Sustainable, Safe & Reliable On-Site Utilities Powering Automation

COMPRESSED AIR | CHILLER & COOLING

# BEST PRACTICES

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August 2026


## Water Conservation

**Blower & Vacuum Best Practices Inside!**

# Your process depends on reliable aeration to conserve water. Our blowers deliver.

In water and wastewater systems, low-pressure aeration is more than an energy load, it is a water conservation enabler. By ensuring stable biological processes and consistent treatment performance, reliable aeration directly supports water reuse and reduces freshwater demand. That's why dependable air delivery is critical.

Atlas Copco blowers are engineered to provide consistent, reliable air at the precise pressures and flows your process requires. The result is stable operation, increased uptime, and improved process performance.

With plug-and-play packages for easy installation and a robust design for long-term reliability, our solutions help you optimize aeration while supporting your water conservation goals.

It pays to save with low-pressure air. Make the switch to Atlas Copco blower solutions, because your process depends on reliable aeration to conserve water.


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## COMPRESSED AIR SYSTEM FEATURES






## COOLING SYSTEM FEATURES



## LATEST NEWS



## EVERY ISSUE




*Cover: The John Deere facility in Paton, IA*

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# FROM THE PUBLISHER

## Consider the U.S. DOE's Better Plants Program

This May, I attended the 2026 Better Buildings & Better Plants Summit in Arlington, VA. Two days of conference sessions and networking with energy, sustainability and facility utility managers from Better Plants partners recharged my batteries to keep assisting industry with best practices.

Over 300 industrial organizations, representing thousands of U.S. plants, have accepted the Better Plants Challenge to set ambitious water, energy and waste goals. The leaders of these partner firms voluntarily commit to set goals to reduce energy intensity across their U.S. portfolio by at least 25% over a ten-year period and share their strategies and results. From our industry, I was proud to see Ingersoll Rand, Trane, Johnson Controls and Baltimore Aircoil involved.

The partner list is a who's-who of manufacturing companies, and it's our job at *Best Practices* to publish the system projects they want to share. *Best Practices* subscribers were present from the Schneider Electric team whose Lincoln, NE, plant was featured as our May 2026 cover story! It was great to say hello to subscribers from Niagara Bottling, Lockheed Martin, SumiRiko, CalPortland, ConAgra, Sika and Intertape Polymer Group, firms recognized for achieving goals and delivering successful projects.

In return for their commitment, industrial partners receive valuable technical assistance at no charge. This includes being assigned a Technical Account Manager (like our columnist Alex Botts on page 48) who helps them access a wide range of resources, including energy assessment instruments on loan, In-Plant trainings and Energy Treasure Hunt training.

Some Energy Managers at the Summit encouraged us to launch a Compressed Air Treasure Hunt Workshop at the Best Practices 2026 EXPO & Conference, October 13-15 in Indianapolis, IN. So, we're doing it! Led by experienced plant personnel and system auditors, this workshop will help plants move beyond the occasional compressed air leak survey and discover new Treasure Hunt ideas. We look forward to seeing you there.

As always, thank you for investing in ***Compressed Air Best Practices***®.

**RODERICK M. SMITH** *Publisher, tel: 412-980-9901, rod@airbestpractices.com*

## David Wayne Perry, 1950-2026 †

Wayne Perry passed away peacefully, surrounded by his loving family, on April 24, 2026, in Silverhill, AL. I met him in 1992 and will always remember him for his intelligence, wit, humility and love for family. After 45 years in our industry, he retired in 2022 as Senior Technical Director for Kaeser Compressors, a position and company he cherished. He'd become a leading technical voice in the United States, working with the United Nations, the U.S. Department of Energy, ISO, the Compressed Air & Gas Institute and the Compressed Air Challenge. He generously offered unwavering support for this publication, serving on our Editorial Board. As a trusted technical advisor, he halted the publication of more than one "revolutionary invention!" I know I speak for the entire compressed air industry in saying his contributions to energy efficiency are permanent. We were fortunate to know him and offer his family our most sincere condolences. God bless you, Wayne.

**Roderick M. Smith** *Publisher – June 16, 2026*

SAUER COMPRESSORS

Sauer Compressors USA

# A CUT ABOVE THE REST

## ENGINEERED AIR SOLUTIONS FOR HIGH-PERFORMANCE LASER CUTTING

Laser cutting applications demand precision, stability, and high-performance compressed air to ensure clean and accurate results. Industries such as metal treatment rely on consistent air quality to achieve optimal finishes, while machine tool manufacturers require reliable systems to support cutting efficiency and equipment performance.

**SAUER** Mistral

Final pressure: **500 psi**

Flow rate: **11.2 - 18.4 scfm**

Rated power: **6.2 - 11 hp**

**SAUER** Mistral

Final pressure: **580 psi**

Flow rate: **26.5 - 47 scfm**

Rated power: **11.7 - 21.4 hp**

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# Subscribers From Around the World

We salute all Best Practices Magazine subscribers from around the world who own, operate, maintain, engineer and provide expertise for the on-site utilities (compressed air, nitrogen generation, vacuum, blowers, chillers, cooling towers and pumps) powering modern plant automation. This subscriber-driven monthly column hopes to build community and recognize all subscribers!


*Manufacturers from all around the world visited the 2025 Best Practices EXPO & Conference, including Gretchem Espada and Naioth Lopez Nieves (left to right) from Baxter International. An American multinational healthcare company with headquarters in Deerfield, IL, the company focuses on products to treat chronic and acute medical conditions. These attendees flew in from the company's Aibonito, Puerto Rico, facility. Visit https://www.baxter.com and https://cabpexpo.com.*


*Our Sales Director was pleased to pay a call on AMSOIL this month, at the company's factory in Superior, WI. In 1972, its founder created the first synthetic motor oil in the world to meet American Petroleum Institute service requirements. Now, its products are found in air compressors, race cars and everything in between. Pictured here are Matt Morgan, Sarah Acheson and Bradon Nash (left to right). Visit https://www.amsoil.com.*


*Founded in 1972, compressed air sales and service company Comairco now counts more than 275 employees across the U.S. and Canada, including 95 manufacturer-certified technicians. It offers new, used and rental air compressors and system accessories, and provides airend repair, system audits and system design. Shown here are Mike Zurat Jr. and Mike Zurat Sr. (left to right) in Aliquippa, PA. Visit https://us.comairco.com.*

### *Submission Guidelines*

*We invite our subscribers to send in pictures so we can see the people who read our Best Practices magazines! Those holding a recent magazine issue will receive first consideration. Please send a high-resolution picture as a JPG with a note describing the team and company to Troy Dreier at troy@airbestpractices.com.*


*Lone Star Turbo is based in Houston, TX, and manufactures centrifugal, geared, gearless and multistage blowers and air compressors at its 16-acre, ISO 9001-certified facility. It sells to customers in water and wastewater treatment, petrochemicals, refineries, power plants, mining, carbon capture and food and beverage. We're happy to count Charlie Davis, Marketing Manager, and Andrew Balberg, President (left to right), among our subscribers. Visit https://lonestarblower.com.*


*Independent Compressor Services is based in Griffith, IN, providing air compressor sales, service, parts and repairs throughout Northwest Indiana, Chicago and the Greater Chicagoland area. Whether it's servicing compressed air systems or supplying air compressor parts, its goal is to deliver value, reduce downtime and keep its customers' operations running efficiently. Shown here is Bob Cerros, President. Visit https://www.independentcompressorservices.com.*

# NEWS Compressed Air Industry & Technology

## BEKO TECHNOLOGIES Appoints Dr. Sebastian Springer as CEO

Dr. Sebastian Springer was appointed Chief Executive Officer of BEKO TECHNOLOGIES. In this role, he assumes overall responsibility for the company and will directly oversee the areas of sales and service, as well as marketing and product management.

With the appointment of Springer, BEKO TECHNOLOGIES is taking a further step in its international development. The focus will be on the consistent execution of its global corporate strategy, continued development of its portfolio and the strengthening of the company's worldwide market position.

"We are delighted to have appointed Dr. Springer, an experienced leader who shares our values, to this key role. In this decisive phase for our family-owned company, he will further refine our strategic direction, strategically steer our global activities and drive the company's sustainable growth," said shareholders Vincent Koch, Annabelle Koch and Yannick Koch. For more information, visit https://www.beko-technologies.com.

*Dr. Sebastian Springer, CEO, BEKO TECHNOLOGIES*

## Ingersoll Rand and Garrett Motion Announce Partnership to Introduce a New Era for Oil-Free Industrial Innovation

Ingersoll Rand and Garrett Motion announced a multiyear, strategic partnership to develop next-generation, oil-free air technologies designed to deliver greater energy efficiency, performance and reliability for customers across key end markets, including food and beverage and life sciences.

The partnership builds on Ingersoll Rand's leadership in compression technology, including its industry leading air compressor platforms, proprietary system level innovation and deep application expertise, combined with Garrett's advanced oil-free centrifugal air compressor modules. Together, the global organizations will focus on oil-free innovation, helping customers reduce energy consumption, improve process efficiency and support sustainability goals in critical industrial applications demanding 100% oil-free air.


*Garrett Motion oil-free centrifugal air compressor module*

These benefits are particularly critical within the food and beverage and life sciences industries, where reliability, air purity and performance are essential, and will bring a superior alternative to existing air compressor solutions.

"This collaboration reflects our continued focus on delivering differentiated solutions that create superior value for our customers," said Vicente Reynal, Chairman and CEO, Ingersoll Rand. "By working closely with Garrett Motion, we are strengthening our ability to innovate at the system level and address markets where performance, purity and efficiency are non-negotiables, helping customers operate more efficiently and sustainably."

Initial products are expected to be introduced to select Ingersoll Rand customers in 2026, with a broader commercial rollout beginning in 2027 across Ingersoll Rand's global sales regions. For more information, visit https://www.irco.com and https://www.garrettmotion.com.

## Compressed Air Sales and Service Provider SteddyAir Opens in Ontario, Focusing on Reliability and Efficiency

SteddyAir is introducing itself to the compressed air industry as a new Ontario-based compressed air sales and service company focused on helping industrial and commercial customers improve reliability, control operating costs and get more value from their compressed air systems. The company serves customers across Southwestern Ontario with compressed air system sales, service, maintenance and optimization support.

The company supports the full compressed air system, including air compressors, compressed air dryers, filtration, piping, storage, controls, preventive maintenance and optimization services. In addition to supplying new equipment solutions, it services all makes and models and works with customers to stabilize pressure, improve flow, reduce leakage, protect downstream equipment and avoid unnecessary energy use.

Founded in 2025 by co-owners Eddie Weesjes and Steve Jurjens, SteddyAir brings more than 40 years of combined experience in compressed air systems. The company was created to give customers a dependable field-based partner for system design, equipment supply, troubleshooting, preventive maintenance and long-term performance improvement. Its work is built around a practical understanding of how compressed air affects production uptime, air quality, energy use and day-to-day plant operations.

*SteddyAir's headquarters in New Hamburg, Ontario, Canada*

"We started SteddyAir because we believe customers deserve a compressed air partner who looks beyond the immediate service call," said Weesjes. "Compressed air systems can lose efficiency through leakage, pressure drop, poor controls, inadequate storage or air quality issues. Our goal is to help customers solve the immediate problem while also understanding how the whole system can operate more reliably and efficiently over time." For more information, visit https://www.steddyair.ca.

## Sumer Introduces PSA Nitrogen and Oxygen Generators to the Americas Market

Sumer AS launched high-efficiency pressure swing adsorption (PSA) nitrogen and oxygen generators tailored for the Americas market. Aimed at transforming how facilities across North and South America manage their industrial gas requirements, this strategic expansion bridges the gap between premium European manufacturing quality and highly competitive pricing. By enabling companies to move away from expensive third-party gas delivery contracts and generate their own supply directly on-site, the technology addresses a critical need for sustainable margin recovery.

Traditional industrial gas distribution relies heavily on bulk liquid deliveries or high-pressure cylinders from centralized cryogenic facilities. For manufacturing plants, food processors, electronics packagers and engineering firms located far from these hubs, logistics surcharges and transportation premiums inflate the total cost of ownership significantly. Companies using liquid nitrogen frequently suffer from ambient heat boil-off, which causes unused gas to vent into the atmosphere, forcing businesses to pay for wasted resources. Sumer's on-site PSA generators eliminate these logistical dependencies entirely, allowing facilities to match production directly with real-time demand and drastically reduce gas expenditures by 50-70%.

A core feature of these PSA systems is the ability to customize gas purity on-site. Unlike standard bulk liquid deliveries providing an unnecessary, uniform ultra-high purity level for all applications, Sumer generators produce the precise purity required by the specific application, reaching up to 99.999% for nitrogen and 99.5% for oxygen. This operational flexibility curtails energy consumption and minimizes waste.


*Sumer's high-efficiency pressure swing adsorption nitrogen generator*

The official product rollout will be highlighted at the upcoming Best Practices 2026 EXPO, where the company plans to secure exclusive regional distributorship agreements. Sumer is actively looking for established compressed air, vacuum and industrial equipment partners to extend its sales and service network across the Americas. For more information, visit https://www.sumerinc.com.

## Mattei Group Launches Advanced Global Training Hub for Rotary Vane Technology

Mattei Group launched the Mattei Academy, a strategic training initiative created to deepen knowledge of Mattei air compressors and rotary vane technology, its application advantages and its fundamental role in improving energy efficiency. It's located in Vimodrone, Milan, Italy.

*The Mattei Academy in Vimodrone, Milan, Italy*

The Mattei Academy is primarily dedicated to the company's global network of distributors and OEM customers. The academy was conceived as a true hub for skills development and professional networking, capable of gathering international best practices, encouraging the exchange of know-how and strengthening a global community of compressed air specialists.

A thorough understanding of system efficiency enables partners to optimize performance, reduce operating costs and deliver greater value to end users. At the heart of the project is the ambition to move beyond traditional one-way training to create a cutting edge international knowledge hub. The academy acts as a meeting point where distributors' field experience, OEM requirements and the technological expertise of the manufacturer converge to generate shared value and continuous innovation.

"The idea behind this hub is to build a network where the experience of seasoned professionals blends with the energy and digital mindset of younger generations because the values that have always defined our air compressors – longevity, reliability and the elimination of waste – must define how we build knowledge, too. Human capital, like a well-engineered machine, only delivers its full value when it is cared for, continuously developed and built to last," said Giulio Contaldi, CEO, Mattei Group. For more information, visit https://www.matteigroup.com.

# NEWS Compressed Air Industry & Technology

## Compressed Air Treasure Hunt Workshop Debuts at Best Practices 2026 EXPO & Conference in Indianapolis, IN

The Best Practices 2026 EXPO & Conference is expanding its lineup in Indianapolis with the new Compressed Air Treasure Hunt Workshop. This session will take place Tuesday, Oct. 13, from 8 to 11 a.m., and attendees will earn three PDH credits.

*The Compressed Air Treasure Hunt Workshop will provide five high-impact, low-cost projects to save energy.*

The Compressed Air Treasure Hunt Workshop will provide five impactful, demand-side Treasure Hunt projects designed to reduce flow and pressure, uncovering energy savings opportunities. It strongly supports the U.S. Department of Energy Better Plants' Treasure Hunt training. The workshop provides hands-on experience with fully operational table-top compressed air labs with pneumatic circuits.

"This workshop was designed for plants wanting to reduce demand for compressed air beyond the occasional compressed air leak audit," said Roderick M. Smith, Publisher, Best Practices Magazines & EXPO. "Attendees will leave with five impactful Treasure Hunt projects they can implement quickly to achieve significant energy savings."

### Treasure Hunt Projects

- **Project #1: 24/7 Leak Detection Auditing**
  Plants have the opportunity to reduce compressed air flow by 20-25% by establishing 24/7 leak detection auditing with flow meters.

- **Project #2: Reduce Blow-off/Drying Air**
  By eliminating misapplications of compressed air and implementing engineered nozzles or air knives and blowers, 50-90% compressed air flow reductions are common.

