers don't always realize their nozzles are clogged and not penetrating as they should. We need consistent pressure and clear nozzles; those simple checks go a long way toward solving most of our problems. There's also definitely a finesse to racking parts correctly."

Moreover, what constitutes corrosion protection is varied, and recommendations and troubleshooting alike make for a particularly "fluid" situation.

"I always use the phrase 'powder's not smart,'" Haponski says. "If it's peeling in one spot but not everywhere, something is going on with that part, or in the pretreatment, where the part wasn't cleaned properly. I'd say about 60-70% of the time it traces back to the preparation, cleaning and pretreatment of the part. But if we're seeing failures all over the part surface, something's off with the compatibility of the powder itself. If it's happening in the same specific spot on the part or panel again and again, the diagnosis is a bit easier.

"The other thing we do for customers, so they're not wasting parts, is hang L-shaped or bent panels ourselves and run those through their entire process to see how they hold up and how they're coated," Haponski continues. "That way, customers aren't wasting their own parts, but we can mimic specific scenarios to help pinpoint the issue. Is it a crevice that's not getting clean? Is a chemical pooling in the pretreatment bath instead of draining, which keeps the part from drying and causes the product not to stick? We'll run those kinds of triage tests for customers."

Any given piece of ag machinery will be constructed of multiple substrates. Front-of-mind concerns regarding corrosion differ from what you would have on a stationary piece of equipment like a power generator. Most ag OEMs look to chipping first when they think about corrosion, because if you think about something going through a field — a harvester or seed planter — a lot of stones and debris come up against it, no matter how well tilled or maintained the field.

"We often say you work toward the worst substrate," Haponski says. "If you have cast iron, or cold-rolled steel that's not pickled in oil, or steel coming in that's just in bad shape, you always treat to that level, that way any other metals coming through the system will receive that same level of protection. Since our systems layer well together, whatever pretreatment you choose for your substrate will work fine with the powder coat on top. Chemicals actually aren't often the biggest driver of corrosion for agricultural equipment.

Fertilizer and manure are harsh, yes, but what's harsher is those stones. So, we do a lot of rock-chip testing and formulate chip-resistant coatings that help with chip and mar."

What it takes

Ag OEMs play their paint spec tests close to the vest, not unreasonably, to safeguard proprietary methodologies. However, a rough outline of one company's coatings certification may shine a light on just how exacting and rigorous a process it is.

John Deere is the largest ag equipment OEM in the world. (A detailed look at Deere can be read on p. 26.) The JDM F17 Enterprise Specification for Paint Performance requires suppliers to submit qualification panels for each substrate type, including CRS, HRS, cast aluminum and cast iron, with each panel coated using an approved John Deere powder coating system. As part of the initial qualification, the coating system is tested to verify compliance with JDM F17 performance requirements.

Depending on the performance level specified, the qualification testing can include any or all of the following: salt spray corrosion resistance; cyclic corrosion resistance; humidity resistance; dry adhesion (cross hatch); pencil hardness; impact resistance (direct and reverse); elongation/flexibility; chemical resistance (water, trisodium phosphate, engine coolant, engine oil, transmission oil, diesel fuel, gasoline, etc.); initial gloss verification; initial color match (instrumental Δe and visual); weathering performance; and additional requirements such as chip resistance, wet adhesion, biodiesel resistance or other supplemental requirements identified by the JDM F17 callout.

John Deere certifies the coating process based on the substrate and the approved color system, rather than on a specific part number, and once approved, the certification applies to that substrate/color combination and is not part-specific. Provided there are no changes to the approved powder coating material, pretreatment system or other process variables that would affect coating performance, requalification testing is only required when one of those approved elements changes.

> **The strongest partnerships are holistic, rather than being focused solely on the powder or liquid alone.**

A mix of stringent and sensible, this certification regimen, like that of other ag OEMs, maintains the integrity of the equipment and serves as a seal of excellence for job shops able to achieve it.





Why do edges fail? The answer often lies in electrostatic powder application and what happens during cure. *Source (All Images) | AkzoNobel*

Advancing **Powder Coating Technologies** for Enhanced Corrosion, Edge Protection

How modern powder chemistry, process control and design strategy are converging to solve one of finishing's most persistent failure modes.

DR. SUNIL KULKARNI CONTRIBUTING WRITER

For all the advances in powder coating chemistry over the past two decades, one stubborn reality continues to vex finishers, OEMs and end users alike: Corrosion still wins more often than it should, and it almost always starts at the edges. Edge protection is no longer just a paint problem. It also strongly affects design, process chemistry and, increasingly, sustainability.

Here is a look at what's driving the surface finishing industry's renewed focus on corrosion and edge performance, and the strategies by which leading powder formulators and applicators are finding success.

The cost of corrosion: Why we must do better

Corrosion is often framed as a materials issue, but at the application level, it is also a life cycle risk. Every premature failure cascades into warranty exposure, customer dissatisfaction and environmental cost.

A recent "Cost of Corrosion" report issued by AkzoNobel subsidiary Interpon surveyed manufacturers across multiple industries to better understand the operational, financial and sustainability impacts of corrosion. Findings show that corrosion is not simply a maintenance issue — it is a business issue.

Surveyed manufacturers point to two dominant categories of corrosion-related loss: 33% cite lost customers, returns and warranty claims, and 30% cite waste, landfill and the environmental burden from shortened product lifespans.

Most of those failures don't originate in the middle of a flat panel. They begin at predictable weak points like edges, cut

profiles, welds and corners. Solving the edge problem can therefore address a disproportionate share of the corrosion problem.

How corrosion happens and how powders protect

To understand why edges fail, it helps to revisit the fundamentals of corrosion. Electrochemical corrosion is the most common mechanism, requiring anodic and cathodic sites, an electrolyte and an oxidant. On steel, the reactions are:

- **Anodic (oxidation):** $Fe \rightarrow Fe^{2+} + 2e^-$
- **Cathodic (reduction):** $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
- **Rust formation:** $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$, which further oxidizes to $Fe_2O_3 \cdot H_2O$ (rust).

Layered on top of this is galvanic corrosion (dissimilar metals in contact through an electrolyte) and concentration cells that create localized attack such as pitting.

Powder coatings protect underlaying metal from corrosion primarily by acting as a dense barrier to the environment, supplemented by strong adhesion to the metal and sacrificial and inhibitive chemistries at the metal-coating interface.

A continuous, low-permeability organic film slows water, oxygen and ions like chlorides and sulfates from reaching the substrate. Strong adhesion and cohesive strength to the metal prevent delamination and undercutting once a defect appears. Sacrificial, inhibitive pigments and smart additives react with corrosion-causing elements, inhibiting corrosion pathways.

In a perfect film on a flat panel, these mechanisms work beautifully. The trouble is that edges are not flat panels. Edges are particularly vulnerable because film thickness is reduced, oxygen concentration gradients form more easily, mechanical damage is more likely and stress concentration can cause microcracking.

The edge corrosion challenge

Why do edges fail so consistently? The answer lies in the physics of electrostatic powder application — and in what happens during cure.

During application, the electric field and resulting powder deposition are nonuniform near edges and recesses. Field lines concentrate at sharp outer edges; once a thin layer of powder builds up, the surface charge on that powder *repels additional particles.* This self-limiting effect produces thinner films at edges than on flat areas. Meanwhile, Faraday cage effects in recesses and inner corners can starve those areas of powder altogether — though for corrosion purposes, the outer edges are usually the more critical concern.

During melting and curing, the situation can worsen. The molten coating may flow away from sharp edges due to surface tension and viscosity gradients. On some substrates, heat distribution can cause slight differences in crosslinking or adhesion at edges, especially in thick sections.

Research indicates that edges can end up with just 30-70% of the nominal film thickness present elsewhere on the part, depending on geometry and application settings.

Historically, industry has tried to compensate with brute-force approaches such as higher overall film build (inefficient and prone to causing defects elsewhere), multiple coats, mechanical edge rounding as a separate fabrication step and better pretreatments (phosphate, chromate, zirconium). These approaches help, but edge protection remains a leading cause of premature coating failure.

Designing powders for edges

Edge coverage isn't just about geometry and gun settings. It's also strongly influenced by coating chemistry, rheology, surface tension, cure kinetics and the pigment/additive package.

Strong adhesion to the substrate and excellent barrier properties of the organic binders, which are achieved by selecting the appropriate resins, crosslinkers and crosslinking chemistries, are the first line of defense against corrosion. Barrier properties are further improved by the addition of lamellar pigments that create tortuous diffusion paths for corrosion-causing molecular interfaces. Anti-corrosive pigments such as zinc aluminum phosphates, molybdate-based pigments and organic corrosion inhibitors can reduce corrosion creep from edges and scribes. Zinc-rich primers provide sacrificial protection at edges and from scratches, and are widely used in structural steel, automotive underbody and offshore applications.

In addition, state-of-the-art formulations designed for edge protection exhibit optimized rheology during powder cure that is engineered around three aspects: rapid viscosity drop, controlled minimum viscosity and a fast gelation window. Controlled particle size distribution, especially bimodal distribution, can help densely pack powder particles and ensure uniformity of the cured film.

Process and design strategies

Even the best-engineered powder needs a thoughtful substrate preparation and application and curing process behind it. Let's break it down into three areas:

DESIGN AND SURFACE PREPARATION

Rounding the edges is one of the single most effective measures available. Edges should be rounded to a radius of 2 millimeters wherever possible, which can potentially double edge protection. While grinding or machining cut edges, it's important to maintain uniform radii by removing burrs.

Maintain blast profile at edges. Edges are notoriously difficult to blast evenly, which directly affects adhesion. It's essential to maintain uniform blast profile on the edges.

Finally, the importance of proper pretreatment cannot be understated. It requires attention to details such as solution pH, solution agitation, part racking and even part positioning. Without appropriate pretreatment, it is exponentially more difficult to achieve superior corrosion resistance.

APPLICATION PROCESS OPTIMIZATION

Application strategies are tailored based on specific component requirements and performance goals. Optimized gun parameters such as voltage, powder output and air pressure, as well as adjusting gun distance and angle, can help with better edge coverage. Multi-pass strategies are employed to cover flat areas as well as edges. Some lines incorporate manual touch-up before or after automated application. Slight pre-heating of substrates increases deposition as powder melts on contact, promoting adhesion and build.

However, it requires careful control to avoid orange peel and other defects. Careful control of a coating material's process conditions helps maintain consistent application performance and repeatable results throughout production. Modern automation and inspection technologies now tailor spray patterns for complex geometries with measurably improved edge coverage.

MULTI-COAT AND DUPLEX SYSTEMS

For severe environments — C4 (high corrosivity), C5 (very high corrosivity), M (marine) or offshore service — best practice involves layered architecture. Dual-coat systems with zinc-rich epoxy primer and polyester or polyurethane topcoat is the go-to system for severe environments. The synergy between zinc in galvanized or metallized steel and organic topcoat enables greatly improved edge protection; corrosion typically initiates only after prolonged exposure. For additional protection, edge strip coating (usually liquid) employed before or after powder application is often specified.

The sustainability dividend

Corrosion protection and sustainability are two sides of a common coin. Extending the service life of coated products reduces the need for repair, recoating and replacement, helping lower material use, waste and associated emissions over the product life cycle. It's one of the reasons why powder coatings are becoming an increasingly attractive choice.

Findings from Interpon's "Cost of Corrosion" report reflect this shift in priorities:

- 48% of manufacturers now use powder coatings, compared to 41% liquid, 40% electroplating and 23% hot-dip galvanizing.
- 40% strongly agree powder improves line speed and lowers cost.
- 40% strongly agree powder provides longer-term durability.
- 74% report reduced environmental impact.
- 83% say powder is safer for the workforce.

The report also found that sustainability is becoming a more important factor in coating selection, with 24% of manufacturers citing it as a key consideration today, rising to 37% when making future coating decisions.

Together, these findings show that manufacturers increasingly view powder coatings not only as a route to corrosion protection, but also as a way to improve operational efficiency and support broader sustainability goals.



Edge coverage isn't just about geometry and gun settings. A multitude of factors from coating chemistry through to the final cure can ultimately contribute to failures.

Achieving long-term corrosion resistance

Next-generation edge and corrosion performance can be distilled into four interlocking principles:

- **Design and surface preparation:** Edge radius 2 millimeters where possible; thorough blasting and robust conversion coatings.
- **Advanced powder formulations:** Optimized rheology, lamellar/barrier pigments, corrosion inhibitors (including nanocontainers) and zinc-rich primers in severe service.
- **Process control:** Targeted application to edges, substrate pre-heating, multi-pass strategies and robotic optimization.
- **Multicoat/duplex systems:** Zinc-rich primer plus a durable topcoat, or a galvanized/metallized substrate plus powder.

When these four elements are combined, contemporary powder coating systems can achieve long-term corrosion resistance of 10-25+ years in C4/C5 environments. But this performance is not automatic. It requires rigorous adherence to design and process guidelines from start to finish.



ABOUT THE AUTHOR

DR. SUNIL KULKARNI is innovation manager at AkzoNobel.

CONTACT: akzonobel.com



The John Deere Way

John Deere's paint specifications continue to uphold one of the most rigorous standards in the agricultural machinery sector.

BY BRIAN BUDZYNSKI SENIOR EDITOR

Many of the things we hold to be purely "American" are anything but. Apple pie was invented in England in the 14th century, for example; hamburgers and hot dogs trace back to Germany, as do automobiles; fireworks originated in ancient China; and denim was first conceived in Italy and France before arriving on this side of the Atlantic, where Levi-Strauss slapped on some copper rivets and patented "blue jeans."

Another decidedly American trope is the concept of the Heartland and its emblem — the farmer. Even though private farms have become a minority and agriculture these days is largely a consolidated enterprise, one aspect of farming, regardless of scale, remains tried-and-true "American," and that's John Deere.

John Deere has been American from the very start. Founded in Grand Detour, Illinois, in 1837 and later reestablished in Moline, Illinois, where access to the Mississippi River's supply and trade route helped the company blossom into a multinational juggernaut, John Deere is among the oldest American-founded companies still operating, and nearly 200 years on, it remains a standard-bearer in the agricultural and earthmoving industries. While there are other large agriculture equipment manufacturers in the U.S. — CNH Industrial, which owns Case and New Holland, and AGCO Corp. come to mind — the undisputed market

LEFT: All John Deere parts undergo thorough inspection to ensure quality coatings.
Source (All Images) | John Deere

leader remains John Deere.

You know a piece of John Deere equipment even if you don't see the company's leaping stag logo on its hull; you know it by the colors. "John Deere Green" and "John Deere Agricultural Yellow" are as ubiquitous to the company's identity as the "swoosh" is to Nike, and in the 1980s, just as that latter company was taking over the sports industry, Deere successfully trademarked its green and yellow color scheme as a symbol of product quality and a means of protecting its brand in the marketplace.

Deere's line of agricultural equipment spans from compact tractors, front-end loaders and skid-steers to harvesting equipment such as combines, sugarcane and cotton harvesters, and planters capable of seeding up to 54 plow rows (around 90 feet wide) at one time. A measure of trust in Deere's products can be traced directly to its colors, not just from an aesthetic point of view, but a quality one. Deere's rigid coatings standards are designed to provide quality assurance in the efficacy and reliability of its equipment. The John Deere JDM F17 Enterprise Specification for Paint Performance, along with supplemental substrate-specific addenda, is upheld internally and throughout its vast third-party supplier network, establishing global specifications for paint performance, quality thresholds for multiple substrates and parts functions, application processes and testing to ensure heavy machinery topcoats that can withstand the harsh environmental and chemical conditions presented by farming and other agricultural enterprises.

John Deere's patented green and yellow color scheme differentiates its machinery from the competition.



Vetting suppliers

Like its dealer network, which has more than 2,200 locations in the U.S. alone, John Deere's third-party coatings supplier network is spread out from coast to coast. The reach of its coatings ecosystem, however, can be gauged by how it manages its coating specifications and the qualification process suppliers must undergo to work with the green and yellow.

"How Deere does its paint performance standards is maybe different than some other companies like Caterpillar and other heavy off-road folks," John Deere manager of global facilities services Rex Krohn Jr. tells *PF*. "We specify weathering, initial color matching, salt spray, physical test and chemical resistance, all based upon a Level 1, 2, 3 kind of scenario — Level 1 being hidden components or ground-engaging, what I would call non-drivable, equipment; Level 2 is predominantly our large agriculture equipment — drivable tractors, combines, self-propelled forage harvesters, sprayers, cotton pickers — and then Level 3 is predominantly for riding lawn equipment."

It's a guided-hand form of specification that not just relies on, but demands in-place capabilities from suppliers.

"We specify the criteria you have to meet; how you get there is kind of up to you," Krohn explains. "We give basic guidelines — for example, if you're trying to meet Level 3 performance, you're not going to do that with a manual wand wash and a single-component liquid paint. Of course, there are exceptions to every rule. We have a lot of shot-blast [surface treatment] and powder direct-to-metal applications with no pretreatment, and they perform perfectly fine because the shot-blast process is highly controlled and very clean, but for modifications to our standards, there are predominantly two drivers. One is more advanced test methods that help us get better answers quicker — for example, we'll do traditional salt spray or scab testing, but we're also doing things like electrochemical evaluations to determine rapid acceleration of corrosion. That drives additional test methods and changes to our standards. The other is customer expectations."