- **Project #3: Upgrade Vacuum Venturis**
  By upgrading to newer, more efficient venturi vacuum models, 50-90% compressed air flow reductions are possible.

- **Project #4: Reduce Flow at Baghouses/Dust Collectors**
  Baghouses/dust collectors require a high volume of compressed air, meaning there's significant savings potential. Opportunities center on upgrading valve technologies that use less compressed air and don't fire when idle.

- **Project #5: Reduce System Pressure to 70 psi**
  Fix the FRL (filter, regulator, lubricator). FRLs can create pressure loss when the filter is obstructed, and are the home of 50% of compressed air leaks. Plants should also identify equipment requiring high pressure, and determine if machines can be modified by retrofitting pneumatic cylinders or actuators, or, if higher pressure is required, adding a booster and storage.

Secure Early Bird rates when you book by Sept. 30. Contact Kimberly Hill for group discounts at kimberly@airbestpractices.com. Register at https://cabpexpo.com/registration-2026.

The Compressed Air Treasure Hunt Workshop is sponsored by SMC Corporation of America.

## ABB Introduces Higher-power Options to Its SD200 841 Severe-duty Motor Line

ABB expanded its SD200 841 severe-duty motor line to 500 horsepower (hp). The larger frame sizes provide more power for demanding applications. Designed for harsh operating environments, the motors provide the rugged performance, reliability and long service life required in severe-duty service.

The SD200 841 line is engineered to meet or exceed IEEE 841-2021 requirements for efficiency, performance, construction, variable-speed operation and long service life. With the addition of larger 5000 series NEMA frame sizes 5009 through 5013, the platform now spans 75 to 500 hp. The expanded range extends beyond the previous 449T frame size, providing greater horsepower coverage for large industrial applications operating in harsh environments. It delivers IP56 protection for operation in wet and contaminated environments. Class H insulation provides increased thermal capacity to support longer motor life in high-temperature applications.

Bearing isolators on both drive and non-drive ends help prevent contamination and reduce unplanned maintenance. Motors operate at low vibration levels of 0.06 IPS, supporting smooth, efficient performance in high-torque applications.

Each motor ships with an IEEE 841 test report and is backed by a five-year warranty. Safety certifications include UR component recognition and CSA listings for Class I Division 2 and Class II Division 2 hazardous locations.

An oversized conduit box and field-modifiable design simplify installation, connection and maintenance. The 5000 frame size motors also feature factory-installed terminal blocks as standard, replacing traditional flying leads. This enhancement improves connection reliability, simplifies installation and provides easier access for maintenance.

*ABB's SD200 841 severe-duty motor*

The SD200 841 FS500 is purpose-built for petroleum and chemical plants, pulp and paper mills, mining and aggregates operations, cement production facilities and industrial process pumping and conveying applications where reliable high-horsepower performance is critical. For more information, visit https://www.abb.com.

## Air Products Membrane Solutions Announces $70 Million Expansion of its Missouri Manufacturing and Logistics Center

Air Products announced a $70 million expansion of its Missouri Manufacturing and Logistics Center in Maryland Heights, near St. Louis, MO. The expansion was driven by growing product demand in biogas and hydrogen recovery applications, as well as customer needs for the use of nitrogen for the aerospace industry and cleaner fuels for the marine industry.

Products manufactured at the new facility will include the PRISM® GreenSep membrane separator for bio-LNG production and the PRISM® N2Sep membrane separator designed to separate nitrogen from compressed air.

"This is a great day for Air Products Membrane Solutions and the area community," said Dr. Erin Sorensen, General Manager. "This expansion of our Maryland Heights facility enables Air Products Membrane Solutions to meet growing customer demand and help our customers work more efficiently and further our collaborative goal of building a cleaner, more productive world."

At the facility's ribbon cutting, the Air Products Foundation announced two grants totaling $30,000 to support nonprofits in the St. Louis area.

The company has completed more than 70 hires in the region to support the new manufacturing facility. More than 250 employees now work at the facility. For more information, visit https://membranesolutions.com.

*Wally Nelson, Air Products; Andy Schollenberger, PARIC Corporation; Erin Sorensen, Air Products Membrane Solutions; Kayla Kueckelhan, Missouri Department of Economic Development; Mayor Mike Moeller and Rob Smegner, Air Products Membrane Solutions (left to right).*

# NEWS Chiller & Cooling Industry & Technology

## Advance Technology Systems Named Southeast Representative for Thermal Care

Thermal Care appointed Advance Technology Systems (ATS) as a principal agency for the plastics industry. This ensures the company's partners and clients receive dedicated support and innovative solutions tailored to evolving industry needs. ATS will serve customers in Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina and Tennessee.

Headquartered in Fountain Inn, SC, ATS is led by Principal Brian Spell. The company's agents Alex Bowden, Bud Carter and Sherri Stubbs bring decades of process automation, injection molding and blow molding experience across a wide range of end products – from automotive and electronics to medical and packaging. On the extrusion side, the company has expertise in wire and cable, non-woven, medical and consumer products.

"Thermal Care supports customers across a wide range of industries, and our sales representatives specialize in the unique requirements of each application. By strengthening our coverage in the Southeast, we're making it easier for customers to connect with experts who can help size, specify and support the right industrial process cooling solution from day one," said Peter Armbruster, Vice President of Sales and Marketing, Thermal Care. For more information, visit https://www.thermalcare.com.


*Bud Carter, Vice President; Alex Bowden, Vice President of Operations and GM; Brian Spell, President and CEO, and Sherri Stubbs, Customer Service and Inside Sales Manager, Advance Technology Systems (left to right).*



## BAC Opens First Latin American Manufacturing Plant in Monterrey, Mexico

Baltimore Aircoil Company (BAC) announced the grand opening of its manufacturing facility in Ciénega de Flores, Nuevo León, Mexico, the company's first production plant in Latin America. The new facility strengthens the company's regional manufacturing footprint and expands support for customers across Latin America.

Strategically located in Ciénega de Flores, the facility offers access to major logistics corridors, strong industrial infrastructure and close integration with the region's manufacturing ecosystem. The site will serve as a distribution and manufacturing center designed to support evolving customer needs across Latin America.

"Across the Americas, we are seeing tremendous growth," said Luke Rubino, Global Vice President and Head of the Americas, BAC. "Driven by urbanization, infrastructure investment, industrial expansion and an increasing focus on sustainability, demand for a partner with technical expertise, high-performing products and reliable operational performance is growing across every market we serve. Our customers are expanding, investing and raising expectations, and as industry leaders, that requires us to invest in the right places and with the right capabilities."

The opening is part of the company's broader global investment initiative focused on expanding world-class manufacturing capabilities. Since 2019, the company has invested significantly in new facilities and operations worldwide. "We have invested more in the last six years than in the previous two decades combined," said Donald Fetzer, President, BAC. "This facility reflects our long-term commitment to innovation, operational excellence and supporting our customers throughout the region." For more information, visit https://baltimoreaircoil.com.

*Baltimore Aircoil Company's manufacturing facility in Ciénega de Flores, Nuevo León, Mexico*

## Johnson Controls Expands European Footprint with Engineering, Production and Customer Centers in Denmark

Johnson Controls announced the expansion of its Holme, Denmark, heat pump and chiller facility, increasing production and testing capabilities to meet growing demand for high-capacity heat pumps across Europe. Operating on 100% green energy, the site strengthens European manufacturing capability while helping to reduce reliance on imported fossil fuels.

The expansion includes 2,300 additional square meters of new production space and a 1,800 square meter customer experience and test center, compliant with the latest European Heat Pump Association testing standard (EN 14511). Together, these additions strengthen Johnson Controls' ability to design, build and validate high-capacity heat pumps for district heating, public infrastructure and industrial applications, including high-stakes environments from research campuses and life-science labs to universities and food and beverage operations. The project is expected to create more than 100 new local jobs and includes modernization of existing buildings at the site.

*Ribbon cutting at the Holme plant: Richard Lek, President EMEA, Johnson Controls, and Benthe Klokkerholm, Vice President, Manufacturing Operations HVAC/R, EMEA, joined by EU Commissioner for Energy & Housing Dan Jørgensen, Mayor Anders Winnerskjold of the City of Aarhus, and EU Policy Assistant Rasmus Beim Hvide, alongside Johnson Controls employees and partners, celebrate the opening of the expanded facility.*

The Holme facility manufactures customized Sabroe-branded heat pumps and chillers, along with remanufactured, aftermarket and marine spare parts. Using zero- and low-GWP refrigerants, the technologies are designed to align with upcoming EU regulations taking effect from 2027 and 2030.

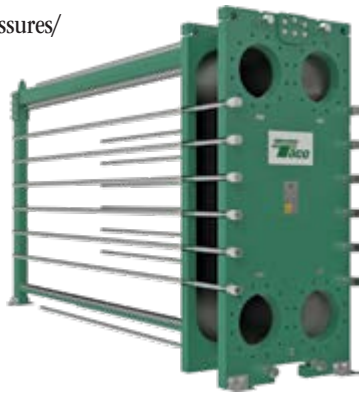
"With generations of manufacturing expertise in Europe and a market-leading position in commercial and large-scale heat pumps, this expansion in Holme reinforces our long-term commitment to building critical technologies here, for Europe," said Richard Lek, President EMEA, Johnson Controls. "By scaling production and real-world testing of large heat pumps, we are enabling municipalities and energy-intensive industries to electrify heat, lower costs and reduce emissions – with solutions designed, engineered, built and tested close to where they are deployed." For more information, visit https://www.johnsoncontrols.com.

## Taco Launches Custom-Designed PS/PA Plate-and-Frame Heat Exchangers

Taco introduced PS/PA plate-and-frame heat exchangers, custom-designed and assembled to specification. They are available in a broad range of connection sizes: 1 inch to 20 inches, with a wide selection of materials to fit various applications. These heat exchangers are designed, constructed and tested to meet ASME Section VIII, Div. 1 requirements.

The ASME-certified heat exchangers offer standard working pressures/design temperatures of 150 or 300 psi (10 or 21 bar) and 284°F (140°C), with higher working pressure and design temperature limits available upon request. The PS/PA plate-and-frame line provides a high degree of flexibility in materials, including the availability of corrosion-resistant 304/316 stainless steel and titanium heat transfer plates, allowing specifiers to meet varying application requirements.

Taco PS/PA heat exchangers are built to handle an almost limitless capacity, meeting or exceeding the most demanding heat requirements in the industry. For more information, visit https://www.tacocomfort.com.



*Taco's PS/PA plate-and-frame heat exchanger*

# NEWS Industrial Energy & Water Conservation

## TERREPOWER Shares Decarbonization Efforts in 2025 Sustainability Report, Including 9% Reduction in Scope 2 Emissions

TERREPOWER, a leader in sustainable manufacturing, refurbishes, recycles and upcycles essential components for the automotive, industrial, solar and electric vehicle markets to extend their useful lives and reduce global waste. The company released its 2025 sustainability report detailing measurable progress in emissions avoidance, resource efficiency and circular production. The report underscores how sustainable manufacturing delivers both environmental impact and economic value, helping customers reduce their carbon footprint while strengthening supply chain resilience and advancing the circular economy.

In 2025, TERREPOWER maintained its momentum and reinforced its position as the world's largest sustainable manufacturer by volume. Increased core recovery enabled deeper material reuse year-over-year, resulting in more than 204,000 metric tons of $CO_2$ emissions avoided.

The company recycled more than 380,000 gallons of water through new graywater and AC condensate reuse systems in its Reynosa, Mexico, campus and had 1.5 million gallons of processed water treated on-site through water clarification systems, avoiding emissions associated with off-site wastewater transport. It had a 9% reduction in Scope 2 emissions, supported by cleaner electricity sourcing and the use of market-based instruments. A strategic supplier transition in Reynosa shifted manufacturing electricity to a portfolio with 13.9% renewable energy, reducing emissions in one of the company's most production-intensive regions. TERREPOWER continued progress in the transition from LPG to natural gas, begun in 2024, helping stabilize Scope 1 emissions despite operational growth.

"Sustainability is not something we add to our business; it's embedded into our operations and a significant factor in our decision-making process across the enterprise," said Duncan Gillis, CEO, TERREPOWER. "In 2025, our teams around the world translated that commitment into action, delivering meaningful, measurable impact while strengthening our transparency, operational resilience and ability to innovate." For more information, visit https://www.terrepower.com.

*Members of TERREPOWER's Detroit team volunteered at Veterans Park in Hamtramck, MI, assisting in preparing a new native pollinator garden for the community.*

## PPG Highlights Momentum Toward 2030 Targets, Sharing a 25% Reduction in Scope 1 and 2 GHG Emissions

PPG, a global manufacturer of paints, coatings and specialty materials, released its 2025 Sustainability Report, showing further progress toward the company's 2030 sustainability targets. Highlights include strong growth in sales from sustainably advantaged products driven by customer demand, as well as reductions in greenhouse gas emissions across operations and the value chain.

*PPG's headquarters in Pittsburgh, PA*

Guided by its validated science-based targets, PPG has made progress in decarbonizing its operations and value chain while expanding its portfolio of sustainably advantaged products that help customers reduce energy use, emissions, water consumption and waste.

The company had a 25% reduction in GHG emissions from its own operations (Scope 1 and 2) compared to the 2019 baseline, driven by energy efficiency improvements, renewable electricity sourcing and process optimization. It also had a 5% reduction in value chain (Scope 3) GHG emissions across purchased goods and services, customer processing of sold products and end-of-life treatment, supported by increased supplier engagement and expanded data-quality initiatives. PPG saw a 29% reduction in water intensity at priority sites in water-stressed areas, surpassing its 2030 target for water stewardship.

"Sustainability is a core element of our enterprise growth strategy and a critical driver of customer productivity," said Peter Votruba-Drzal, Vice President, Global Sustainability, PPG. "By embedding sustainability into how we innovate and operate, we are delivering measurable value for our customers through high-performing, efficient solutions while strengthening our competitive position and advancing progress toward our 2030 commitments." For more information, visit https://www.ppg.com.

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# John Deere Mows Down Energy Costs with Operating Discipline

By Jose Sarmiento Escalante, Facilities/Maintenance Engineer II, John Deere

Most energy-improvement stories start with a capital request – new equipment, a major retrofit or a control system upgrade. Those projects can be valuable, but they're not always the fastest path to better performance, and they're rarely the reason results stay in place year after year. At John Deere's Paton, IA, facility, the most durable gains came from something less glamorous: tightening everyday operating discipline, building clear ownership and using simple, repeatable checks to confirm our systems were behaving as expected.

Improvements were not tied to a single shutdown or a one-time event. They accumulated because the team made energy and reliability part of normal work.

This article shares the approach, practical lessons learned and kinds of evidence we used to keep the gains real. Compressed air is used as a detailed example because it touches so many parts of production, but the same discipline was applied across other electrical loads such as dust collectors, ventilation fans, lighting and supporting systems.

At the Paton facility, operations focus on building large-scale agricultural planters used in row-crop production. The work brings together a wide range of processes including metal fabrication, welding, machining, assembly, surface preparation and powder coating, all within a single operation. Compressed air supports these processes every day. It powers tools and actuators, assists with material handling and ensures production-support systems such as dust collectors and indoor air quality equipment operate reliably and consistently in the background.

The facility encompasses approximately 300,000 square feet and operates on a single production shift rather than a continuous 24/7 schedule. Once the shift ends, production activity slows or stops, creating clear periods of reduced demand. These natural pauses in operation helped highlight where systems continued to run beyond what production required, providing a practical starting point for improving control, alignment and consistency across the plant.

*Above: The John Deere facility in Paton, IA*

## Systems that Worked, but Didn't Always Work Wisely

Before we changed anything, the facility met production needs. The challenge was variability and unnecessary run time. In early 2024, the electrical team noticed consistently high consumption levels, along

*The facility's compressed air system includes dual oil-flooded rotary screw air compressors, along with compressed air dryers and coalescing filters, configured so one system operates while the second remains available as backup.*

with recurring equipment issues linked to harmonics and continuous operation. That concern led to an Energy Treasure Hunt Assessment, which formally began on March 14, 2024, starting with the compressed air system and expanding to lighting and industrial fans over the following three weeks.