But before a supplier even reaches that threshold, there is an advanced vetting gauntlet.

"There's a lot of background vetting," Krohn says. "We have a group we call supply management that manages our supplier base and vets suppliers before we ever do any testing. It asks, 'What's your safety record? Your track record? Your financial stability and ability to supply where we need it?'

When data creates value, and when it doesn't

In the course of a larger-spectrum conversation, which can be heard in full on *PF*'s On the Line podcast series, we asked John Deere manager of global facilities services Rex Krohn Jr. the following question: Does data feedback into process control adjust process parameters in real time, or is it evaluated on a longer, regular schedule, versus just flagging parts for rework or scrap after the fact?

"It depends on the process," he explains. "For a pretreatment process, we have ongoing monitoring for pressures, pH and temperatures, and a lot of those systems will feed in replenishment materials based on that data — cleaner concentration, for example, based on the conductivity or pH of the bath. So, part of the answer is yes — that gives us more process consistency.

"But in many cases, such as at our harvester plant, for instance, where we have a 60,000-gallon ecoat tank, we could run it for a week without the percent solids changing at all. So, we don't monitor that on a routine basis; we'll check it once a day or once a shift, but it's not real-time monitoring, because the tank is so large that the variable barely moves. You could run 20 combines through there and it might change a tenth of a percent. Real-time online monitoring of solids percentage would essentially flatline — even hourly sampling wouldn't show meaningful change. So, there's an extra cost to that kind of monitoring, and we choose not to do it. Not that it can't be done, it just doesn't create value for us."

To listen to the full interview with Rex Krohn, Jr., visit **pfonline.com/podcast**.

Once a supplier gets through that vetting, we'll do what I'd call round-robin testing — taking generic base or formulation platforms and seeing how well their two-component urethanes, two-component epoxies, urethane primers or TGIC powders perform against known products. If it performs well, we do further testing. If it doesn't, we tell them their stuff isn't quite where we want it yet, and to continue development."

The sustainability mix

While precise numbers remain under wraps, Krohn estimates about 80 factories worldwide provide products across all of Deere's customer segments, from road building to lawn and garden and everything in between. Around 50% of all components that go into a Deere agricultural vehicle are painted by suppliers. Sustainability measures go hand-in-hand with the overall vetting regimen, and as with every other aspect of Deere's supplier partnerships, open lines of communication are the truss that keeps the bridge network strong.

"We have a restricted material list," Krohn says. "We don't use lead, chrome or other heavy metal 'bad actors,' and we require that across our supply network. We use X-ray fluorescence [XRF] to test for lead in our coatings, and if we get a failure, we halt use of that supplier and work with them until it's resolved.

"When you think about Deere and greenhouse gas emissions, the amount coming out of our painting operations is minuscule compared to what's produced by our vehicles — burning diesel fuel produces much more. Our whole manufacturing footprint is less than 10% of our total emissions, so while paint operations are a meaningful share of our factory emissions, they're a small piece of Deere's overall environmental footprint. We do what makes sense from a financial and stewardship standpoint but switching to a zero-VOC paint at a given factory, for example, isn't going to move the needle on our total footprint. That's predominantly driven by local regulations and permit limits — that drives more of our material selection than trying to shrink Deere's footprint by optimizing paint."



For third-party partnerships, John Deere sets strict paint specs, but the manner of meeting those standards is left up to suppliers.

Choosing the right coating

Agricultural equipment is exposed to a wide array of corrosive substances, including herbicides such as glyphosate, insecticides and fungicides (often sulfur-based), pressurized anhydrous ammonia fertilizers and various other solvents. And then there are the persistent environmental aggressors that are out of



Many sub-assemblies happen at Deere's facilities, the largest of which are located in Waterloo and Dubuque, Iowa, and East Moline, Illinois, where it is headquartered.

a farm operator's hands — rain, direct sunlight, soil and husk. A machine's coating must be capable of withstanding all of it.

Reciprocity between Deere's own internal protocols and how it works with suppliers hinges on a two-fold qualification process, and before a coating system is approved for production, a decision is made as to which components get powder, which liquid and which ecoat.

"The first aspect is what we call our X1 approval process, which tests the coating materials — the paint materials — on a known pretreatment and substrate," Krohn says. "We run tests over traditional ACT panels, evaluating color, gloss, chemical resistance, physical properties, hardness and adhesion. The X2 process is line-specific and substrate-specific, where we ask, 'How well do the coatings perform on the line, or on the product or in the factory we're dealing with? Does that line have an iron phosphate cleaner-coater or a traditional cleaner-rinse zinc sealer?' The testing is based on the actual physical parameters at that specific site, and there are a lot of variables. For our highest level of performance, Level 3, we typically only get there through ecoat and powder, as they provide very high corrosion protection, durability, hardness and scratch resistance. If the requirement is lower, a lot of it comes down to the product itself. A large combine, for example, is difficult to powder coat because of the sheer cost of heating those parts up, curing them and cooling them back down."

Deere also coats a lot of sub-assemblies and final assemblies that include electronic components, drivetrain components or smaller engine components, and those don't tend to do well against the high-temperature requirements of ecoat and powder, so by default, those products demand liquid coatings. Still, Krohn says, if a part can be powder coated, that's the preference, because the overall performance, cost and environmental profile tend to be better than that of liquid.

"Powder utilization is significantly higher than liquid," he explains. "In manual systems we might get 35-40% transfer efficiency on liquid; on robotics, 65-70%. Powder is more like 95%, because you're recycling and reusing the overspray. Ecoat is even higher — typically 97-98%. But if you take a 15,000-pound mainframe on a loader and try to heat that up to 350-375°F, that takes a long time to cure, and a long time to cool back down. That's what will drive us to liquid coatings."

Keeping the customer happy

When a dealer or customer reports a coating issue in the field, such as chipping, corrosion or color fade, that's where Deere's vast dealer network comes back into play, and the result of addressing that fix can lead to improvements in the greater coatings process.

"If paint falls off a piece of equipment because of poor adhesion, the customer takes it back to the dealership, which fixes it and processes it as a warranty claim," Krohn says. "That can trigger quality digging and due diligence to figure out how widespread the issue is, and it may result in a product improvement process, where we go out into the field and address it. For the most part, in the decade I've been in this role, we haven't had any of those for paint, knock on wood. We've had issues, but we typically catch them before they get into the field, through internal checks, quality checks and repair loops. We don't have a lot of field warranty issues relative to paint."

While the adage "never judge a book by its cover" is generally considered true, when it comes to agricultural machinery, appearance *is* a key indicator of underlying quality and an important marker of customer satisfaction.

"Appearance can be a dissatisfier if it doesn't meet expectations, even though that's not why they bought the machine," Krohn points out. "They buy it for performance, but it can still bother them if it's not green enough or glossy enough. The other is resale; a lot of resale value in the ag equipment market is based on the appearance of the part or vehicle. If the tractor looks bad, you don't get as much money for it. So, there's a natural tension we manage with customers — giving them paint that performs well enough to protect resale value, without spending an over-exuberant amount to achieve an automotive-style finish they don't want to pay for. We just use good materials that maintain the appearance and quality of the parts."

Ecoclean Launches Intelligent Process Control Solutions for Water-Based Cleaning

Ecoclean's two automated process control solutions, the Lab-on-a-Chip (LOC) system and Smart Drying technology, are designed to meet the high quality standards of water-based cleaning processes.

Increasing demands on component quality are leading to more complex cleaning processes. Specified cleanliness specifications must be maintained in a stable and reproducible manner. This is increasingly associated with higher documentation requirements for process parameters. At the same time, there is a demand for more energy- and resource-efficient cleaning in order to reduce CO_2 footprint and costs. This is offset by a shortage of skilled personnel with the appropriate training and cleaning expertise.

Ecoclean (Southfield, Michigan), a provider of industrial parts cleaning solutions, is responding to this situation with developments such as the Lab-on-a-Chip (LOC) system and Smart Drying technology for automated monitoring and intelligent control of cleaning quality. The LOC maintains the quality of cleaning and rinsing baths at a precise level through automated analysis based on various measurement methods. The Smart Drying technology enables AI-supported, intelligent control and optimization of drying processes with hot air and vacuum. Together, these solutions ensure that cleaning and drying processes run optimally and also meet documentation requirements through constant parameter recording.