Even before that assessment, the electrical profile showed a pattern difficult to ignore. On some weeks, it looked stable; on others, it carried a stubborn baseline load even when production was light, or the plant wasn't running production or was unoccupied. This pattern wasn't caused by a single broken component. Instead, it had developed gradually through normal equipment left running "just in case," setpoints creeping upward over time and maintenance issues tolerated because their impact wasn't immediately visible.

A key turning point came when the conversation shifted from "How much does this cost?" to "What behavior do we expect when demand is low, and do we actually see it happening?" That change in mindset made it easier to focus on operational controls that were low-cost, quick to implement and easy to verify, while still supporting production requirements.

*The facility's oil-flooded rotary screw air compressors discharge 100-125 psig (6.9 to 8.6 barg) compressed air to a horizontal wet receiver tank, with downstream compressed air dryers, filters and overhead piping supplying plant air for CNC laser cutting, powder coating and assembly operations.*

The findings from the assessment were consolidated into a report issued on February 27, 2024. What stood out was not a single major failure, but a consistent pattern of systems running longer than needed. These results set the stage for a corrective action plan, with the objective of implementing improvements ahead of the next building season in July 2024.

## A Practical Starting Point: Focusing on What We Could Control

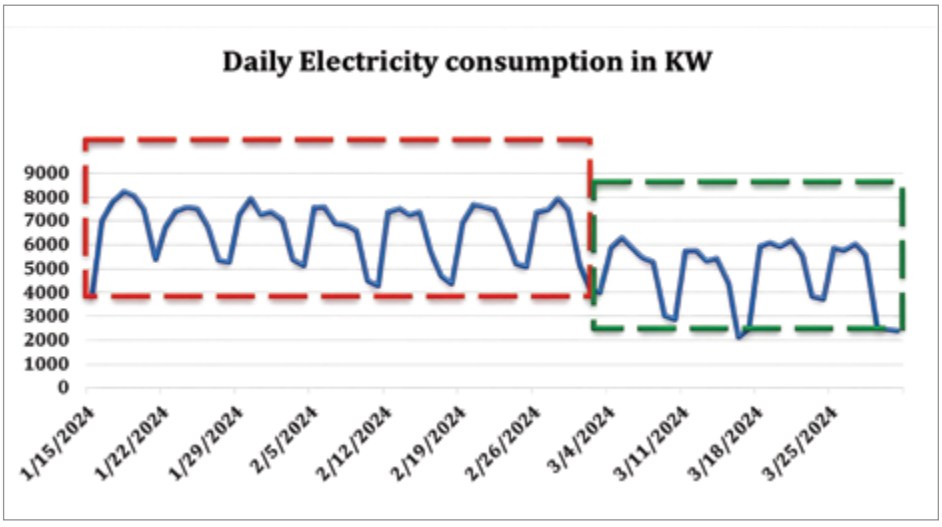
A facility Energy Treasure Hunt effort helped focus attention on opportunities hiding in plain sight. Rather than uncovering a single large issue, the review highlighted patterns in how equipment operated, particularly during off-shifts and weekends. Systems such as dust collectors, overhead fans and lighting often ran outside true demand windows, not because they were needed, but because schedules and expectations hadn't been clearly defined.

This behavior became more visible when we looked at daily demand trends over time. As shown here, the electrical profile before changes were made showed noticeable variability and a persistent baseline load, even during periods when production activity was reduced or the plant was unoccupied. After operational schedules and shutdown expectations were aligned more closely with actual demand, the profile became more consistent, with clearer separation between production and non-production periods.

These observations created momentum, but the long-term value came from what followed. Expectations were written down, ownership for each control was clearly assigned and a simple habit of reviewing trends was established to confirm the plant was behaving the way the plan intended. Instead of relying on assumptions, the team could quickly see when equipment was running as expected and just as quickly identify when it was not.

## What Changed: Turning Observations into Daily Discipline.

Once those early opportunities were visible, the focus shifted from identifying issues to making sure the changes would hold. We didn't chase a perfect model or a single project. Instead, we concentrated on a few practical behaviors that could be repeated every day and applied across systems.




*Daily electrical demand profiles illustrate reduced baseline load and improved stability following the alignment of equipment schedules and shutdown expectations with actual production demand.*

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Operating expectations were clarified first. We defined what should be running during production, what needed to be ready for startup and what should be shut off during inactive periods. Just as importantly, ownership was established. Someone had to own the schedule, ensuring the right operating hours were communicated clearly so the facilities and maintenance teams could program, service, align equipment with production needs and follow up when something drifted from plan.

Verification tied everything together. Reviewing trends became a simple habit used to confirm the plant was behaving the way the plan intended. When the data didn't match expectations, it was treated as a signal to learn and adjust, not as a failure. That mindset helped turn early momentum into lasting change by keeping the focus on understanding how systems operate day-to-day.

This same approach was applied across multiple systems, but compressed air quickly stood out as the clearest example because it's both energy-intensive and production-critical.

### Compressed Air as a Production-Critical Asset

At Paton, compressed air is provided by two 75-horsepower oil-flooded rotary screw air compressors serving the entire facility, with system distribution pressure maintained at approximately 110 psig (7.6 barg). These air compressors are industrial continuous-duty units designed for high reliability and stable airflow under varying production demands. Unlike reciprocating air compressors, rotary screw air compressors use intermeshing helical rotors to deliver a steady, pulse-free supply of compressed air with lower vibration and noise levels. The oil-flooded design provides internal cooling, sealing and lubrication of the compression chamber, improving efficiency, reducing wear and supporting long operating intervals in demanding manufacturing environments.

*A worn and leaking compressed air system component was identified during routine service. While the condition was not immediately disruptive, it contributed to system instability and highlighted the need for better visibility into long-term operating behavior.*

The air compressors support a centralized compressed air network powering production tools, pneumatic actuators, indoor air quality (IAQ) systems, dust collectors, hydraulic support equipment and the powder-coating process. Because compressed air is both energy-intensive and production-critical, system reliability depends not only on the air compressors themselves, but also on proper scheduling, pressure control, monitoring, condensate management, filtration and preventive maintenance practices.

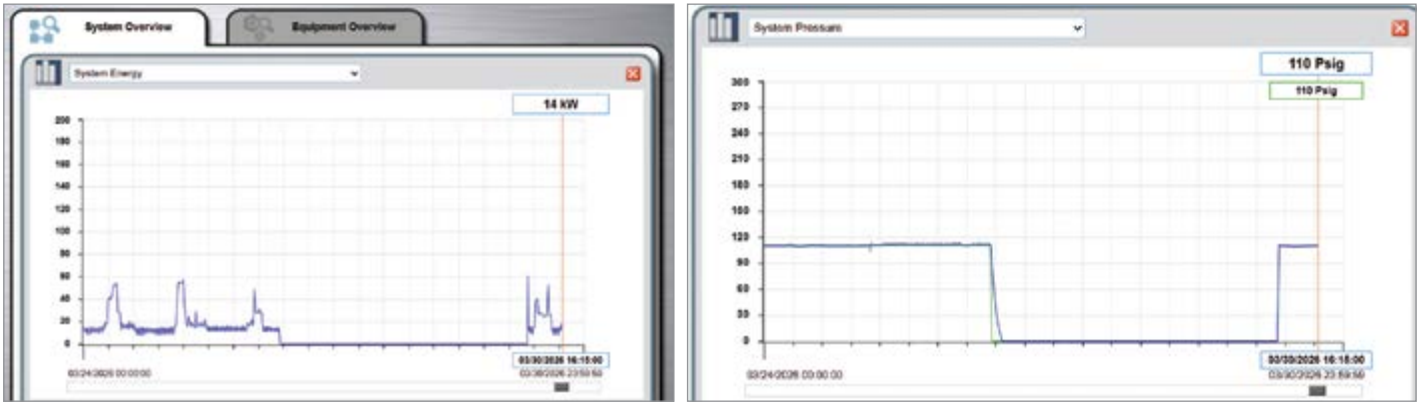
Early on, our understanding of the compressed air system was largely based on physical observation and maintenance history. At that time, no formal monitoring system was in place, and access to live operating data was limited. That meant issues were often identified only when something became visible during inspection or service, rather than when performance first began to drift.

This began to change in early 2024, after repeated repair events and ongoing concerns from the electrical team related to high energy consumption, harmonics and continuous operation. Around that same time, we were already using an Ignition-based platform on other systems that depended on compressed air, such as dust collectors, a powder coating booth and hydraulic pumps. Those systems gave us visibility into how the equipment behaved, but not into the air compressors supplying them, which made it difficult to see the full picture. As we started looking for ways to monitor the air compressors directly, we found the capability was already there; we just weren't using it. After reaching out to our service contractor, we confirmed an existing monitoring interface had been installed but not put into operation. With some configuration support and team training, we brought the system online so maintenance and facilities could access real-time data such as pressure, electrical demand, system status, alarms and schedules.

Once implemented, the system provided visibility into key performance indicators such as system pressure, air compressor run status, electrical demand, alarms and operating schedules. It also allowed limited remote access to review system behavior and confirm whether or not the air compressors ran as expected. With visibility in place, the way we approached the system changed. Instead of relying solely on physical checks and reactive maintenance, we observed trends, identified abnormal behavior earlier and focused troubleshooting efforts more precisely.

What had previously been a reactive process became more predictive in nature. The team could now see how the system responded to production demand, recognize when something was drifting from normal behavior and take action before it developed into a larger issue. Just as importantly, it gave us a way to verify scheduling and operational expectations were actually being followed, reinforcing the same discipline was being applied across the rest of the plant.

One example was a worn and leaking component on the air compressor discharge piping discovered during service. The condition itself wasn't




*Monitoring data verified compressed air operation aligned with production schedules, maintained stable pressure and avoided unnecessary run time during idle periods.*

dramatic, but it was enough to introduce instability into the compressed air system and increase the effort required to maintain pressure. Situations like this highlighted an important gap: While maintenance teams addressed what they could see, we could not yet consistently observe how the system behaved over time.

That changed once the compressed air monitoring system was set up and access was established. With visibility into compressed air system behavior, we could see when the air compressors were running, how the system responded to production demands and whether or not schedules were being followed. This allowed the team to confirm the system was operating as intended, running during production hours, shutting down during non-production hours and maintaining stability without risking air availability for production.

At the same time, the data supported better preventive maintenance planning. Instead of reacting to issues after they became noticeable, the team could identify abnormal patterns early and address them before they affected reliability. This combination of physical maintenance, clear scheduling and verified operation reduced the risk of unexpected interruptions while reinforcing confidence compressed air would be available when production needed it.

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### Extending the Same Discipline Beyond Compressed Air

Once compressed air demonstrated how effective clear schedules and verification could be, the next step was applying the same thinking to other loads where behavior (not equipment design) drove unnecessary demand. Systems such as dust collectors, overhead fans and lighting showed similar patterns. This process took place after July 2024, as efforts shifted toward expanding the approach beyond individual systems to include a broader set of assets tied directly to production hours and overall plant operation. They were reliable and familiar but often operated longer than production required simply because expectations were not clearly defined or consistently verified. In many cases, the solutions were straightforward: time-based controls for lighting, replacement of legacy fixtures with LED lighting and automated schedulers aligned to production hours rather than fixed assumptions.

Supporting systems with tighter quality or safety constraints required additional care. Assets such as IAQ equipment, the powder coating booth and manual blast operations directly support welding and paint processes, where unintended changes could affect product quality or disrupt production flow. For these systems, schedule adjustments were approached cautiously. Safeguards were built in, access was actively managed and behavior was monitored to ensure waste was reduced without introducing risk. These changes began in 2025 and were validated against production needs before being fully adopted, ensuring efficiency improvements never came at the expense of reliability.

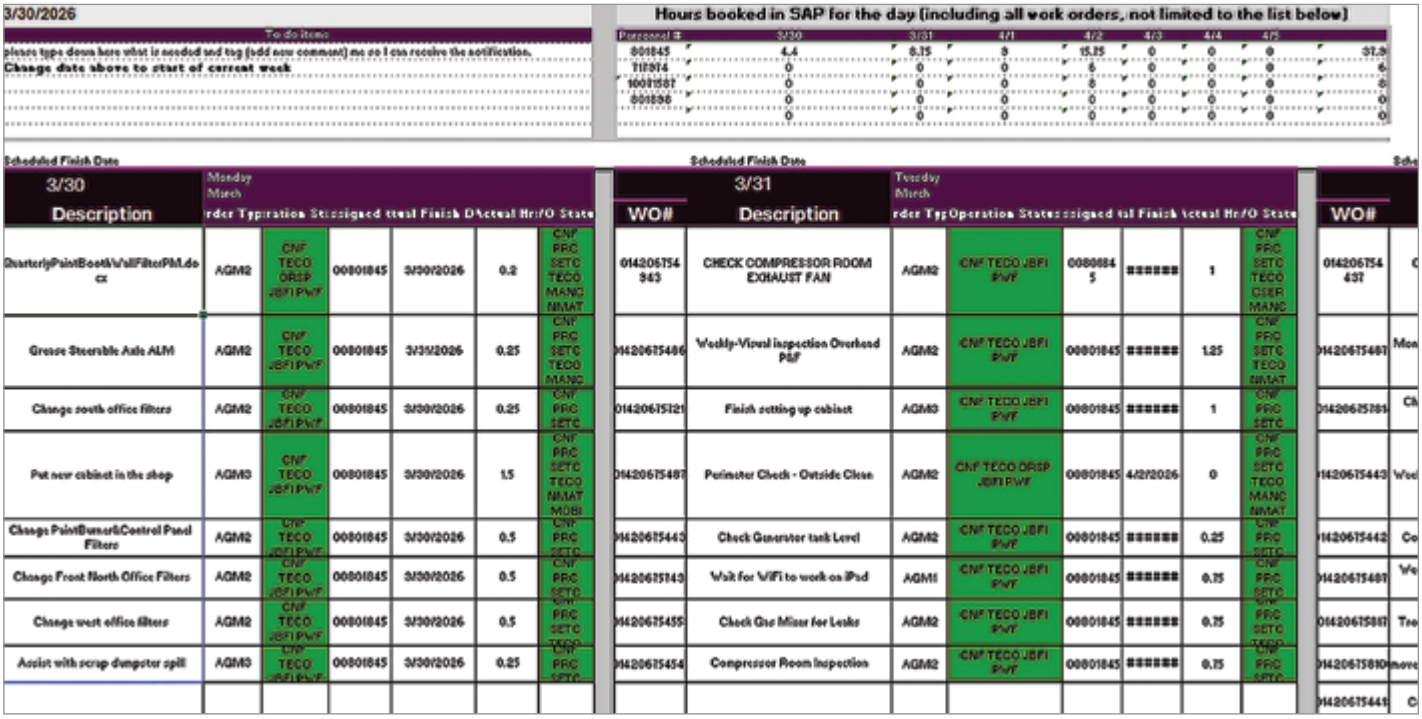
Rather than relying on memory or informal shutdown practices, these systems were deliberately aligned to how the plant operated. Automatic schedules were paired with clear end-of-shift expectations, so equipment behavior was consistent day-to-day. This consistency mattered. When systems followed predictable patterns, it became easier to confirm changes were being held, identify when something drifted and correct items early. Over time, disciplined operation reduced the need for reminders and made efficient behavior part of normal work.

Following a maintenance and operations workshop in 2024, a digitalization process was introduced to support this approach. Monitoring played a key role in sustaining these improvements. Both the maintenance and facilities teams were given access to the digital platforms supporting each asset, as well as direct access to the physical equipment. This ensured those responsible for systems could see real-time behavior, review trends and connect what the data showed with what was happening in the field.

To further integrate the broader plant community, a facilities and maintenance service request tool was established in May 2025. What had once been informal favors or hallway conversations became a structured, trackable process. Requests, observations and follow-ups were captured in one place, turning everyday needs into actionable information.

Over time, this tool became more than a request system; it became a way to document behavior, track responses and ensure no issue, large or small, was lost or overlooked. The result was a repeatable approach respecting the unique role of each asset, strengthening collaboration across teams and reinforcing confidence operational improvements would hold over time.

In 2026, as part of a continuous improvement effort, feedback from the production team highlighted the need for more immediate and transparent communication regarding service requests and facility




*Planning and request tools used by facilities and maintenance teams to coordinate schedules, document operational needs and ensure expectations were clearly communicated and consistently followed.*

support. In response, an enhanced digital tool was launched to provide multiple facilities and maintenance service options, supporting team needs throughout the production process. Requests such as janitorial services or snow removal were formalized into a system communicating progress to the requester while also capturing critical data. This information allowed the team to continuously improve internal processes and increase overall reliability.

Across these combined efforts, the impact became measurable in reduced electrical demand and total energy consumption. Breaker-level analysis associated with dust collector scheduling improvements indicated an annual reduction of approximately 702,395 kWh. Additional schedule alignment actions contributed further savings, including approximately 70,200 kWh per year from overhead fan (HVLS) scheduling and an estimated 373,338 kWh per year from lighting timers, controls and reduced runtime. In total, these documented improvements represent a combined reduction of approximately 1.15 million kWh annually, achieved primarily through operational discipline, scheduling and verification rather than major capital investment.

## Closing Thoughts

These results were achieved by actively reviewing and stabilizing multiple utility systems, not by relying on a single technology solution. Energy was managed as an operational outcome through clear schedules, defined ownership and routine verification. To sustain these gains, the focus now is on strengthening preventive and predictive maintenance systems, ensuring long-term performance, reduced risk and continued reliability of production-critical assets such as compressed air. BP

*About the Author*

*Jose Sarmiento Escalante is a Facilities and Maintenance Engineer II at John Deere, where he supports manufacturing operations and infrastructure performance in Paton, IA. His work centers on reliability engineering, maintenance strategy, safety, capital project execution and sustainable energy optimization, with a focus on driving operational excellence across critical utility and production systems. He'll present this case study at the Best Practices 2026 EXPO & Conference, held October 13-15 in Indianapolis, IN. For more information, visit https://cabpexpo.com.*

*About John Deere*

*John Deere designs and manufactures equipment and solutions supporting agriculture, construction, forestry and industrial applications. The Paton, IA, facility supports manufacturing operations and continuous improvement efforts focused on safe, efficient and reliable production. The site's primary manufacturing focus is on agricultural planters, producing large-scale planting equipment used in row-crop operations. For more information, visit https://www.deere.com.*

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# Understanding Centrifugal Air Compressor Intercoolers

By the CAGI Centrifugal Compressor Section

The process of creating compressed air produces significant amounts of heat that must be removed from the compressed air system. The amount of energy removed between stages has a direct result on the overall efficiency of the air compression process. A centrifugal compressor uses heat exchangers, called intercoolers, to cool the compressed air between stages of the air compressor.

Heat exchangers simply transfer heat from one medium to another. In the case of a centrifugal air compressor, the intercoolers must transfer the heat of the compressed air to another fluid. This cooling fluid can be many different things, but often it is either water (sometimes a glycol/water mixture) or air. The cooling medium employed is used to classify centrifugal air compressors into two general types: air-cooled or water-cooled.

As the intercoolers sit between the air compressor stages, any pressure loss can reduce the efficiencies of later stages, reducing the overall efficiency of the air compressor. Air compressor manufacturers understand this, and centrifugal air compressor intercoolers and interstage piping are designed to be as efficient as possible.

*Above: Air cooler skids for centrifugal air compressors*

The function of the intercooler is to bring two fluids, compressed air and a cooling medium, into close proximity to each other so they can transfer energy between themselves. The two fluids are kept separate from each other by a physical barrier. Careful design of this barrier is critical to cooler performance, as the amount of heat/energy transfer between the fluids across the barrier is predominantly governed by:

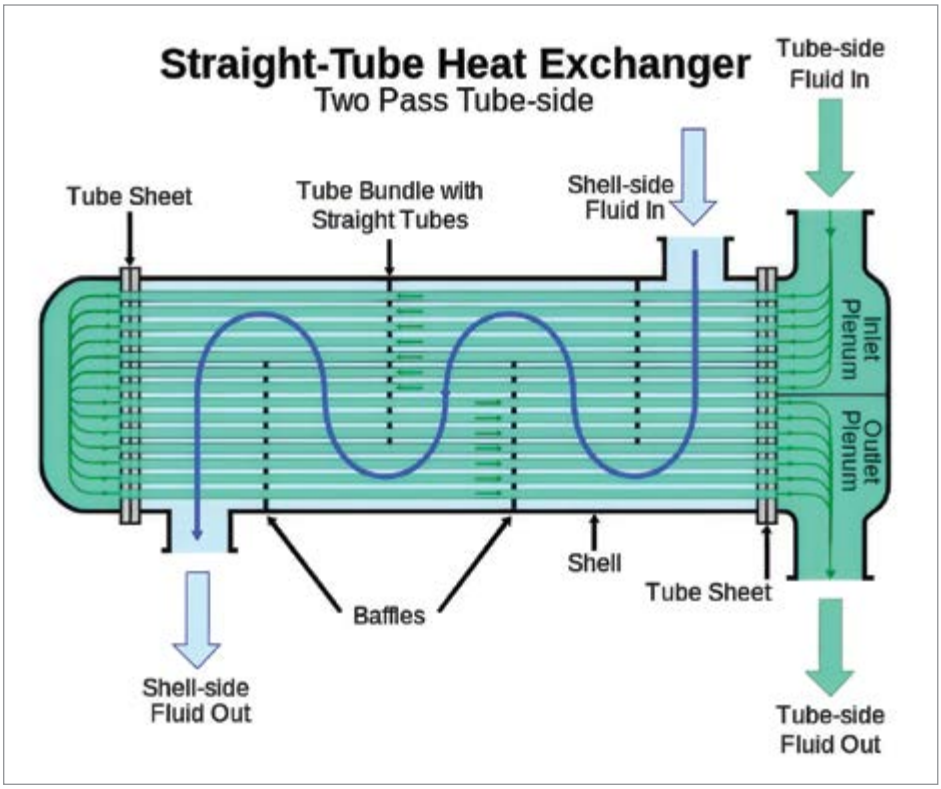
- Material thermal conductivity
- Material thickness
- Surface area
- Fluid velocity

Metal tubes make effective barriers for intercooler designs due to their strength and ease of manufacturing. Intercoolers found on a centrifugal air compressor package use tubes. These intercoolers are designed with tubes made with heat-conductive materials, made as thin as possible, and having maximal surface area.

To maximize the efficiency of the intercooler, the selection of the tube material is critical. The thermal conductivity of the material is key to allowing maximum transfer of energy across the tube wall. The mechanical properties of the material are important, as stronger material allows for thinner tube walls, which allows better heat transfer. In addition to the thermal conductivity and mechanical properties of the tube material, corrosion resistance is also a critical factor in tube design. Care must be taken to ensure the material will not erode or corrode during the operational life of the air compressor. Air compressor intercoolers commonly use tubes made from copper, copper/nickel and stainless steel. More exotic materials can be used for special applications, such as titanium and duplex stainless steel.

*The tube bundle of a heat exchanger*

Maximizing the surface area contact between the intercooler fluids will maximize heat transfer. The easiest way to increase the surface area available for heat transfer is to increase the tube length. However, this approach is limited by the physical constraints within the air compressor package. To get around this, heat exchangers use a group of tubes, or bundle of tubes, to increase the surface area. This bundle is connected with a tube sheet and head. The tube sheet mechanically connects the tubes while maintaining separation of the two fluids. The head connects the tubes into a singular volume. In water-cooled heat exchangers, a shell is used to contain both the tube bundle and the cooling water. The accompanying illustration shows the basic anatomy of a heat exchanger, including the shell, the head(s), the tube-sheets and the tubes.




*This graphic shows the basic parts of a shell-and-tube intercooler with compressed air in the shell and cooling water in the tubes. (Credit: H Padleckas)*

Another factor affecting intercooler efficiency is the velocity of the cooling fluid. Simply stated, more heat is transferred as the velocity of the cooling fluid increases. With a fixed tube cross-sectional area, fluid velocity is directly proportional to flow rate. The relationship of flow rate and velocity is critical in cooler design because if flow rates are too fast, the cooling fluid will prematurely wear away the thin tube materials, and if velocities are too slow, heat exchange decreases and any impurities that are in the cooling fluid will drop out and potentially clog smaller diameter tubes. To maintain the ideal zone of cooling fluid velocity and flow rate, intercoolers are designed to flow the cooling fluid through the cooler multiple times. This is accomplished either by simply bending the tubes into a U-shape or putting special channels in the cooler head. Often, centrifugal air compressors will be seen with two, four or even six-pass coolers.

In addition to intercoolers, some centrifugal air compressors also have aftercoolers. Aftercoolers are a heat exchanger that is located after the discharge of the final stage of compression. They are responsible for cooling the compressed air prior to delivering it into the compressed air system. They can be located alongside the intercoolers within the air compressor package, located in customer piping or even omitted entirely, depending on the needs of the compressed air system.

Another approach used to increase the surface area contact within the heat exchanger is reducing the diameter of the tubes. This allows

## Understanding Centrifugal Air Compressor Intercoolers

*A pipeline-style aftercooler mounted in customer piping (Credit: Alnitak3)*

more tubes to fit into the same cross-sectional area, increasing surface area while maintaining the overall shell diameter. Common tube diameters are 3/8-inch, ½-inch and 5/8-inch. However, there are practical limits to how small the tubes can be made. The smaller the tube diameter, the more susceptible the tubes are to fouling, and the harder they are to clean and maintain.

Most centrifugal air compressors have intercoolers between stages of compression. Proper design of the intercoolers is critical to the performance of the air compressor. Size, cost, materials of construction, efficiency, reliability and maintenance concerns are design variables that result in the wide variety of centrifugal intercoolers you'll find in air compressor rooms throughout the world.

Some common types of intercoolers are:

**Plate Fin.** The plate fin cooler design is the most common cooler found on centrifugal air compressors. This cooler has water in the tubes and compressed air on the shell side. The tubes run through a series of plates mechanically connected to the tubes to form fins, similar to what you find on a car radiator. These fins increase the surface area for the air to transfer its heat. The water in the tubes cools the plates, and by maximizing the surface area contact between the plates and the compressed air, the size of the cooler can be reduced.

The plates allow for condensation to easily form within the cooler and be removed from the airstream. This helps prevent ingestion of water into the stages of the air compressor, which prevents premature wear on the air compressor stage. Proper condensate management is key to any air compressor, and not only benefits the air compressor, but also the entire downstream compressed air system.

The tube bundles use either straight or U-bend tubes. U-bend tubes remove the need for a second tube sheet/head. This provides a more compact and cost-efficient bundle. The straight tubes allow for physical cleaning of the interior surfaces of the tubes, which may begin fouling due to water quality issues.

**Shell-and-Tube.** While the plate fin cooler is a shell-and-tube heat exchanger, some applications call for special shell-and-tube coolers that can comply with general heat exchanger specifications for a project. These coolers are manufactured according to traditional heat exchanger designs and are not tailored to the specific needs of a centrifugal air compressor. These coolers often have tubes with exotic materials and/or larger sizes. These coolers can be custom-designed for any environment, even the most demanding petrochemical applications. These coolers are often larger than the equivalent plate fin cooler.

**Air-in-Tube.** Another variation of the shell-and-tube heat exchanger design, used for centrifugal air compressor intercoolers, is to use

*Typical plate fin coolers for a three-stage centrifugal compressor*

*A complete integral intercooler*

cooling water in the shell and flow compressed air through the tubes. To increase the surface area contact between the air and the wall of the tube being cooled by the water, a sleeve of internal fins is mechanically fixed to the inside of the tube. The center of the sleeve is plugged, so all the compressed air is directed across the cooling fins. These fins serve the same function as fins in a plate fin intercooler. The air-in-tube design results in low pressure drop through the cooler. Its high efficiency allows for more compact, integral intercooler designs. If cleaning of the tubes is required, the cooler must be chemically cleaned.

**Air-Cooled.** The air-cooled intercooler is unique among the variations seen on centrifugal air compressors. It uses ambient air to cool the tube bundle, so it doesn't need the traditional shell found on most heat exchangers. It uses a fan and plenum to direct air in a cross-flow arrangement across tubes containing the compressed air. As a cooling medium, air is not as efficient as water. Air is limited in its thermal conductivity and ability to store heat. As such, larger quantities of air at higher velocities are required to remove enough heat between stages of compression. An air-cooled intercooler is significantly larger than an equivalently sized water-cooled intercooler and requires additional considerations for the interstage piping. Air-cooled air compressors, however, have a significant advantage at sites with severe water restrictions or even no water at all.

## Conclusion

Intercoolers are an essential component of a centrifugal air compressor package. Whether integrated into the airend or mounted separately on the package and piped to their proper locations, intercoolers are required to remove the significant heat of compression between the stages of air compression. The most prevalent cooling medium used in centrifugal air compressor coolers is water; however, air-cooled coolers are an option where no water or contaminated water is available at the site. Proper intercooler design is critical to the air compressor performance, and there are several intercooler options available. Intercooler size, cost, materials of construction, efficiency, reliability and maintenance concerns are design variables allowing for the many types of intercoolers and aftercoolers found on centrifugal air compressor packages and installations. To understand the tradeoffs amongst these design variables and determine which cooler design best fulfills your application expectations, it's prudent to consult with your compressed air consultant. BP

### *About CAGI*

*The Compressed Air and Gas Institute (CAGI) is the united voice of the compressed air industry, serving as the unbiased authority on technical, educational, promotional and other matters affecting compressed air and gas equipment suppliers and their customers. CAGI educational resources include e-learning coursework, selection guides, videos and the* Compressed Air & Gas Handbook. *The Centrifugal Compressor Section consists of the following member companies: Atlas Copco Compressors, FS-Elliott, Hanwha Power Systems, Ingersoll Rand and Sullair. For more information, visit http://www.cagi.org.*

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# Magnetic Pickups Reduce Compressed Air Demand at Automotive Plant

By Nasr Alkadi, Ph.D., CEM, CSRM, Strategic Energy Management Consultant and Coach, CLEAResult

*Replacing venturi vacuum cups with spring-return magnetic pickups for ferrous metal parts shows the value of efficient production design.*

Compressed air is one of the most expensive utilities in a manufacturing plant, yet it is also one of the easiest to misuse. It's often referred to as the fourth utility, alongside electricity, gas and water. It's a clean, flexible utility well understood by maintenance teams and already distributed across most production areas. Those benefits are exactly why compressed air often becomes the default answer for every gripping, lifting, blowing, clamping and control function. For a plant manager or engineer who has lived through launches, model changes, weekend maintenance windows and Monday morning pressure complaints, the question is not whether or not compressed air has value. The question is whether or not a specific end use deserves to consume compressed air continuously when a mechanical or electromechanical alternative can do the same job with less risk, maintenance and energy.

This article focuses on a project to replace vacuum cups with spring-return magnetic pickups for handling ferrous metal parts at an automobile assembly plant in Missouri. The application is most familiar in automotive stamping and body shop operations, but the lesson applies to any plant using vacuum cups to grab steel blanks, panels, brackets or formed parts. The original equipment in this case study used vacuum cups served by venturi devices. While a part was being held, the pneumatic vacuum system consumed compressed air. The retrofit replaced continuous pneumatic holding with magnetic pickups, using compressed air only for release. In other words, compressed air was moved from the holding function to the control function.

*Above: At a similar automotive assembly plant, venturi vacuum cups were replaced with magnetic pickups, offering an ROI of under one year.*

The distinction is important. A vacuum cup uses compressed air to create the useful force holding the part. A magnetic pickup uses magnetic force to hold the part and a small, regulated air pulse to break contact when the part must be released. That change may look small at the end effector, but it changes the load profile seen by the header, the compressed air dryer and the air compressor room. The project economics were compelling: A total installed cost of approximately $497 per magnetic pickup, average annual savings of about $592 per pickup and a simple payback of 0.83 years. The measured plant-wide air reduction after the first implementation phase was 800 cfm, with 436 cfm attributed to the magnetic pickup conversion.