Comprehensive cleaning and bath analysis

Previously, a wide variety of sensors have been required to analyze the concentration of cleaning or passivation media and bath contamination, which are used in the baths in accordance with the respective medium or process. The measurements also usually require numerous manual interventions. The time-consuming determination of bath quality often leads to cleaning media being added regardless of consumption. Likewise, bath changes are still sometimes carried out on a time-dependent basis. Both situations can lead to suboptimal bath and cleaning quality, as well as a waste of resources.

The LOC system is designed to confront this issue with the ability to integrate into both multi-bath immersion and chamber systems. The combination of different measurement methods in a single system opens up a wide range of possibilities for cleaner and bath analysis. This is possible without having to equip each bath with different sensors and regardless of the cleaning or passivation medium and process used. With this system-integrated solution, sampling is carried out automatically from the respective stations connected to the evaluation unit.

Titration, pH value, conductivity and now surface tension measurement are available for determining the cleaner concentration. In modular cleaning systems, the latter enables the surfactant content in the bath to be determined separately, enabling targeted re-dosing of this component. The contamination of the baths can be determined by means of fluorescence and conductivity measurements.

In the future, these measurement methods will be supplemented by methods for determining total organic contamination (TOC) and particle measurement. The measurements to be performed on the sample taken from the bath can be entered via the system control. Between sampling from the baths, an automatic rinsing system will ensure that results are displayed accurately and, if necessary, appropriate actions are initiated, such as the addition of medium or water, or a bath change.

With the standalone version, test samples are taken from the baths manually, and the rest of the procedure is also automatic. With both alternatives, measurement methods can be combined as required, and additional functions or new measurement methods can be easily integrated.

Optimal drying with minimal time and energy consumption

Drying is not only one of the most energy-intensive processes, but also a primary bottleneck in parts cleaning due to the time it requires. Problems also often arise — especially when different components need to be cleaned and dried. To be on the safe side, drying processes are often



When it comes to consistent, high process quality and savings in energy, resources and operating costs, the Lab-on-a-Chip (LOC) system opens up new perspectives through automated analysis of cleaning and rinsing baths based on various measurement methods. *Source | Ecoclean*

designed based on a worst-case scenario, which can result in increased energy consumption with correspondingly high costs and reduced productivity.

The goal, therefore, is to obtain optimally dried parts from the system with minimized energy and time requirements. Ecoclean has implemented this with its AI-supported, intelligent Smart Drying solution for combined hot air vacuum drying processes. The basis for this is a humidity and temperature sensor specially developed for this application, which is now standard in various types of the manufacturer's systems.

In order to control the drying process in a time- and energy-optimized manner, the technology's AI model was first trained with data from thousands of drying tests with a wide variety of components and target parameters. Based on this know-how, the AI evaluates the quality of the respective drying process by analyzing humidity,





The methods available for determining the actual cleaner concentration are titration, pH value, conductivity and surface tension measurement, while bath contamination can be detected by means of fluorescence and conductivity measurement. Measurement methods can be combined as required, and additional functions or new measurement methods can be easily integrated. *Source | Ecoclean*

temperature and pressure parameters in the process chamber. It then decides which action is most appropriate for optimal drying.

For thin-walled parts or plastic workpieces, for example, this may be the supply of warm air. Essential for the use of Smart Drying technology are process-stable, reproducible processes that enable consistent conditions in the process chamber. Worn seals or sensors that are not calibrated regularly, for example, lead to changes.

One of the next development steps at Ecoclean is to transfer findings from machine learning to the use of AI for the control and optimization of cleaning and rinsing processes.

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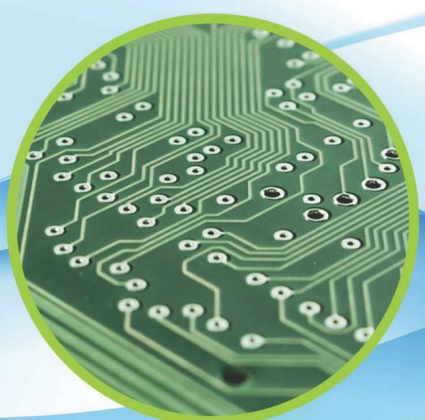
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High-Performance Vapor Degreasing Solvents Reduce Environmental Impact

EnviroTech has launched a generation of PFAS-free, high-performance vapor degreasing solvents for sensitive and detailed components.

Across aerospace, automotive, electronics, medical devices and precision engineering, achieving the required level of component cleanliness is essential to optimizing product performance, reliability and compliance.

To address this need, EnviroTech Europe (Woking, Surrey, United Kingdom) has developed a line of PFAS-free vapor degreasing solvents, led by formulations such as ProSolv 5408e and ProSolv AS-1. These formulations aim to demonstrate that environmental responsibility and uncompromising cleaning performance are no longer mutually exclusive.

Molecular mechanics behind effective vapor degreasing

Vapor degreasing has been a cornerstone of industrial cleaning for decades. The process exploits the physics of phase change: a solvent is heated to boiling, generating a stable vapor zone in which cooler components are suspended. As vapor condenses on the part surface, it dissolves oils, greases, machining fluids, waxes and particulate residues before draining away under gravity. This leaves components clean, dry and residue-free without any mechanical scrubbing.

Cleaning occurs in a closed loop; solvents are continuously distilled and recovered via cooling coils. Cycle times are short and efficient, results are repeatable and measurable, and the absence of mechanical agitation enables delicate components to emerge unscathed.

Understanding why modern solvents are high performing requires a look at the molecular properties that drive cleaning effectiveness. Several characteristics, which work in concert, are described below.

Low surface tension. A solvent that cannot wet a surface cannot clean it. Low surface tension enables the fluid to spread rapidly across complex geometries — penetrating micron-scale features, tight clearances and blind holes that could hurt many conventional cleaning methods. This is particularly critical in sectors such as electronics assembly or medical device manufacturing, where intricate topographies are the norm rather than the exception.

Solvency strength and polarity. Most industrial soils, like oils, greases and machining fluids, are nonpolar and hydrophobic. Matching solvent polarity to contaminant type is fundamental to efficient cleaning. Low-polarity solvents dissolve these soils readily, and when paired with low surface tension, the combination can deliver consistent removal even in hard-to-reach areas. Solvency strength is typically expressed as a kauri-butanol (Kb) value; a higher figure indicates broader capability across a wider range of contaminants.

The solvation mechanism. When a solvent molecule contacts a contaminant, it progressively surrounds and separates individual molecules or particles. This weakens intermolecular forces until the soil detaches and is carried away. In a vapor degreasing system, this occurs continuously as fresh condensate flows across the component surface, enabling dissolved soils to be consistently drained rather than redeposited.

A high-performance vapor degreasing solvent

The ProSolv 5408e solvent is engineered for critical cleaning applications. It is a PFAS-free formulation with a Kb value of 98, placing it in the high-solvency category with zero ozone depletion potential (ODP).

"With a Kb value of 98 and a global warming potential [GWP] of less than 1, ProSolv 5408e demonstrates that high cleaning performance and low environmental impact can coexist in a single formulation," says Envirotech.

Its low surface tension enables penetration into fine features and complex geometries, resulting in the ability to clean everything from a multilayer printed circuit board assembly to an aerospace turbine component. Parts exit the degreaser clean, dry and residue-free, with non-volatile residue below 10 parts per million (ppm) and with no additional drying required.

Operationally, the formulation is designed to be simple to manage. Its mid-range boiling point of approximately 46°C enables safe handling, while its stable chemistry eliminates the need for additives or routine test kits. It is nonflammable, carries no flash point and is classified as nonhazardous for transport — a possible advantage for sites managing COSHH compliance or seeking to streamline their chemical safety burden.

ProSolv 5408e is also compatible with standard vapor degreasing equipment and supports ultrasonic-assisted cleaning. High fluid density, combined with high solvency,

HOW DO CLEANING TECHNOLOGY BREAKTHROUGHS ADVANCE?



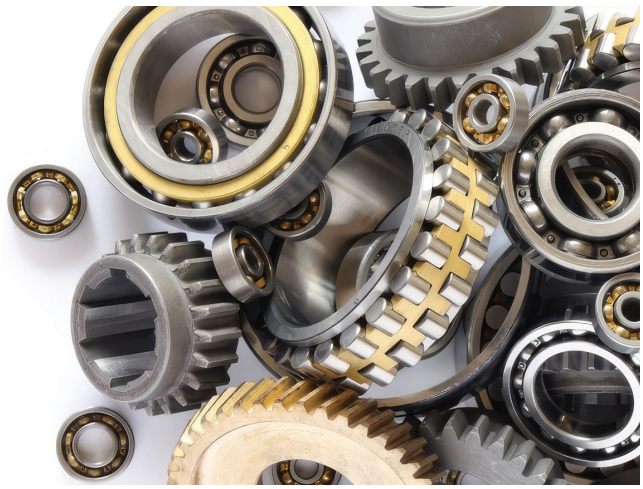
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The ProSolv 5408e and ProSolv AS-1 vapor degreasing solvents are designed to clean a range of components with high precision and efficiency, while reducing environmental impact.
Source | EnviroTech Europe

means it can perform reliably in conventional and ultrasonic-assisted systems without modification.