## Start at the End Use, Not the Air Compressor Room

The engineering logic behind this retrofit follows an inside-out approach. Instead of starting with air compressor efficiency, controls, compressed air dryers or storage receivers, the evaluation starts at the manufacturing process. What is the part? What force is required to hold it? How long does the gripper hold the part? How many times per hour does the cycle repeat? Does compressed air create value during the full holding time or only during a short release event? These questions are closer to the press, robot and

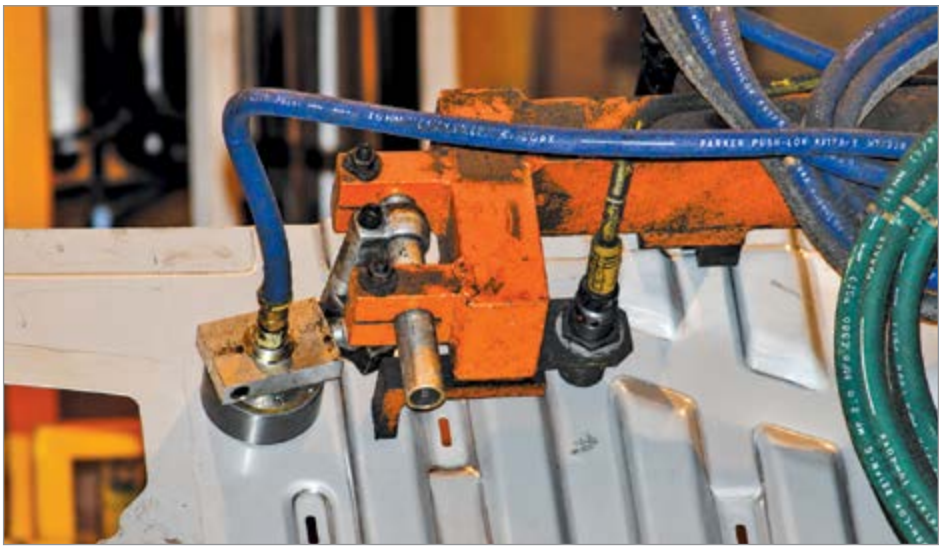

*Figure 1. An overview of the end effector showing the magnetic pickup, adaptive tooling, 1 1/8-inch ball interface and compressed air release connection.*

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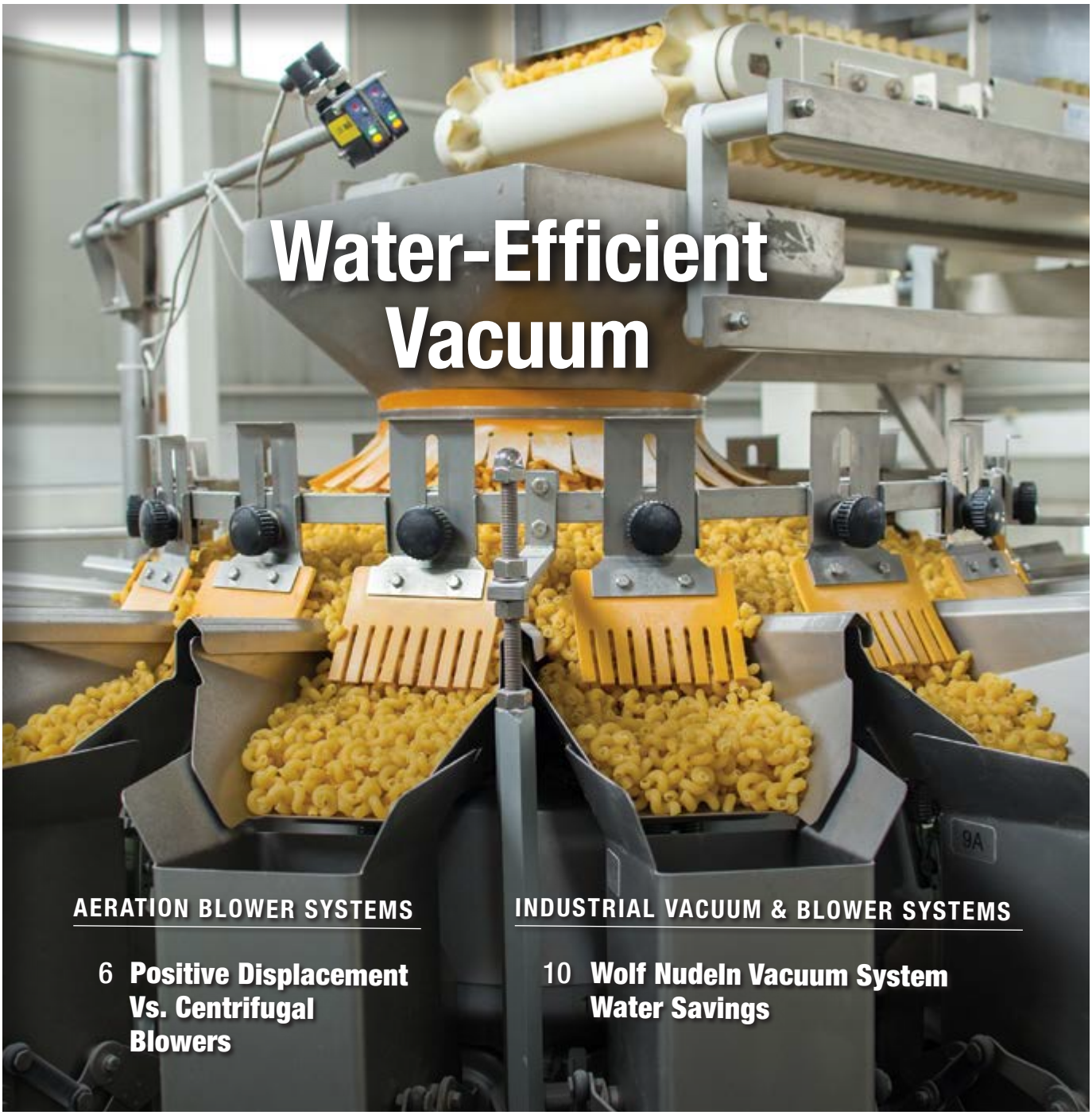

# Water-Efficient Vacuum

AERATION BLOWER SYSTEMS



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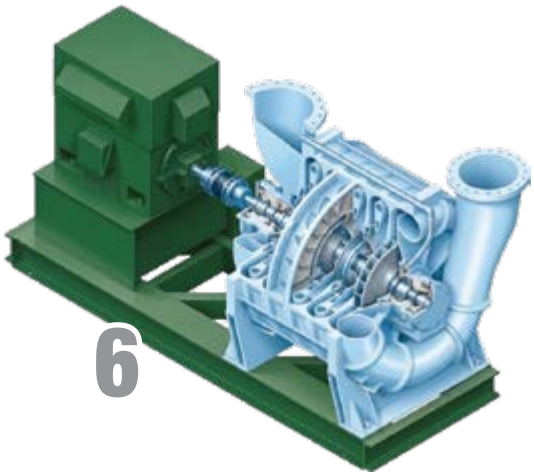
## AERATION BLOWER SYSTEMS





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## INDUSTRIAL VACUUM & BLOWER SYSTEMS



## EVERY ISSUE



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# NEWS Blower & Vacuum Industry & Technology

## Atlas Copco Releases DHS 3000 VSD+ Dry Screw Vacuum Pump for Massive Flow Industrial Applications

Atlas Copco launched the dry screw vacuum pump DHS 3000 VSD+, developed specifically for massive flow industrial applications. As dry technology, it's well-suited for paper processing, conveying technologies and pick-and-place applications in the food industry, and as a central vacuum system. Powered by a highly efficient IE4 motor with a patented asymmetrical rotor design, it lets users benefit from energy savings of up to 50% compared to competitive products. The low-maintenance, compact vacuum pump has a low noise level and runs vibration-free.

An integrated, intelligent control system with a frequency converter automatically adjusts the speed of the DHS 3000 VSD+ to the requirements, ensuring the exact vacuum level required is delivered in each process section. This results in significantly lower energy consumption and reduced wear on all moving components. This also extends the maintenance intervals and service life of the vacuum pump. A wear-free gearbox ensures optimum power transmission from the motor to the screw.


*Atlas Copco's DHS 3000 VSD+ dry screw vacuum pump*

A range of ergonomic advantages and straightforward handling make the DHS 3000 VSD+ extremely user-friendly. The easy-to-use Elektronikon® control system gives users a constant overview of the latest status updates on operating times and downtimes, errors and alarms.

"We have achieved a long service life for the gear wheels by using a cooled oil flow," said Carol Pignatelli, Product Manager, Atlas Copco. "We have also equipped the DHS VSD+ with an air intake filter to protect the operational process from dust and particles." For more information, visit https://www.atlascopcogroup.com.

## Busch Vacuum Solutions Expands MINK Line, Introducing the MINK MV 0360 A ECOTORQUE Claw Vacuum Pump

Busch Vacuum Solutions launched the MINK MV 0360 A ECOTORQUE, an intelligent and energy-efficient addition to the MINK family of claw vacuum pumps.

The MINK MV 0360 A ECOTORQUE claw vacuum pump is equipped with an IE5 integrated permanent magnet motor, achieving up to 10% energy savings compared to conventional IE3 asynchronous motors. The integrated variable-speed drive ECOTORQUE automatically adapts performance to process demands, further reducing energy consumption and operating costs by an additional 50% across the entire vacuum range.

With a pumping speed of up to 360 m³/h and an ultimate pressure of 100 hPa (mbar), the new model delivers superior performance for customer processes. A speed-independent cooling fan ensures reliable temperature control even at low operating speeds. A pressure sensor replaces the mechanical vacuum relief valve, providing precise control and extending the operating range.

The plug-and-pump design ensures easy installation. The Harting connector and easily accessible interfaces further simplify setup and integration. Using Busch Vacuum Manager software, operators can monitor parameters such as power consumption and pressure, switch between control modes and activate eco mode for additional energy savings.

Thanks to its reduced footprint compared to other vacuum pumps of its class, the MINK MV 0360 A ECOTORQUE requires minimal installation space. Its high efficiency and energy-saving options result in a rapid return on investment. The plug-and-pump design and intelligent control software ensure simple installation and use, while the pump delivers high performance with precise pressure control for reliable operation. Its compact, efficient and low-maintenance construction makes the MINK MV 0360 A ECOTORQUE ideal for energy-conscious users in woodworking, pneumatic conveying, vacuum lifting and pick-and-place applications. For more information, visit https://www.buschvacuum.com.


*MINK MV 0360 A ECOTORQUE (Source: Busch Vacuum Solutions)*

# NEWS Blower & Vacuum Industry & Technology

## Sulzer Announces Compact, High-efficiency HST 5 Turbo Air Compressor for Smaller Municipal and Industrial Applications

Sulzer introduced the HST 5 turbo air compressor, marking a significant advancement, particularly for smaller wastewater treatment plants processing less than 5,000 cubic meters per day. The HST range from Sulzer has established the proven advantages of high-speed turbo air compressor technology for a wide range of facilities.

The HST 5 is not just for municipal applications. It is also well-suited to industries such as pulp and paper, food and beverage, chemicals, pharmaceuticals and mining, where it can enhance both core production processes and integrated wastewater treatment systems.

Central to the HST 5's performance is its advanced design, which prioritizes efficiency while reducing mechanical complexity. The air compressor combines cutting-edge turbo technology with a permanent magnet motor engineered specifically for this application. Magnetic bearings and air cooling eliminate the need for lubrication systems, significantly lowering maintenance requirements.

*Sulzer's HST 5 turbo air compressor*

The HST 5 provides a stable, low-maintenance alternative operating with minimal vibration and significantly reduced noise. Its compact footprint, low noise and almost vibration-free operation optimizes the installation and allows units to be housed in space-efficient structures, helping to reduce infrastructure and operational costs.

Once in operation, the HST 5 delivers precise control and consistent performance. An integrated variable speed drive enables airflow to match process demand, ensuring optimal efficiency under varying conditions. This adaptability, combined with the reliability of the system, provides operators with a dependable and cost-effective solution. For more information, visit https://www.sulzer.com.

## APG-Neuros Launches Ventura Control AI to Drive DOE-Backed Aeration Innovation and Cut Wastewater Energy

APG-Neuros highlighted its role in a U.S. Department of Energy project, DE-EE0009509, "Transforming Aeration Energy in Water Resource Recovery Facilities (WRRFs) through Suboxic Nitrogen Removal." The project demonstrated that operating activated sludge processes at WRRFs at low-DO with modern, model-based control can materially cut aeration energy while maintaining stringent effluent performance, with site assessments indicating substantial OPEX reductions and compelling return on investment potential.

The project's final report highlighted the critical role of APG-Neuros as the commercialization partner bringing these technological advancements to the wider industry. The company is honored to be recognized for its contribution, which has culminated in the development of its state-of-the-art control system.

The report states, "APG-Neuros served as a critical commercialization partner for this project through the development of its Ventura Control AI system. Leveraging decades of expertise in aeration technology and wastewater treatment optimization and a diverse team of controls, aeration and blower experts, the company developed Ventura to address the dynamic demands of secondary treatment processes, providing substantial energy savings, improved effluent quality and enhanced operational stability."

APG-Neuros introduced Ventura Control AI as its innovative, advanced control and optimization product for WRRFs, delivering predictive, plant-wide optimization. It includes several treatment modules.

ABAC DO Setpoint Optimization dynamically sets DO setpoints by load to meet ammonia targets and minimize airflow. DO/Airflow/Valve Control calculates zone airflow and coordinates valves with dynamic most-open-valve to lower header pressure. SRT and WAS Control allows predictive solids management to hold MLSS/SRT on target and stabilize biology. Nitrate Control provides joint optimization of internal recycle and external carbon to meet pre-anoxic $NO_3$ setpoints at the lowest cost. Nitrous Oxide ($N_2O$) Control minimizes GHG emissions via coordinated DO, recycle and carbon dosing strategies. Digester Optimization provides smarter mixing/feeding/temperature strategies to stabilize gas production and reduce energy. Dewatering Optimization offers real-time polymer and equipment setpoint control to improve cake dryness and capture. For more information, visit https://apg-neuros.com.

## CAGI Updates Blower Selection Guide

The Compressed Air and Gas Institute announced its Blower Selection Guide has been newly updated to better support engineers, system designers, educators and anyone seeking a clearer understanding of blower technologies.

This refreshed resource is designed to help readers build foundational knowledge of today's blower technologies and understand how different blower types operate and where they are commonly applied. It allows readers to compare performance characteristics across rotary lobe, screw, claw, vane, centrifugal, liquid ring, regenerative and other technologies, and helps strengthen decision-making with unbiased, technically grounded information.

Whether evaluating options for a new system or replacement, the updated guide provides a structured, easy-to-navigate overview of the blower landscape to help determine the most appropriate technology for a specific application. For more information, visit https://www.cagi.org/blower-guide.

## OTC Expands Flowserve SIHI Vacuum Pump Distribution

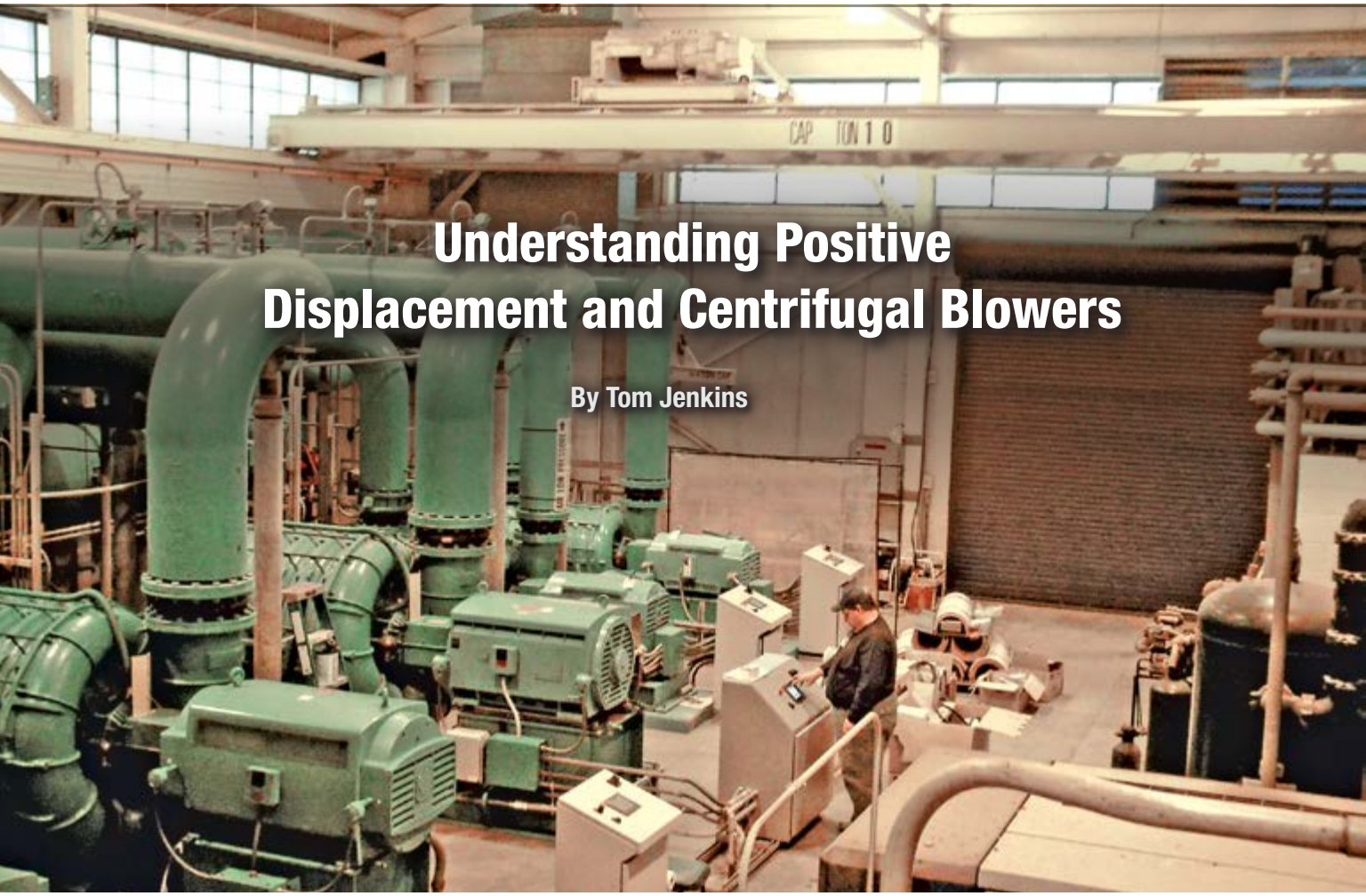
Fleetwood Industrial Products, an OTC Industrial Technologies company, was named an authorized distributor of Flowserve SIHI vacuum pump products across select counties in Pennsylvania, New Jersey and Delaware. The agreement includes liquid ring vacuum pumps and air compressors, dry vacuum systems, gas ejectors and custom-engineered SIHI vacuum solutions.

Founded in 1986, Fleetwood is a trusted Flowserve distributor, supported by two Flowserve Authorized Repair Centers, including a certified Diamond Level Service Center in Boothwyn, PA. OTC acquired Fleetwood in August 2025, further strengthening its service and repair capabilities across the region.

*Representation of OTC and Fleetwood's custom-engineered SIHI vacuum solutions*

"Fleetwood's Diamond Level status reflects its technical expertise, quality standards and ability to solve complex challenges for customers across a range of industries," said Brett Stanton, President, OTC Rotating Equipment Group.

With an extensive operating footprint, local service presence and a dedicated field service team, OTC delivers timely in-shop and on-site repair solutions to a diverse customer base across the region. For more information, visit https://otcindustrial.com.



# Understanding Positive Displacement and Centrifugal Blowers

By Tom Jenkins

In the 1970s, the market for aeration blowers was dominated by two technologies. Small systems generally used two-lobe positive displacement (PD) blowers. Midsized and many large facilities generally used multistage centrifugal blowers. Both types were almost always operated at constant speed. There were exceptions, of course, but the majority of systems fit these generalizations.

Recent developments in technology have upset the standard practices of the past. Two-lobe PD and multistage centrifugal blowers are still common, but additional choices are available, including:

- Geared single-stage centrifugal blowers
- Turbo blowers (gearless single-stage centrifugal blowers)
- Three-lobe PD blowers
- Screw-type PD blowers
- Variable-speed control for both PD and centrifugal blowers
- Factory-built blower packages

*Above: Multistage centrifugal blowers used for wastewater aeration*

Most of these variations were developed to improve the basic blower efficiency or reduce noise. Other factors, such as simplified installation, also played a role in their adoption.

The fundamental thermodynamics are shared by all blower types, but operational details, physical construction and control requirements vary with the blower type. Understanding these variations is key to optimizing the blower system selection for each application.

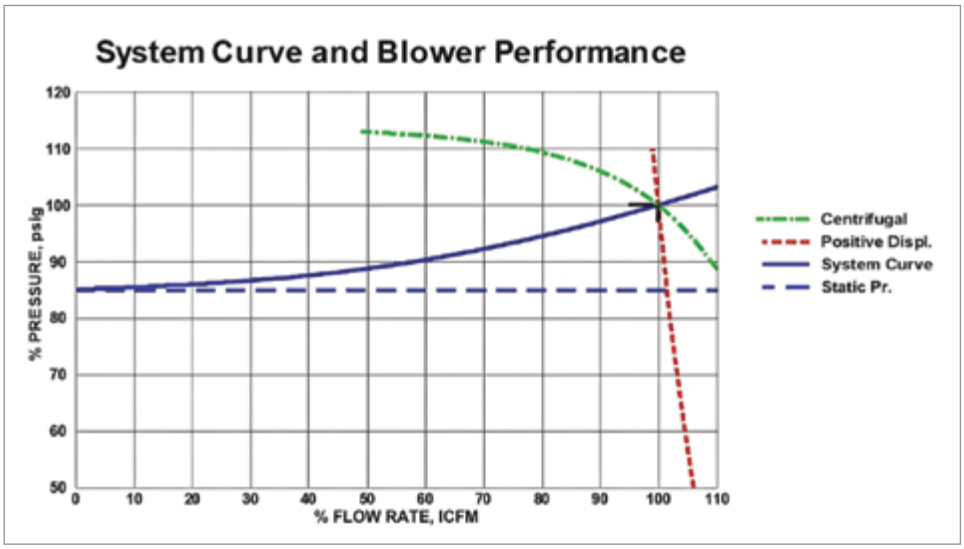
## Mechanisms of Compression in Blowers

Both new and traditional blowers are divided into two categories based on the mechanism of compression employed.

When the volumetric air flow rate is plotted against discharge pressure, the blower performance can be displayed as a characteristic curve. The intersection of this curve with the system curve – the resistance of the system to flow – identifies the actual operating point of the blower.

A dynamic – centrifugal – blower relies on a spinning impeller to impart kinetic energy

to the gas being compressed (ke = ½ mv²). The impeller consists of a disk with protruding vanes, similar to the impeller of a centrifugal pump. As the gas exits the impeller at its outside diameter, it enters a diffuser section and the velocity decreases. This converts some of the kinetic energy to potential energy. The potential energy is static pressure. At constant speed and constant inlet conditions, the characteristic curve and the variation of discharge pressure and flow rate is fixed.




*Example blower and system curves*

Because of the low density of gases, the kinetic energy imparted to the gas by the impeller is limited. In order to obtain the required discharge pressure, the multistage blower uses several impellers arranged in series.

The PD blower performance is based on the geometry of the impellers. Each time the impellers rotate, a fixed volume of the gas is moved from the inlet side to the discharge side of the case. This is the displacement of the blower. As the lobes mesh, the displaced gas is forced out of the blower. The pressure will rise to meet the required system pressure. The resulting characteristic curve is theoretically a vertical line. The deviation from vertical is due to internal leakage, known as slip.

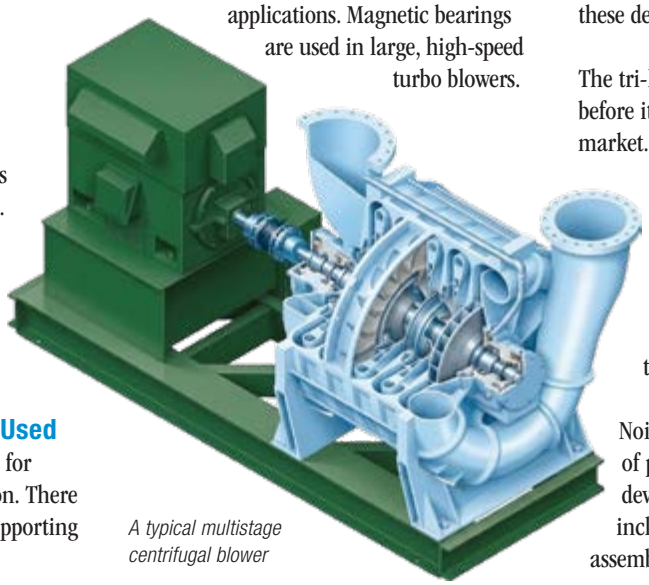
For both types of blowers, power consumption is a function of the pressure ratio and the mass flow rate of the gas being compressed. It's important to remember for both types of blowers the flow rate is volumetric. Since the density of the gas is influenced by inlet temperature and pressure, the performance of a blower is greatly influenced by inlet conditions.

## The Three Types of Bearings Used

Bearings are a potential failure point for blowers and influence blower selection. There are three types of bearings used in supporting blower shafts:

- Journal bearings, with the shaft rotating inside a sleeve and supported by a fluid film
- Anti-friction bearings, with the shaft supported by balls or rollers
- Magnetic bearings, with the shaft levitating in a magnetic field

The journal bearing and anti-friction bearings are most common. Both types are used in both centrifugal and PD blowers. Journal bearings are used primarily in large or high-speed applications. Magnetic bearings are used in large, high-speed turbo blowers.



*A typical multistage centrifugal blower*

Bearing friction is low for all three types. The bearing selection is based on mechanical considerations and only has a minor impact on power consumption.

## Blower Developments Since the 1970s

A number of blower technologies have been implemented since the 1970s, and the market has been increasingly willing to adopt them. The drive to optimize energy consumption is often the primary incentive for the changes. Decreased noise and more convenient installation also play a part in these developments.

The tri-lobe PD blower was popular in Europe before it was widely accepted in the U.S. market. Although claims of higher efficiency are often made for the tri-lobe, its principal advantage is noise reduction. The higher frequency noise produced by the tri-lobe PD blower is easier to attenuate than the lower frequency produced by two-lobe blowers.

Noise abatement was one of the goals of pre-engineered blower package development, which nearly always includes sound enclosures. These factory-assembled packages normally include

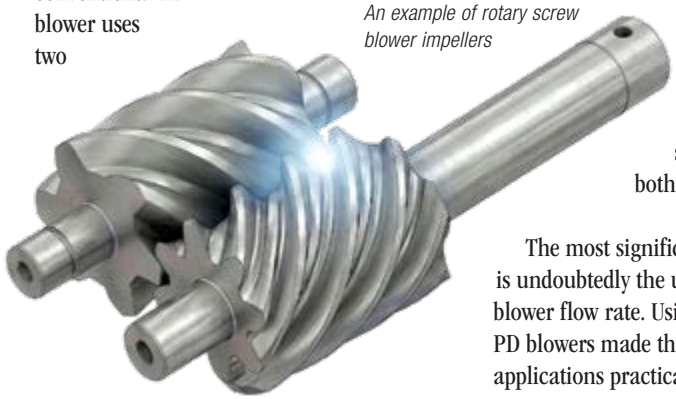
## Understanding Positive Displacement and Centrifugal Blowers

inlet and discharge silencers matched to the blower type and characteristics. Controls, instrumentation, blow-off valves, drive systems and other required accessories are usually included to create a complete blower system. The result is reduced footprint, simpler installation and improved operator convenience. These pre-engineered packages are available with many types of blowers, both PD and centrifugal.

Geared single-stage centrifugal blowers were once only applied to large facilities with high flow rates. New manufacturers have entered the field, and geared single-stage units are now available down to 15 horsepower (hp). They offer high efficiency and compact packages.

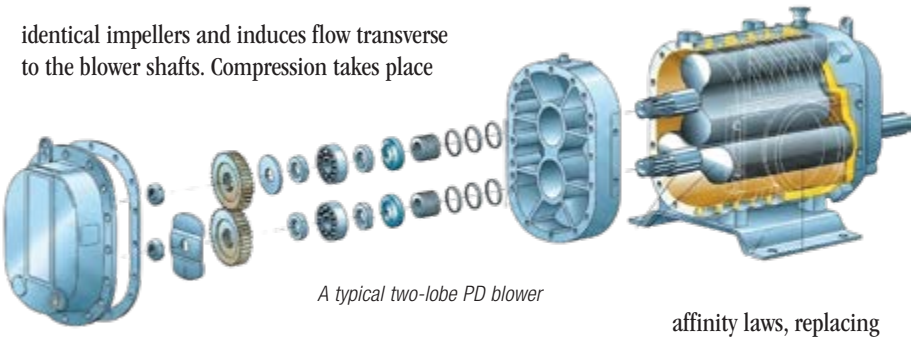
One of the most popular innovative designs is the gearless single-stage centrifugal blower, commonly called a turbo blower. They operate at extremely high speeds, typically several thousand rpm. An integral variable-frequency drive (VFD) with output frequencies of several hundred Hertz is required to obtain these high speeds. A synchronous motor has the blower's impeller mounted directly on the motor shaft. The motor employs specialized journal bearings to accommodate the high speeds. Smaller units use ambient air for the fluid film supporting the shaft. Larger units require magnetic bearings to levitate the motor's shaft.

The most significant development for PD blowers is the rotary screw blower. The conventional PD blower uses two identical impellers and induces flow transverse to the blower shafts. Compression takes place externally to the impellers.



*An example of rotary screw blower impellers*

On the other hand, the rotary screw blower uses a male and a female rotor to move the gas axially. Some compression takes place internally. Although the rotary screw air compressor has been used for many years at higher pressure ratios, it is only relatively recently that rotors were available for the low pressure ratios needed for blower applications. This PD technology exhibits high efficiency across the blower operating range and has excellent turndown.



*A typical two-lobe PD blower*

### The Importance of Blower Controls

For both custom-built and pre-engineered packages, the control system can be of equal importance to the blower itself. Energy consumption, equipment life and operator satisfaction are significantly influenced by the control system.

Controls can provide blower health monitoring, protecting the blower from unusual operating conditions. The controls can stop the blower before catastrophic failure occurs. The control system can also optimize energy consumption by matching the flow rate to meet actual process demand. Pre-engineered package systems generally offer control systems combining both functions.

The most significant control development is undoubtedly the use of VFDs to control blower flow rate. Using a VFD to control PD blowers made their use in variable flow applications practical. And, by virtue of the affinity laws, replacing throttling valves or guide vanes with VFDs greatly reduces power consumption for centrifugal blowers.

### Applications for PD and Centrifugal Blowers

Blower applications can be distinguished by inlet and discharge conditions:

- Constant or variable flow rate
- Constant or variable discharge pressure
- Wide or narrow range of inlet conditions

The selection of the optimum blower for each application must consider each of these parameters.

In the past, variable discharge pressure generally mandated the use of PD blowers, since they inherently adjusted to discharge pressure deviations. On the other hand, variable flow applications tended to use centrifugal blowers, since the flow rate could be economically controlled by throttling or guide vanes.

This is no longer the case. The combination of blower technology and control capabilities allows any type of blower to be applied to virtually any application. This opens opportunities for optimization, but also complicates the system designer's task.