Precision cleaning solvent for sensitive components

ProSolv AS-1 is a high-performance, sustainable PFAS-free precision cleaning solvent engineered for flushing applications, monosolvent and as a rinsing agent for co-solvent and bi-solvent applications. With controlled solvency strength, clean evaporation characteristics and broad material compatibility, it delivers consistent removal of common contaminants for sensitive and delicate components.

ProSolv AS-1 is said to be an environmentally friendly, nonflammable vapor degreasing solvent cleaner, suited to replace HFE, HFC and HCFC solvents. Designed for the cleaning of medium oils/fluxes or light cleaning work, it features zero ODP and GWP of less than 1.

It delivers moderate solvency suited to light-to-medium soil loads, making it effective without being aggressive on sensitive components. Its mid-to-high boiling point (54°C) enables stable vapor phase performance, while clean evaporation and low residue characteristics benefit closed-loop solvent systems. It is compatible with stainless steel, aluminum, copper, brass and common engineering alloys.

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How to Stop Rust on Outdoor Powder Coated Steel

Q: We make metal outdoor furniture for a number of residential and commercial customers. We have an older powder coating system with a five-stage iron phosphate washer, dry-off oven, two powder booths with automatic and manual application equipment and convection cure oven. We apply a single coat of a high-quality, UV durable powder. We have problems with corrosion on some of our installations, and we are not sure of the best way to tackle improvement on our system. We have considered replacement of our washer but are looking for some direction on the best approach to additional corrosion resistance. Can you give us some ideas of best practices to ensure good corrosion protection over steel furniture?

A: An organic coating over ferrous metal can provide some protection against moisture penetration and oxidation but the process has to be done right and consistently. The surface has to be treated in a way that will ensure a good bond and makes sure there are no corrosive cells



left under the film. All foreign matter (dirt, dust, oils, wax, markers, etc.) must be 100% removed to prevent the formation of a corrosion cell. The surface preparation and coating material work together to prevent oxidation.

Before you consider your surface preparation options, you need to review your metals, soils and fabrication techniques. Make sure all of your parts are free from excess burrs and sharp edges. If you must bend the sheet metal over into a tight fold, make sure the inside of the bend can be treated and covered with powder so rust cannot bleed out when it is exposed to the outdoors.

Next, focus on cleaning. Do a good evaluation of the soils and amount of rust inhibitor that is normal on your incoming steel. Make sure the cleaner is strong enough and has enough time and temperature to be effective. You can clean with a good chemical cleaner or by abrasive blasting, so long as all organic soils are removed and there is no scale, weld stains or other inorganic material left on the surface.

There are different ways to provide protection once the soils are removed. You can use a conversion coating that adds corrosion protection such as zinc phosphate, chrome treatment, zirconium treatment or similar materials to provide barrier protection under a powder film. Iron phosphate does not provide much benefit as a corrosion inhibitor, so if you use it as your conversion coating you should include a powder primer before you apply the topcoat to enhance protection. The primer will add significant protection, with or without an enhanced conversion coating.

In your case, the five-stage washer may do a decent job of cleaning, but the iron phosphate will not add significant corrosion resistance. It may be hard to change to something better because the equipment needs to be made of stainless steel for most of the better conversion coatings. You will also need very high-quality water (deionized or reverse osmosis filtered) and you must have the right number and size of stages. If you are able to replace your washer and enhance the conversion coating, that will go a long way to solving your problems.

If washer replacement is not an option, then I would recommend that you add blast and prime to your process. If you do a good job of blasting, you will have a good surface for bonding. If you add a layer of zinc-rich powder primer, you will add a major additional barrier to moisture penetration and a reactive layer of zinc for corrosion protection. This may be the most cost-effective and reliable way to improve your corrosion resistance.

Improved pretreatment or primer are your two best options. What you cannot do is continue to rely on iron phosphate with one coat of powder. That will inevitably lead to some failures for outdoor steel.



ABOUT THE AUTHOR

RODGER TALBERT has more than 30 years of experience in the powder coating industry.

Beyond the Plating Bath

Q. When a customer reports a plating defect, it can be tempting to immediately focus on the plating chemistry. From a technical perspective, what approach should be taken to systematically evaluate the process and determine where the actual source of the problem may be?

A. A plating defect should be treated as a process issue until the evidence identifies a specific cause. The plating bath is important, but it is only one part of a connected system that includes the incoming substrate, part preparation, rinsing, electrical delivery, equipment, solution control, handling and posttreatment. Changing bath chemistry before evaluating the rest of the process can temporarily hide a symptom, create a second problem or make the original cause harder to find.

The most effective investigation begins by defining the defect precisely, then follows the part through the process in the same order in which it is produced. The objective is not to prove that one department or one tank is responsible. It is to narrow the possibilities with observations, records and controlled tests until the defect can be reproduced, corrected and prevented.

1. Define and contain the problem

Before making adjustments, document what is actually occurring. Terms such as pitting, blistering, peeling, roughness, staining, burning, haze and poor coverage describe different failure modes and point toward different mechanisms.



Source | Products Finishing

Record where the defect appears on the part, when it began, how frequently it occurs and whether it affects every load, a particular rack or barrel, one part orientation or a specific current density area.

Photograph the complete part and close-up details of the part. Representative rejected parts, acceptable parts and parts from intermediate process stages should be retained whenever possible. If suspect material could reach the customer, contain the affected production and identify the last known acceptable lot while the investigation proceeds.

2. Review what changed

A defect that appears suddenly usually has a change associated with it, even when the connection is not obvious. Review production history immediately before the first known failure and compare it with a period of a stable operation. Relevant changes may include:

- A new substrate lot, supplier, heat treatment, forming operation, weld condition, rust preventative type or surface finish.
- A change in cleaners, acids, additives, water source, replenishment practice or rinse flow.
- New racks, repaired contacts, different loading density, altered part orientation or barrel maintenance.
- Rectifier work, heater or chiller problems, pump or filter changes, anode maintenance or ventilation changes.
- Long shutdowns, line stoppage, unusual production volume, extended idle time or a change in operator or operating sequence.

This comparison often provides the fastest path to a useful hypothesis. However, timing alone does not prove causation; the suspected change should still be tested.

3. Inspect the substrate before blaming the deposit

The final coating reproduces, and sometimes magnifies, the condition of the underlying surface. Base metal porosity, scale, rust, embedded abrasive, polishing compound, weld residue, cold-working damage, laps, seams and heat-treatment scale may appear after plating as pits, roughness, blisters, stains or nonuniform appearance. Inspect unplated parts under appropriate magnification and compare affected and unaffected areas. When practical, cross-sectioning or other surface analysis methods can help

determine whether the discontinuity begins in the substrate, at the coating interface or within the deposit.

4. Verify cleaning activation and rinsing

Cleaning and activation must be evaluated as a complete sequence. A cleaner can meet its analytical limits and still perform poorly because of excessive soil loading, oil accumulation, inadequate temperature, insufficient time, weak agitation, poor electrical contact during electro cleaning or an incompatible step for the substrate. Likewise, excessive etching or an activation step that is too aggressive will damage the surface and create defects that appear to originate in the plating tank.

Observe actual parts moving through the line. Confirm that solutions contact recessed areas, blind holes, welds and tubular sections. Check for water breaks after cleaning, but do not rely on a water-break test as the only evidence of cleanliness. Evaluate rinse quality, flow direction, dwell time, contamination and drag-in between stages. Where appropriate, measure conductivity or another site-specific rinse control parameter and compare it with the facility's established baseline.

5. Evaluate electrical and mechanical conditions

Many apparent chemistry problems are caused by the way current reaches the part or by how solution and gas move around it. Verify rectifier output with an independent measurement when readings are questionable. Inspect cables, busbars, hooks, rack tips, barrel contacts and connections for heat, corrosion, looseness, coating buildup or excessive voltage drop. Confirm the actual current density using the plated surface area rather than relying only on total amperage.

Also check part spacing, orientation, shielding, thieves (sometimes called a "dummy cathode" intended to absorb excess current and prevent uneven plating), anode condition and placement, anode-to-cathode distance, solution level, agitation, filtration, pump performance and temperature uniformity. A defect limited to high current density edges, recessed areas, one rack position or one side of the tank is especially important evidence because it may indicate current distribution, contact, anode or solution flow effects.