The best method for comparing the options is to begin with an evaluation of the lifecycle cost:

*LCC=Equip+Inst+Energy+Maint*

Where:

*LCC* = Total lifecycle cost

*Equip* = Initial cost of the blower system, including accessories

*Inst* = Cost of installing the blower system, including mechanical and electrical installation

*Energy* = The total cost of energy, calculated as the annual energy cost x the expected service life

*Maintenance* = The anticipated cost of preventive and corrective maintenance

The option with the lowest lifecycle cost is not always the best selection. Other factors to consider in making the final selection include experience with the supplier, robustness of the system and operator preference.

## Summary

New developments in blower and control design have expanded the options available to designers. The two basic categories – PD and centrifugal – remain the same. The original designs are still valid and may still be the best choice for many applications. However, high efficiency, reduced noise or process flexibility may make the new configurations a better choice for other applications. BP

*About the Author*

*Tom Jenkins has over 40 years' experience in blowers and blower applications. As an inventor and entrepreneur, he has pioneered many innovations in aeration and blower control. He is a former Adjunct Professor at the University of Wisconsin, Madison, and is a Fellow of the Water Environment Federation. Tom is the current Chair of the ASME PTC 13 Committee. For more information, visit https://www.jentechinc.com.*

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# Wolf Nudeln Reduces Water Use with Claw Vacuum Pumps

By Lisa Glatt, Head of Marketing, Busch Austria

➤ The pasta manufacturer Wolf Nudeln chose rotary claw vacuum pumps from Busch Vacuum Solutions for its manufacturing processes, with the aim of reducing water consumption, maintenance and energy requirements. State-of-the-art vacuum technology replaced a maintenance-intensive liquid ring solution. The Austrian company now benefits from a reliable, efficient vacuum supply in flour conveying and dough manufacturing – with a significantly reduced failure rate and lower operating costs.

## A Family Business with a Focus on Sustainability

The family business Wolf Nudeln, based in Güssing, Austria, is run by the third generation with Joachim Wolf at the helm. The fourth generation, his two sons, are already lined up as successors. The company dates back to 1890, when the Wolf bakery was founded. In 1956, the bakery started producing pasta, with the first variety being the fine, thin "Goldfaden", which is still popular today as a classic soup topping. The company's 50 employees process around 5,500 tons of pasta annually in a three-shift operation five days a week. Production is completely $CO_2$-neutral, as the company's biogas plant covers all energy requirements and is operated with corn and green cuttings from the company's agricultural production and waste material from in-house poultry farming. The manure comes from an independent egg production facility, which has existed since 1968 and continues to supply the company with all the eggs it needs.

*Above: Penne pasta from the traditional foods company Wolf Nudeln (Source: Wolf Nudeln)*

*The company began a pilot implementation in the dough pot area with two claw vacuum pumps. During operation, it became apparent that switching to a version of the pumps better suited for humid environments was necessary due to the residual moisture in the application.*

Sustainability is a core building block of the company's philosophy, with Wolf Nudeln relying on 100% Austrian raw materials such as durum wheat semolina and spelt, as well as fully paper-based packaging. 90% of sales are via the Austrian food retail trade, and catering companies are also supplied directly.

## Dough Pot and Flour Suction Systems Transition to Centralized Claw Vacuum Pumps

Vacuum pumps are used in two food manufacturing processes. In one process, grains such as spelt, semolina and durum wheat are taken in and processed via seven flour suction lines. In another process, vacuum pumps ensure controlled oxygen reduction during dough production in seven dough pots. The vacuum system also preserves the color of the pasta – a crucial quality factor, especially when processing fresh eggs.

In the past, Wolf Nudeln relied on eight liquid ring vacuum pumps to operate the dough pots. They were associated with comparatively high water consumption, increased humidity and considerable maintenance effort in this application. The vacuum pumps were housed in a technical room with an open basin, which made the system prone to scaling and occasional malfunctions. The vacuum system required regular cleaning and a change of water

on the weekend. In addition, water cooling was needed, which significantly increased the use of energy and resources. The company relied on compressed air technology for the flour suction systems. This was often clogged with flour dust, resulting in system failure and requiring complex, time-consuming cleaning.

Joachim Wolf became aware of Busch through an article in an industry trade magazine and contacted the company directly. At the start of 2020, the company began a pilot implementation in the dough pot area with two claw vacuum pumps. During operation, it became apparent that switching to a version of the pumps better suited for

*Continued on page 14*

*A claw vacuum pump in use at Wolf Nudeln. (Source: Busch Group)*

## Vacuum-Based Leak Testing in Food Processing

Imagine preparing a bottle of milk for your baby – or a cup of coffee for yourself – and wondering whether the packaging has truly preserved its taste and healthiness. Many products use Modified Atmosphere Packaging (MAP): the air inside is replaced with a protective gas mix to extend shelf life by keeping oxygen out. But even tiny leaks can let oxygen back in, which influences the quality and expiration date of the product in a negative way. Vacuum-based leak testing methods offer clear advantages over traditional techniques, helping maintain quality without slowing down production.

Cans of baby formula, once filled and sealed, are expected to protect their contents for a long period of time. That's an important requirement, especially when even invisible leaks can let in oxygen, slowly degrading the product. For foods like infant milk powder, that's a risk no one wants to take.

And it is not just about baby food. Comparable requirements apply to products like coffee capsules or chip canisters. In all cases, packaging must hold up over time, across transport, and under varying climatic conditions, while reliably preventing oxygen ingress. These products typically rely on protective gas atmospheres to preserve freshness. However, regardless of the packaging concept used, long-term product quality ultimately depends on one factor: a consistently tight and verifiable seal.

### Vacuum-Based OES and Helium Methods Replace the Water Bath Test

There are several ways to check if packaging is tight. One of the most commonly used methods for leak testing in food packaging is the water bath test, also known as the bubble test. The principle is familiar to anyone who has ever searched for a puncture in a bicycle tire: submerge it in water and watch for bubbles. In food production, the process is similar.

Due to its simplicity and low equipment cost, the water bath test is widely used in food production. However, the method has clear limitations. It

*Continued on page 12*

## Wolf Nudeln Reduces Water Use with Claw Vacuum Pumps

*Vacuum-Based Leak Testing continued from page 11*

can be destructive, as tested packages and often their contents must be discarded or at least dried before re-entering production. Manual bubble tests depend strongly on operator attention and subjective interpretation, leading to a higher risk of human error and inconsistent results. Even in automated setups, the test typically provides only a pass/fail result without reliable information on leak size. In addition, detecting small leaks often requires long observation times; tiny leaks generate bubbles only sporadically.

Where the bubble test reaches its limits, other methods come into play. One of these vacuum-based methods involves helium as a test gas. Here, a bit of helium is added inside the package. It's placed in a vacuum chamber, and a detector based on mass spectrometry checks how many helium atoms escape over time. The quantity defines the size of the leak.

This method is highly sensitive. Helium atoms are so small they can slip through even the tiniest gaps. That's why it's often used to develop and qualify new packaging on a laboratory scale. However, helium testing requires careful handling of the gas and extra steps after testing to verify conditions, especially in high-speed food production, where thousands of packages roll off the line. As a result, helium management and verification can increase both operational effort as well as overall cost.

An alternative method is Optical Emission Spectroscopy (OES). Rather than adding any tracer gas, OES analyzes gases already present inside the package, such as nitrogen or carbon dioxide. Under vacuum, escaping gas is briefly excited into a plasma, emitting light with a unique spectral signature. A sensor analyses this light pattern to identify even the smallest leaks, similar to recognizing a substance by its unique color signature.

### Food Packaging Confidence without Compromise

Unlike traditional water bath tests, both helium and OES methods are non-destructive and deliver objective, reproducible results. OES in particular offers a practical balance: high sensitivity without additional gas handling or sample preparation.

Modern OES systems can be positioned at-line, operating with short cycle times and minimal operator intervention. This allows manufacturers to increase testing frequency and ensure consistent packaging integrity without slowing production.

Whether it's milk powder, coffee capsules or chips, tight packaging does more than just protect contents. It preserves shelf life, flavor and consumer trust. Vacuum-based leak detection turns invisible risks into measurable certainty.

In vacuum technology, leaks are quantified in units like mbar·l/s. In food packaging, quality is judged differently: how much oxygen enters a package over months or years. Connecting these two worlds is essential. A defined leak rate can be translated into oxygen ingress, helping manufacturers predict whether or not a package will still meet its oxygen limits at the end of its shelf life. Understanding this relationship turns leak testing from a technical exercise into a tool for long-term quality assurance and helps bridge the gap between physics and food safety.


*Leak detection tests must be performed in a stable environment with a consistent temperature for precise results. (Source: Busch Vacuum Solutions)*

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# Wolf Nudeln Reduces Water Use with Claw Vacuum Pumps

*Wolf Nudeln continued from page 11*

humid environments was necessary due to the residual moisture in the application. In addition, two filter systems were added to the two vacuum pumps: one filter prevents water from being sucked in, while a polyester filter retains flour particles and ensures no dust enters the vacuum pump.

Based on these positive experiences, the solution has been gradually expanded. In May 2024, five additional claw vacuum pumps with an identical configuration were added. Today, the new solution includes seven vacuum pumps placed in a separate technical room, with two used for the flour suction systems and five for extracting oxygen from the dough pots. Thanks to an intermediate vacuum buffer, the lines can now be operated energy-efficiently even in standby mode. The vacuum pumps operate at an ultimate pressure of 70 to 100 mbar, with a power consumption of only 3.5 kWh (50 Hz) per vacuum pump.

*The new solution includes seven vacuum pumps placed in a separate technical room, with two used for the flour suction systems and five for extracting oxygen from the dough pots. Thanks to an intermediate vacuum buffer, the lines can now be operated energy-efficiently even in standby mode.*

Another benefit is that by placing the central system in the separate technical room with active ventilation, the temperature in the room does not exceed 104°F (40°C). The system is low-noise, more hygienic and requires little maintenance. Both filters are easy to clean.

## Vacuum Pumps Offer Less Maintenance, More Reliability

"I am very satisfied with the vacuum pumps. We have not had any problems since we began using Busch solutions," says Joachim Wolf. Operating costs have fallen, and water consumption, humidity and maintenance have also been drastically reduced. While several vacuum pump failures per year were previously registered, system operation is now stable. At the same time, the current solution allows the system to switch to a replacement pump at any time, without interrupting manufacturing.

*A flour conveyor in Wolf Nudeln's manufacturing facility. (Source: Busch Group)*

Wolf Nudeln is planning to switch to new technology for packaging in the future. A dry rotary vane vacuum pump with a vacuum regulating unit and inlet filter will be used in a tubular bag machine to keep the packaging stable during the filling process. To extend maintenance intervals, reduce operating costs and avoid downtime, the company relies on oil and filter material for the seven solutions. BP

### *About the Author*

*Lisa Glatt is Head of Marketing at Busch Austria, where she leads strategic marketing and communications initiatives. With a passion for storytelling and industrial innovation, she highlights customer success stories demonstrating the value of vacuum and overpressure solutions across diverse industries.*

### *About the Busch Group*

*The Busch Group is one of the world's largest manufacturers of vacuum pumps, vacuum systems, blowers, air compressors, chambers and gas abatement systems. Under its umbrella, the group houses two well-known brands: Busch Vacuum Solutions and Pfeiffer Vacuum+Fab Solutions.*

*The company's extensive products and services include solutions for vacuum, overpressure and abatement applications in all industries, such as food, semiconductors, analytics, chemicals and plastics. This also includes the design and construction of tailor-made vacuum systems and a worldwide service network. The Busch Group is a family business managed by the Busch family. More than 8,000 employees in 47 countries worldwide work for the group. It's headquartered in Maulburg, Baden-Württemberg, in the tri-country region of Germany, France and Switzerland. It manufactures in its 20 own production plants in China, the Czech Republic, France, Germany, India, Romania, South Korea, Switzerland, the U.K., the U.S. and Vietnam. It has an annual consolidated revenue of €2 billion. For more information, visit https://www.buschgroup.com.*

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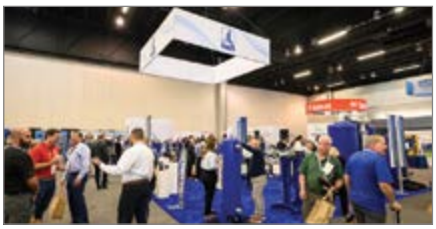

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tooling than to the air compressor room, which is exactly why they are powerful.

The baseline application used vacuum cups to grip metal parts on robotic or press-transfer tooling. The existing vacuum cup assembly included a venturi device. One red venturi uses a 0.04-inch orifice. Manufacturer data indicated air consumption of 1.6 scfm at 60 psig (4.1 barg) and estimated at 2.52 scfm at 90 psig (6.2 barg). A larger blue venturi with a 0.078-inch orifice uses 6 scfm at 60 psig (4.1 barg) and is estimated at 9.18 scfm at 90 psig (6.2 barg).

For plant personnel, the exact venturi color is less important than the operating behavior. The vacuum cup was effectively on while holding the part, and it operated at full line pressure. That means compressed air consumption was tied to holding time, not just to the motion event. If the part is held during a transfer, wait state, hesitation, production interruption or dry cycle, the end effector continues to consume air. In a plant where compressed air is shared by many processes, this kind of load contributes to base demand and reduces the room available for real process peaks.

Vacuum cups also bring maintenance realities. Cups wear, harden, crack, deform and lose sealing effectiveness. Oil, dirt, part surface variation and misalignment can reduce holding reliability. A small leak at the cup can become a continuous compressed air demand at the venturi. Maintenance teams know these failures because they show up as dropped parts, nuisance faults, repeated cup replacements, inconsistent pickup, pressure complaints or operators increasing air pressure to overcome a mechanical issue. Energy waste is often the accounting symptom of a reliability problem production already understands.

## The Retrofit: Magnetic Holding, Pneumatic Release

The replacement was a spring-return magnetic pickup designed for ferrous metal handling. The magnetic pickup held the part mechanically through magnetic attraction. Compressed air was not required to maintain the holding force. Instead, compressed air was supplied only when the part needed to be released. During release, compressed air entered the pickup through a

*Figure 2. In this project, a vacuum cup (top left) is replaced by a spring-return magnetic pickup (top right) while retaining the existing adaptive tooling (bottom) where practical.*

## Magnetic Pickups Reduce Compressed Air Demand at Automotive Plant

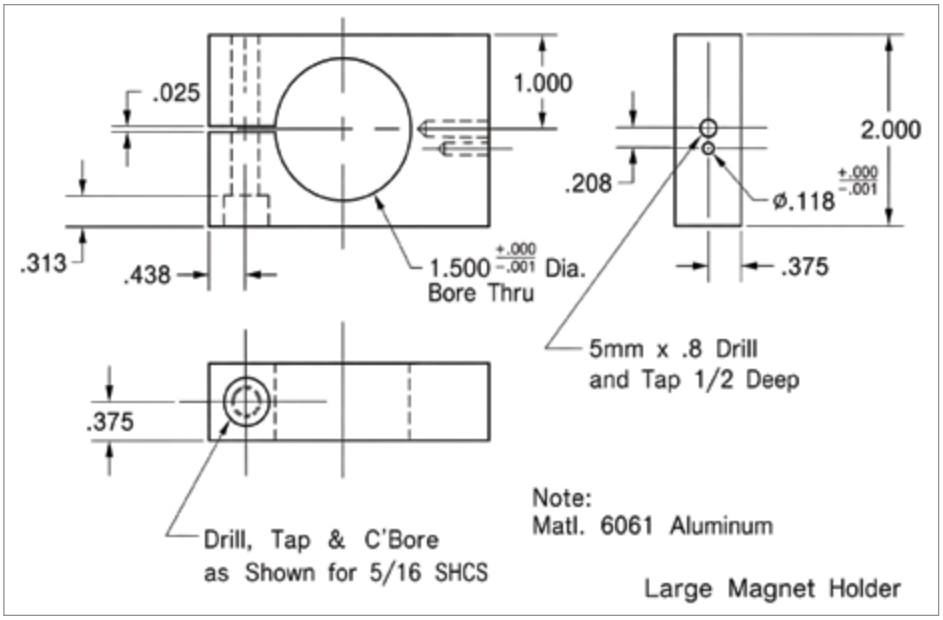


*Figure 3. Manufactured 6061 aluminum adaptive tooling was used to adapt the magnetic pickup to the existing end effector interface.*

small inlet port, pushed the internal magnet plates against a spring and created an air gap between the magnet face and the metal part. Once the gap was created, the magnetic holding force dropped enough for the part to release. When air was vented through small equalization openings, the spring returned the magnet plates to the holding position.