6. Confirm bath condition with data

Only after the process has been reviewed should bath chemistry be adjusted, and then only from reliable data. Confirm sampling technique, sample location, analytical method, calculation and instrument condition before responding to an unusual result. Review the bath's trend rather than a single data point, including metal concentration, supporting salts, pH, temperature, additives, contaminants and operating history as applicable to that process.

A laboratory result within specification does not prove that the bath is functioning correctly, and an out-of-range value does not automatically prove that it caused the defect. The analytical result must agree with the observed failure mode and with process evidence. Hull cell panels, bend or adhesion tests, thickness measurements, roughness evaluation, microscopy and other process-specific tests can help connect bath condition to deposit performance.

7. Examine posttreatment and handling

The investigation should continue after electroplating. Poor rinsing, contaminated conversion coating or sealing stages, incorrect dwell time, solution imbalance, drying conditions, trapped solution, contact marks, packaging and storage environment can all alter the final appearance or performance. The location and timing of the defect are useful clues. Inspect parts after each major stage to determine the earliest point at which the condition becomes visible.

8. Use controlled trials to isolate the variable

Once the evidence supports one or more hypotheses, change one variable at a time whenever production conditions allow. A split-lot comparison is particularly useful. Process equivalent parts while changing only the suspected factor, such as substrate lot, rack, cleaner condition, current density, filtration condition or posttreatment step. Include a known-good control. Record the conditions and results so that the test can be repeated. Avoid making several chemical and mechanical adjustments simultaneously. If the defect disappears, it will be impossible to determine which change was corrective, and the problem may return.

9. Verify the root cause for corrective action

A suspected cause becomes a verified root cause only when the evidence explains the defect and corrective action produces repeatable, acceptable results. Ideally, the relationship can also be demonstrated by reproducing the defect under controlled conditions, provided this is done safely and without risking customer product.

After verification, establish controls that prevent recurrence. These may include reviewed operating limits, improved sampling or analysis, preventive maintenance, rack contact frequency cleaning, rinse monitoring, incoming material checks, operator training, alarm limits or a clearer reaction plan. Continue monitoring long enough to confirm that the correction remains effective across normal production variation.

By following the part through the entire process, comparing acceptable and defective production, and testing one hypothesis at a time, a plating operation can identify the true source of a defect more quickly and implement a corrective action that lasts.



ABOUT THE AUTHOR

KENNYA ALONSO is a technical service engineer with Pavco Inc.

CONTACT: pavco.com

Is Your Coating System Holding Your Operation Back?

Q: Our current coating system has worked for years. How do we know when it's time to reevaluate it?

A: A coating system does not have to fail completely to hold your operation back. In fact, some of the most expensive finishing problems develop gradually. Production demands increase, equipment ages, regulations evolve and customer expectations rise, but the coating process remains unchanged because it has always been considered "good enough."

Reevaluating a coating system does not necessarily mean replacing it. It means confirming that the products, processes and support behind your finishing operation still align with where your business is today and where you want it to go next.

Performance starts with the right specification

The first question is whether your coating delivers the performance your customers expect.

Agricultural equipment, for example, is regularly exposed to sunlight, moisture, chemicals, abrasion and demanding working conditions. Its finish must withstand extreme wear while maintaining brand image, color, gloss and corrosion protection throughout the expected service life.

The goal is to find the right level of performance for a product's end use, expectations and price point, without overengineering. That may mean improving weathering or corrosion resistance for equipment used outdoors. In other cases, it could mean eliminating an unnecessary layer or selecting a more economical technology that still meets the required specifications.

If you're seeing early signs of corrosion, chipping, gloss loss or fading, it may be time to review whether your current coating is still matched to the environment in which these finished products will operate.

The right coating system

Coating materials typically represent a relatively small portion of total manufacturing expenses, but the finishing process can have an outsized effect on operating costs. The true cost to get the coating onto the part also includes the labor needed to apply it, energy to cure it, time, material handling, rework, waste, etc. A lower-priced coating can end up costing significantly more in the long run if it requires more application effort, adds complexity, slows production or produces inconsistent results.

Warning signs that your process may deserve another look could include increased scrap, waste or overspray; low transfer efficiency; recurring defects; high rework or touch-up rates; excessive part handling; long cure, dry or cooling times; rising energy consumption and costs; a finishing line that cannot keep pace with production; or too much complexity for operators to manage consistently.

Each problem may appear minor when viewed individually. But together, these challenges limit throughput, consume labor and ultimately hold a business back.

The best coating for your part may not necessarily be the best coating for your unique operation. The technology and process must also work within the capabilities of your people, equipment and production schedule. A system that requires tight application tolerances or complicated mixing procedures, for example, may be difficult for a small team to maintain. Likewise, a coating with a long cure schedule may meet every performance requirement but still become the bottleneck on a high-demand production line.

Fortunately, coatings continue to evolve around these manufacturing challenges. From non-isocyanate liquid solutions that balance extended pot life with flexible cure schedules, to dust-on-dust powder coatings, new technologies create opportunities to simplify processes without sacrificing required performance.

Finding the right supplier

A coatings supplier offers much more than product deliveries. The right partner can offer in-depth expertise, help evaluate your finishing process, troubleshoot defects, review equipment settings, train operators and develop specifications based on your actual needs.

Suppliers should also introduce new technologies to solve bottlenecks or recurring issues. Whether that is by shortening cure times, simplifying processes, reducing energy costs or anticipating evolving VOC requirements, your supplier can act as a partner to support your success.

Your coating system should support both today's production and tomorrow's business goals. If demand ramps up, can your finishing line keep pace? Does your coating technology align with upcoming environmental regulations and/or your business' sustainability goals? Could a more durable or vibrant finish differentiate your products in the market or make them more enticing to dealers?

Your existing system may still be the right one. But recurring defects, rising costs, limited capacity or changing customer expectations may signal that "good enough" is no longer enough.



ABOUT THE AUTHOR

AARON WAGNER is global director of heavy equipment for Sherwin-Williams General Industrial.

CONTACT: industrial.sherwin-williams.com

Engineered Ceramic Grain Is Changing Carbon Steel Grinding

Q. When grinding carbon steel parts, we go through abrasive discs very quickly. Is there a more durable solution?

A: Carbon steel remains one of the most widely used materials in metal fabrication because of its strength, affordability and versatility. Yet these same characteristics also create significant challenges during grinding and finishing operations. Whether removing welds, beveling plate, deburring components or preparing edges for welding, fabricators demand abrasives that can withstand sustained pressure while maintaining consistent cutting performance.

Recent advances in engineered ceramic grain technology are helping address these longstanding challenges by improving cutting performance and abrasive durability.

Engineered shaped ceramic grain advantages

Grinding carbon steel presents a unique combination of stresses that differ from those encountered with stainless steel or aluminum. Large welds, mill scale and heavy stock removal require aggressive material removal rates, while continuous grinding subjects abrasives to prolonged heat and mechanical loading.

As temperatures rise, conventional abrasive grains can dull more quickly, forcing operators to apply additional pressure to maintain cut rates. Increased downforce, in turn, places greater stress on the fiber backing, potentially causing deformation or premature failure. The result is often inconsistent grinding performance, shorter disc life and more frequent disc changes.

For manufacturers seeking higher productivity, improvements in grain geometry and backing strength have become increasingly important. Unlike conventional abrasive grains that tend to plow through material, engineered shaped ceramic grains — such as those featured in Norton RazorStar FS1190 Fiber Discs — are designed with precisely shaped cutting edges that slice through metal more efficiently. This cutting action reduces friction and heat generation while requiring less force from the operator.

Advanced engineered grain geometry also improves grain retention. Individual abrasive particles remain securely anchored to the backing for longer periods, minimizing the edge shedding commonly associated with heavy-pressure grinding.

Another advantage is the controlled micro-fracturing of the ceramic grain. As the abrasive wears, microscopic fractures expose fresh, razor-sharp cutting edges rather than allowing the grain to become rounded and dull. This self-renewing action maintains a more consistent cut rate throughout the life of the disc.

Backing construction plays a role

While abrasive grain often receives the most attention, backing construction plays an equally important role in demanding carbon steel applications.

Heavy grinding operations frequently require significant operator pressure, particularly during weld removal or beveling. Under these conditions, a stronger fiber backing provides greater dimensional stability, resists deformation around sharp edges and corners, and helps reduce vibration during use.

The combination of engineered shaped ceramic grain and a more robust backing allow the abrasive to better withstand sustained heavy-duty grinding while extending usable disc life.

Finding the right disc for the job

Fiber discs designed for stainless steel commonly incorporate supersize coatings that include grinding aids to reduce heat and minimize discoloration. Carbon steel applications, however, present different requirements.

Because carbon steel does not require lubrication additives to prevent heat-related discoloration or metal capping, a non-supersize design — such as the design seen in Norton RazorStar FS1190 Fiber Discs — enables the abrasive grain to engage the workpiece more directly. This more aggressive cutting action maximizes the efficiency of the ceramic grain and supports demanding operations such as weld removal, heavy stock removal, beveling, deburring and edge preparation.

Matching abrasive construction to the workpiece material allows fabricators to optimize cutting performance without incorporating features intended for different metals.

Notably, modern abrasive portfolios increasingly include products engineered for specific materials rather than relying on a one-size-fits-all approach. Premium supersized ceramic fiber discs remain well suited for stainless steel and high-alloy materials, where heat reduction is critical. Conversely, premium non-supersize ceramic discs optimized for carbon steel prioritize aggressive cutting action and durability under high-pressure grinding conditions.

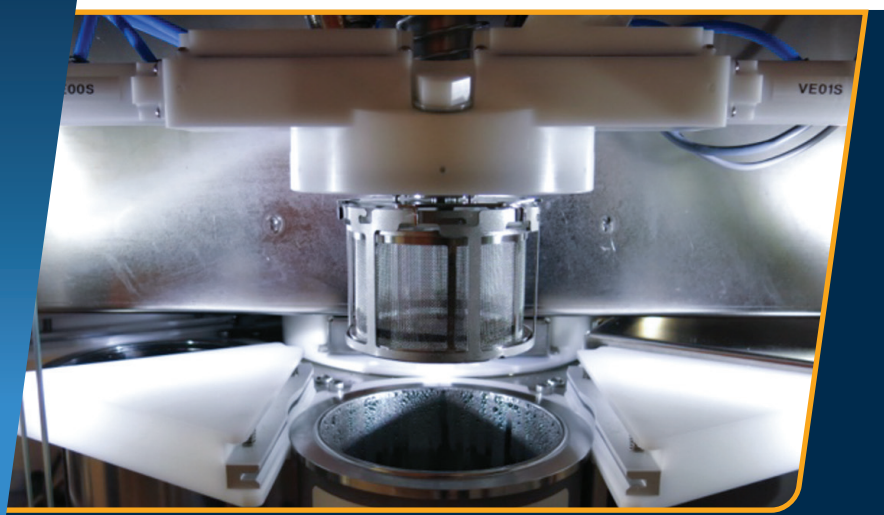
This application-specific approach enables fabricators to match abrasive technology to the demands of the material being processed, improving productivity and reducing total abrasive consumption.



ABOUT THE AUTHOR

JEREMY SPENCER is the product manager for coated abrasives for Norton | Saint-Gobain.

CONTACT: nortonabrasives.com



PF PRODUCTS FINISHING INNOVATOR

Ginova Electronics AG
ginova.ch/en

Ginova Electronics Introduces P6 for High-Purity Ultrasonic Cleaning

Within a small footprint, the Ginova P6 was built to handle precision parts cleaning, combining multi-frequency ultrasound, vacuum tech and complete process documentation.

BY GRACE STUBBINS SENIOR MANAGING EDITOR

Ginova Electronics AG (Port, Switzerland) has launched the Ginova P6, a custom ultrasonic precision parts cleaning system designed to combine high-purity cleaning, vacuum technology and complete process documentation in a footprint of less than 1 square meter. The P6 reportedly closes the longstanding gap between lab- and production-scale cleaning, targeting medical technology, watchmaking, micromechanics, sensor manufacturing and aerospace applications.

The Ginova P6 cleans parts up to 100 mm in diameter using multi-frequency ultrasound (25-132 kHz, up to 100 W) combined with a custom vacuum system featuring pulsated phase system (PPS) technology. The combination is said to be especially effective on capillaries and cannulas with passages under 0.05 mm, blind holes and 3D-printed implants with complex adhesion structures.

Many cleaning agents cannot be used under vacuum because they foam too aggressively. Standard foam sensors often fail once contaminated, leading to overflow and unplanned downtime. After an extended development effort, Ginova also engineered a system designed to significantly reduce foam formation at the source.

An optional DualDry process — combining hot-air and vacuum drying in the same vessel — increases throughput by 25% and eliminates a separate drying station transfer. Six independently configurable 2-l stations, SpinDry up to 3,000 rpm and Permanent-Flow filtration with 360-degree straining are designed to support fully automated, operator-independent processes. An optional AutoDose system supporting up to four cleaning agents, a blow-off function and two water qualities promotes maximum process reliability.

The control system, which is touchscreen or PC-Suite, stores up to 10,000 recipes and is optionally SCADA- and MedTech-ready, including full validation documentation. This brings the functional scope of large-scale production cleaning systems into a compact, flexibly deployable machine. Beyond production use, the P6 is also being adopted for recipe development ahead of scale-up to large production systems.

Configurable variants for regulated markets include:

- **P6 Med.** Validation, SCADA, sterile applications (implants, cannulas), cleanroom compatible (ISO Class 7/6).
- **P6 Micro & Optic.** Final cleaning of highly sensitive, polished surfaces.
- **P6 Pure.** Space and vacuum applications requiring minimal particle counts.

Companies can also book a full day of free process development and analysis using their own parts at Ginova's Clean Center in Port, Switzerland. Participants leave with recipes, images and full reports.

Be a *Products Finishing* Innovator: Contact *Press@PFonline.com*, to highlight your latest innovations in finishing.

AirSprayTech.com Introduces The Academy for Coatings, Finishing Education

AirSprayTech.com, produced by Azimuth Spray Systems LLC (Denton, Texas), now includes The Academy, an educational resource focused on paints, coatings, finishes and application equipment.

The Academy is for those working across automotive refinish, powder coating, OEM finishing, job shops, roof coatings, line striping, corrosion control, moisture vapor issues and secondary containment, all with a common goal: to help people understand the materials, equipment and decisions behind the work.

Readers looking for a specific answer are able to explore standalone articles in Getting Started, Equipment Guides, Buying Guides, Troubleshooting, Maintenance & Repair, Safety & Compliance and Technical Papers sections.

For deeper study, The Academy Series organizes related lessons into self-paced programs. Learners who complete a series and pass its final assessment can earn a personalized Certificate of Completion.

"A good finish begins before anyone pulls the trigger," says James L. Robertson, president of Azimuth Spray Systems LLC, the company behind AirSprayTech.com. "The Academy is built to help people understand why a process works, what can go wrong and how to make better decisions on the job."

Azimuth Spray Systems LLC | airspraytech.com/default.php

PPG Expands Marine Coatings Portfolio For Onboard Fleet Maintenance



PPG (Pittsburgh, Pennsylvania) debuts its One Range portfolio of five one-component marine coatings. Designed to simplify onboard fleet maintenance, the portfolio helps crews complete maintenance projects more efficiently, offering ready-to-use, one-component coating solutions that support a broad range of onboard maintenance applications with simplified product preparation, storage and handling, and reduced waste.

"Coatings maintenance is essential for extending vessel life cycles, but preparation and application can be time-consuming for crews managing other operational responsibilities," says Ewout Bosman, PPG segment director, seastock, protective and marine coatings. "We focused on eliminating mixing requirements and simplifying application to help crews complete projects more efficiently."

The portfolio includes waterborne, alkyd and polyurethane technologies for interior and exterior maintenance applications. Products incorporate technologies that support low volatile organic compound (VOC) compliance and low flame spread certification.

PPG | ppg.com/en-US

Russelectric Power Control Design Maintains Uninterrupted Power for Water, Wastewater Facilities

Siemens business **Russelectric** (Hingham, Massachusetts), a manufacturer of power control systems and automatic transfer switches, highlights its RTSMV 5/15 kV automatic transfer switch (ATS) and RTSMV 5/15 kV bypass/isolation switch built for dependable medium-voltage power transfer in mission-critical settings. These circuit-breaker-style switching units are UL 1008A listed for applications above 600 V and below 15 kV, and are designed to meet or exceed IEEE, NEMA and ANSI standards.

The RTSMV ATS supports voltage classes of 5 kV and 15 kV with continuous current ratings of 1,200 A and 2,000 A, respectively, and short-circuit withstand ratings up to 50 kA, depending on configuration.

The system operates under the Russelectric RPTCS programmable microprocessor control system, enabling high-speed switching from primary to backup sources under open- or closed-transition modes, and includes an adjustable center-off time delay (factory preset at 3 sec) to minimize voltage transients during transfer.



Safety and maintainability are built in. The metal-clad design houses draw-out circuit breakers with self-aligning contacts, automatic safety shutter covers, closed door racking and fully compartmentalized bus, control wiring and power sections. Busbars are insulated with high-dielectric epoxy coatings and are separated by polyester glass barriers to ensure electrical isolation and system integrity. Up to 12 current transformers per breaker (two per phase on the line and load sides) and draw-out potential transformers are accommodated for comprehensive metering and monitoring.

The RTSMV bypass/isolation switch complements the ATS by offering manual bypass capability for emergency load transfer, maintenance or testing. A selector switch allows the operator to choose between load-break or no load-break bypass modes. The compartmentalized design enhances safety by isolating the transfer switch components during bypass operations.

On the control side, the RPTCS provides a VGA color display enabling real-time metering of phase-to-phase and phase-to-neutral voltage, source frequency and, with optional configuration, current and power parameters. Communications via Modbus RTU are standard; optional Modbus TCP/IP over 10/100 Base-T Ethernet and web server gateway accessories enable integration into SCADA and industrial networks.

Russelectric's RTSMV ATS is engineered for demanding sectors such as healthcare, data centers, telecommunications, water and wastewater treatment and renewable energy installations, where uninterrupted power transfer and equipment protection are imperative.

Russelectric | russelectric.com/

One More Call: The Compounding Value of Going the Extra Quarter Mile

One man's story of turning tenacity into eventual financial success provides a powerful lesson in discipline, persistence and the magic of compounding.



MATTHEW KIRCHNER
Host of the TechEd Podcast
mkirchner@labmidwest.com

My friend Charles (not his real name, but close) is a bazillionaire who parlayed a career in sales into a huge real estate empire. How'd he do it?

From humble beginnings, as the story goes, he drove an old bus west from Iowa to Stockton, California, and when the bus broke down, he set up camp and started a career in sales. It wasn't easy at first, but as time went on success came. He kept his overhead low, lived below his means and as the money flowed he banked the difference between his growing income and his low overhead and invested it in real estate. Residential at first, then commercial, then large developments.

Charles understood the compounding nature of investing. The rule of 72s reminds us that money doubles every 10 years at 7.2%. My sense is that Charles did quite a bit better than 7.2%.

A quick aside on compounding returns — it's amazing how they build wealth. Consider a frugal and forward-thinking young woman who has managed to save $100,000 by her 30th birthday. Even if she doesn't save another penny, if she invests that amount and earns, on average, 7.2% per year, that sum will become $200,000 by age 40, $400,000 by 50, $800,000 by 60 and $1.6 million by 70. Compounding works!



Back to Charles. He was able to "retire" years before his 60th birthday. I put retire in quotes because he continues to manage his considerable real estate holdings, but he no longer makes sales calls. At the event at which his retirement was announced and celebrated, he was asked to share the secret of his success. His answer?

"I always made one more call."

This answer necessitated an explanation, so he went on. He shared that at the end of every day, after a series of customer visits and sales calls, the time came to return home or to whatever hotel at which he was to lay his head on a pillow that evening. On his way there, he kept his eyes open for an opportunity to make one more stop. And he always did.

A potential customer that still had a handful of cars in the parking lot. One where there were still a few lights on in the front office. A stale lead, a project that had become stalled, a quote that went dead, a prospect gone ghost. He always stopped.

Charles could have driven by. Could have gone home or to the hotel. Might have given into the temptation of a warm dinner or a cold beer at the end of an already long day. But he didn't.

He always made one more call. That last visit, he noted, was the key to his success.

He knew he could have mailed it in. It turns out his customers recognized this, too. They appreciated his tenacity, his work ethic and his genuine interest in learning how he could help them. And help them he did.

Over time, this practice of making one more call paid dividends. That one last call — every workday — meant one more customer conversation, one more opportunity to ask the right questions, one more quote, (in time) one more purchase order, one more commission check. This practice, day upon day, week upon week, month upon month and year upon year, produced results beyond measure.

It occurs to me that Charles understood the value of compounding returns not just in real estate, but in sales. His discipline to make one more call over all those years, compounded just like his real estate investments did. His extra efforts stacked up not just into one more order, but to many more satisfied customers, many more success stories to share with his new prospects, many more referrals and eventually into many, many more orders.

This lesson should resonate not just with those in the profession of selling, but to all in manufacturing. A general manager makes one last trip through the plant at day's end, noting and correcting anything that's out of place or process. An accounting manager makes one more phone call on a past due receivable. The quality tech checks one more order before calling it quits for the day. The shipping and receiver supervisor preps one more order for shipment as the sun goes down. The marketing coordinator preps one more social media post as the lights dim about the office.

Over time, the head starts these provide to the following days' work compound in ways that generate exponential returns over time.

How do we compound results in sales, in manufacturing, in life? Make one more call.

FINISHING INDEX



COMPONENTS SCORECARD

	Change vs Month Ago	Change vs Year Ago
Supplier Deliveries	▼	▲
Production	▼	▲
New Orders	▼	▲
Backlog	▼	▲
Employment	▼	▲
Exports	▼	▲

FUTURE BUSINESS INDEX





MIKE SHIRK
Senior Market Research Analyst
GROW Industrial Intelligence
Mike has been an essential part of GROW Intelligence for over eight years, and has led research and analysis in various industries. **mshirk@gardner.media**

The Gardner Business Index (GBI) is an indicator of the current state of finishing industry activity considering survey responses regarding new orders, production, backlog, employment, exports and supplier deliveries. Over 50 is expansion. Under 50 is contraction.

The GBI Components Scorecard reports the monthly change rate of primary finishing industry market factors contributing to the overall monthly index reading.

Reading the Scorecard: **Color** indicates where a component value falls relative to 50 for the current month. **Shade** indicates a value's distance from 50 — the darker the shade, the farther from 50. **Direction** indicates a value's change versus the previous time period.

The GBI Future Business Index is an indicator of the future state of composites fabricating considering industry respondents regarding their opinion of future business conditions for the next 12 months. Over 50 is expansion, under 50 is contraction.

GARDNER BUSINESS INDEX

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More information about the Finishing Index can be found at **gardnerintelligence.com**.

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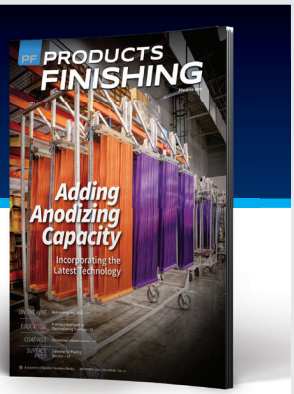
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EVENTS & WEBINARS

COURSE/SEMINAR

IFCA Industrial Finishing & Coating Association

NOVEMBER 4-5, 2026

IFCA Industrial Finishing Safety Seminar

This day-and-a-half, comprehensive seminar focuses on NFPA 33, the Standard for Spray Application Using Flammable or Combustible Materials, and will deliver important and critical information on how to safely operate an industrial finishing line.

industrialfinishing.org/events/event_list.asp

CONFERENCE

NE SURFACE FINISHING REGIONAL

NOVEMBER 6, 2026

NESURFIN Regional Conference

This is an annual professional event hosted by the New England Chapter of the National Association for Surface Finishing (NASF) dedicated to the metal and surface finishing industry. The conference begins with registration and breakfast from 7:00 – 9:00 a.m., followed by educational sessions from 9:00 a.m. – 5:00 p.m.

regional.nenasf.org/

CONFERENCE

AMPP

JANUARY 5-7, 2027

AMPP 60th Annual SIEO Intermountain Winter Symposium

The SIEO Intermountain Winter Symposium is put on annually by the Association for Materials Protection and Performance (AMPP). The Symposium will host approximately 10 in-depth professional presentations concerning corrosion within the AMPP utility network.

ampp.org/events/event-listings/chapter-events

TRADE SHOW

NASF National Association for Surface Finishing

FEBRUARY 28 - MARCH 3, 2027

NASF Leadership Conference

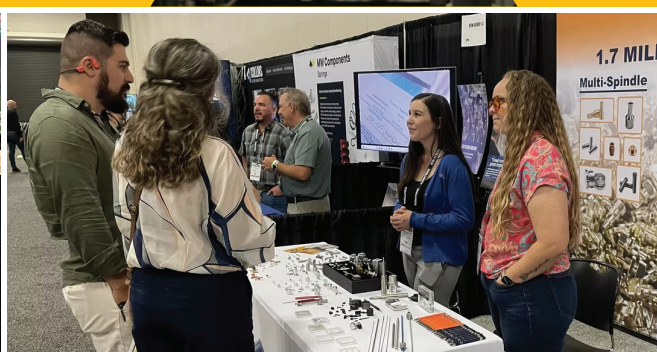
Each year, conference attendees hear from a diverse group of exceptional speakers presenting on subject matter that directly impacts executives and owners of companies in the finishing industry.

nasf.org/events/leadership-conference/

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