This control sequence is the core of the savings. The old system consumed compressed air while holding the part. The new system consumed a small amount of compressed air during blow-off. The magnetic pickup release air was approximately 0.29 cfm, with the release circuit regulated to 25 psig (1.7 barg).

A plant should resist the temptation to think of this as a simple component substitution. The better framing is functional substitution. The function is holding a ferrous part securely through a defined motion profile and releasing it cleanly at the right time. A vacuum cup accomplishes that function by continuously converting compressed air into suction. The magnetic pickup accomplishes the holding function without continuous air and uses compressed air only to create a release gap. Once that is understood, this project becomes easier to evaluate: Part material, part geometry, motion forces, face contact, release timing, residual magnetism and tooling adjustment become the key engineering questions.

### Mechanical Integration: Reuse What Works, Replace What Wastes

One reason this project was practical was it didn't require a full redesign of the end effector. Existing adaptive tooling was reused in retrofit applications where the geometry allowed it. New adaptive tooling was manufactured from 6061 aluminum, using a 1 1/8-inch ball interface and a holder arrangement connecting the magnetic pickup to the existing tool structure. This simple conversion, requiring minimal reprogramming or mechanical adjustment, makes the opportunity more attractive. That matters because the largest barrier in a production plant is rarely the cost of a single component. It's the risk of disrupting production, increasing cycle time or creating an adjustment problem maintenance inherits.

A magnetic pickup is not a universal replacement for every vacuum cup. It's appropriate where the handled part is ferrous, where the contact surface supports reliable pickup and where release can be controlled without affecting part placement or quality. Plants should evaluate part thickness, coatings, oil film, curvature, temperature, available flat contact area, part orientation, acceleration, deceleration and the consequences of a failed pickup. In some cases, one magnetic pickup can replace one vacuum cup. In other cases, one magnetic pickup can replace two or more vacuum cups. **Figure 7** shows an example where four magnetic pickups replaced eight vacuum cups.

The air-side design is simple but important. The magnetic pickup release circuit used new piping, manifolds, hoses and fittings from a central filter and regulator to the magnetic pickups. The regulator reduced pressure to 25 psig (1.7 barg) for blow-off. A spring-return, single-position on/off pneumatic valve controlled the release event. Under normal holding conditions, the magnetic pickup didn't need a continuous compressed air supply. During release, the valve passed regulated compressed air to the pickup long enough to create the air gap and let the part drop or transfer as intended.

### The Economics: Small Hardware, Fast Payback

The material cost is $320 for each magnetic pickup, $32.50 for manufactured adaptive tooling and $80 for miscellaneous hoses, fittings, filters and pressure regulators. Labor was estimated at one man-hour per pickup at $63.42. The total installed cost was therefore $497 per magnetic pickup. The total includes the component, bracket, air-side accessories and labor to install the retrofit. It's not a catalog price.

The savings estimate was built around the number of vacuum cups replaced. If one magnetic pickup replaced two vacuum cups, the annual energy cost savings were $790. If one magnetic pickup replaced one vacuum cup, the annual savings were $395. Taking the average of those two cases produced an expected savings value of $592 per magnetic pickup. Dividing the $497 installed cost by $592 per year produced a

*Figure 4. An existing vacuum cup and venturi assembly, including a 0.04-inch venturi orifice used on the original pneumatic pickup.*

simple payback of 0.83 years. In practical plant language, that's a maintenance-friendly project paying back in less than a year while reducing a continuous pneumatic load.

The economics become more interesting when the project is scaled. A single pickup may not move the plant utility bill, but a body shop zone, transfer line or press line can. The first implementation phase attributed 436 cfm of compressed air reduction to the magnetic pickup conversion. At that level, the savings are no longer a theoretical calculation per cup. They are visible on the plant air chart. For a plant manager, that's the difference between an energy idea and a production utility improvement.

## Measurement and Verification: Trust the Trend, but Know Its Limits

Measurement and verification for compressed air projects are rarely perfect in a real plant. Department-level air meters may be missing, inaccurate, out of calibration or located in a way that mixes multiple project effects. The team acknowledged plant-wide air tracking was the most practical method available because department air flow metering was not sufficiently accurate. That's a useful lesson. Don't let imperfect metering stop a good project, but don't pretend the metering is better than it is. State the boundary, explain the method and compare the results to production conditions.

The plant-wide compressed air chart shows a reduction from 16,000 cfm to 15,200 cfm after the first implementation phase. The total achieved compressed air savings were calculated as 800 cfm. Of that reduction, 436 cfm was attributed to the magnetic pickup conversion. For an experienced engineer, the right response isn't blind acceptance or automatic rejection. The right response is asking what else changed, if production volume was comparable, if pressure settings were stable, if air compressor operation changed, if other projects were implemented and how the attribution was developed. That is how compressed air savings should be discussed with operations.

Even with those caveats, the result is meaningful. A several hundred cfm end-use reduction is large enough to affect air compressor staging decisions, especially during lower-load periods. It can reduce blow-off on centrifugal air compressors, reduce compressed air dryer load, lower heat rejection and create room for maintenance flexibility. The best measurement and verification practice

*Figure 5. A cutaway view of a magnetic pickup. Compressed air at 25 psig (1.7 barg) is used for blow-off/release rather than continuous holding.*

## Magnetic Pickups Reduce Compressed Air Demand at Automotive Plant

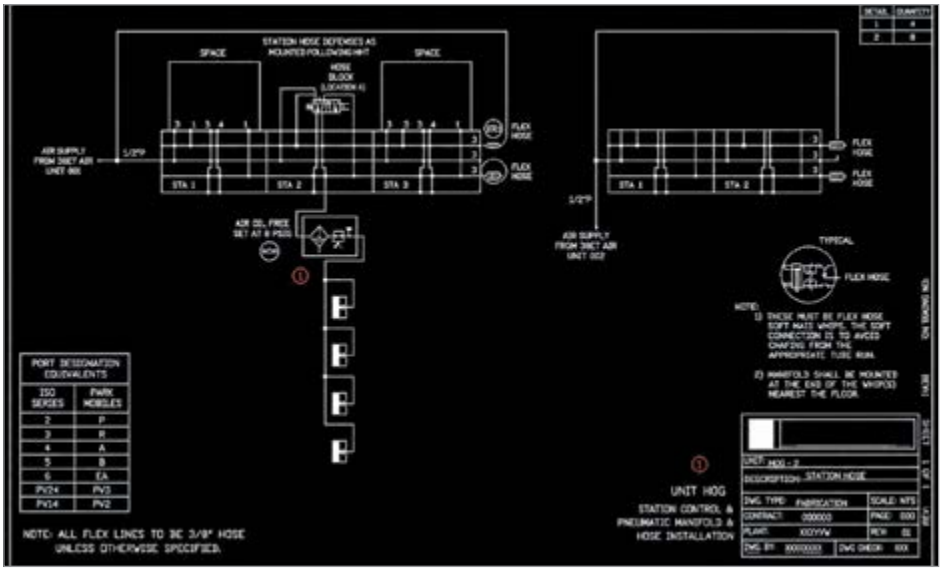


*Figure 6. An after-installation pneumatic schematic showing four magnetic pickups and a filter/regulator reducing blow-off air pressure to 25 psig (1.7 barg).*

is combining component-level engineering estimates with plant-level compressed air demand trending. The estimate tells you what the retrofit should save; the trend tells you whether or not the plant actually saw a reduction. When both point in the same direction, the project becomes credible.

### What Can Go Wrong and How to Prevent It

The most common mistake is treating the retrofit as only an energy project. The production team will support the project when it improves or protects reliability. They'll resist it if it appears to trade production confidence for utility savings. The project team should therefore bring production, maintenance, controls, safety and energy personnel into the same review. The discussion should cover part-hold force, release confidence, robot motion, emergency stops, lockout behavior, adjustment methods, spare parts, PM tasks and operator response to faults.

Another risk is assuming every vacuum cup should be replaced. Some cups handle non-ferrous parts, plastic, glass, fabric, painted surfaces or geometries where vacuum is still the correct tool. Some applications need compliance a rigid magnetic pickup may not provide. Some parts may be susceptible to marking, residual magnetism or release variation. A good plant standard should classify candidate applications rather than force a universal rule. Ferrous metal parts with repeatable contact surfaces, high vacuum holding hours and frequent cup maintenance are strong candidates. Marginal contact, sensitive surfaces, non-magnetic material and high release precision requirements need deeper testing.

### How to Replicate the Project in Another Plant

Replication begins with a survey of vacuum cup applications touching ferrous metal parts. The survey should capture the number of cups, venturi type or orifice size, line pressure, operating hours, holding time, cycle count, maintenance history, part material and tooling constraints. The strongest candidates are usually not the most visible ones. They are the end uses consuming air continuously while holding, running during long production windows, requiring frequent cup replacement or remaining pressurized during idle periods. If local metering exists, trend the branch or cell before and after. If local metering is weak, use air compressor room flow data and document other changes.

The business case should be written in plant language. Discuss installed cost, air reduction, avoided maintenance, part-holding reliability and payback. Avoid overselling technology as a universal replacement. Present it as an engineered alternative for the right class of parts. A practical project screen might ask whether or not the part is ferrous, the contact surface is repeatable, the vacuum cup currently consumes compressed air while holding, one magnetic pickup can replace more than one cup, release can be controlled with a short, low-pressure compressed air pulse and the retrofit can be installed without major reprogramming. That's the kind of screen a 30-year plant engineer will respect.


*Figure 7. A plant-wide compressed air chart after the first implementation phase, documenting a reduction from 16,000 cfm to 15,200 cfm, with 436 cfm attributed to the magnetic pickup conversion.*

*Figure 8. Four magnetic pickups replaced eight vacuum cups on this robotic end effector.*

## The Bigger Lesson: Lowering Demand-Side Use

The larger lesson from this case study is compressed air efficiency isn't only an air compressor room discipline. It's a production design discipline. The air compressor room responds to decisions made at hundreds of end uses. If those end uses require continuous air for functions that can be done mechanically, the most efficient air compressor in the world is still serving avoidable load. When a plant replaces continuous pneumatic vacuum holding with magnetic holding and a small release pulse, it removes demand at the source. That's the cleanest form of compressed air savings.

Compressed air should still be used where it's the right tool. It's rugged, fast and deeply embedded in industrial operations. But it should not be allowed to hold steel parts all day when magnetic force can do the holding, and a short, regulated air pulse can handle release. The best plants will continue to challenge old assumptions. They'll look beyond leaks, move upstream from the air compressor room and ask each end use a direct question: Are you using compressed air because you need it, or because nobody has asked a better question in years? BP

*About the Author*

*Nasr Alkadi, Ph.D., CEM, CDSM, CSRM, is an energy and sustainability expert with over 20 years of experience in industrial energy management, compressed air systems, decarbonization, measurement and verification and strategic energy management. His work has included automotive manufacturing, DOE national laboratory research, energy program delivery and practical implementation of energy efficiency projects connecting plant-floor reliability with measurable cost and emissions reduction. He's authored or co-authored over 20 technical publications and is a named inventor on seven patents covering industrial energy analytics, remote inspection, sensing, emissions monitoring, air-fuel ratio regulation and related energy technologies.*

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# Alternative Water Source Strategies for Evaporative Cooling Systems

By Nicole Babb, Product Manager – Water Systems, EVAPCO

Across industrial and commercial facilities, evaporative cooling system design is entering a new phase. For decades, water has been treated as an assumed utility input – readily available, sufficiently consistent and relatively inexpensive. System design prioritized thermal performance, while water chemistry and treatment were addressed during operation. That assumption is no longer viable.

Evaporative cooling remains one of the most efficient and widely deployed heat rejection technologies in use today. Commercial buildings, data centers, district energy systems, manufacturing facilities, food processing plants, petrochemical operations and power generation continue to rely on evaporative equipment because of its unmatched thermal efficiency. The physics haven't changed. What has changed is the context around water.

In many regions, water availability and water quality now directly influence whether or not a cooling system can operate reliably over its service life. Increasing freshwater constraints, rising water and sewer costs, tighter discharge regulations and heightened expectations around public health and transparency have shifted water stewardship from the margins of system design to the center of it.

Today, cooling system performance, sustainability goals, regulatory compliance, risk management and long-term operating costs are tightly coupled through water quality and quantity decisions.

*Above: Evaporative cooling systems must now be engineered around water variability, balancing heat rejection performance, water conservation and treatment flexibility as facilities increasingly adopt alternative water sources.*

## Water Consumption, System Operation and Cost Drivers

Evaporative cooling systems reject heat through the evaporation of water. That same mechanism creates a direct and unavoidable dependence on water consumption.

In open cooling towers, closed-circuit coolers and evaporative condensers, water is lost through three primary pathways: evaporation, blowdown and drift. Evaporation represents the largest component and is dictated by heat load and system operating conditions.

Blowdown is required to control the concentration of dissolved solids in the recirculating water, while drift accounts for small losses of entrained droplets. Makeup water is required to replace these losses and maintain system operation.

While the basic water balance is straightforward, its implications are not. As water evaporates, dissolved constituents – including but not limited to calcium, magnesium, silica, alkalinity, chlorides, sulfates and trace metals – remain behind and become concentrated in the recirculating water. This increase in dissolved solids reduces heat transfer efficiency and drives the risk of scaling, corrosion, microbiological growth and fouling.

Cycles of concentration (COC) – the ratio of dissolved solids in the recirculating water to those in the makeup water supply – define this balance. COC is essentially the balancing point between water conservation and system risk, constrained by solubility limits, system metallurgy and treatment capability. In practical terms, COC defines how many times dissolved solids are allowed to build up before water is discharged. Higher COC reduces blowdown and total water consumption, but increases the risk of deposition and corrosion. Lower cycles reduce risk but increase water usage and discharge volume.

Because evaporation is largely fixed by thermal demand, intentional blowdown becomes the primary adjustable variable.

From a consumption standpoint, this has significant implications. Large evaporative systems routinely consume millions of gallons of water annually, with total usage driven by both evaporation losses and the intentional blowdown required to maintain acceptable water chemistry. As cycles are reduced or variability increases, blowdown volume – and therefore total water consumption – rises accordingly.

Economic impact follows directly. The cost of water is no longer limited to supply. It also includes:

- Incoming water cost
- Sewer and discharge fees
- Treatment and chemical costs
- Compliance and risk management

In many regions, combined water and sewer costs now represent a major operating expense, often rivaling or exceeding treatment program costs. This economic pressure, combined with supply constraints, is a primary driver behind the increasing adoption of alternative water sources (AWS).

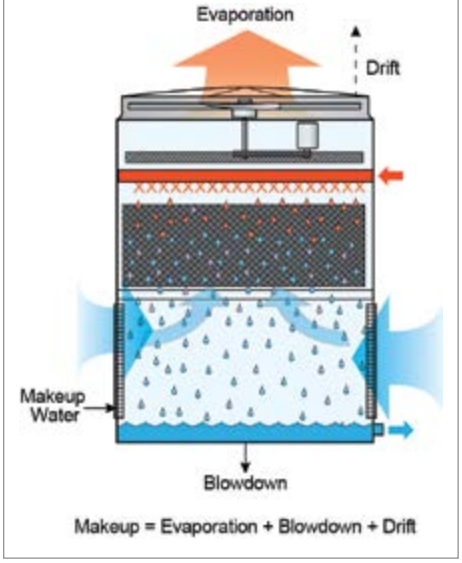
AWS is any non-traditional makeup water supply used in place of, or in addition to, potable or

municipal water. The specific source or sources used depends on site availability, water quality and quantity requirements and economic feasibility, typically requiring evaluation and treatment to ensure compatibility with system design, metallurgy and operating conditions.

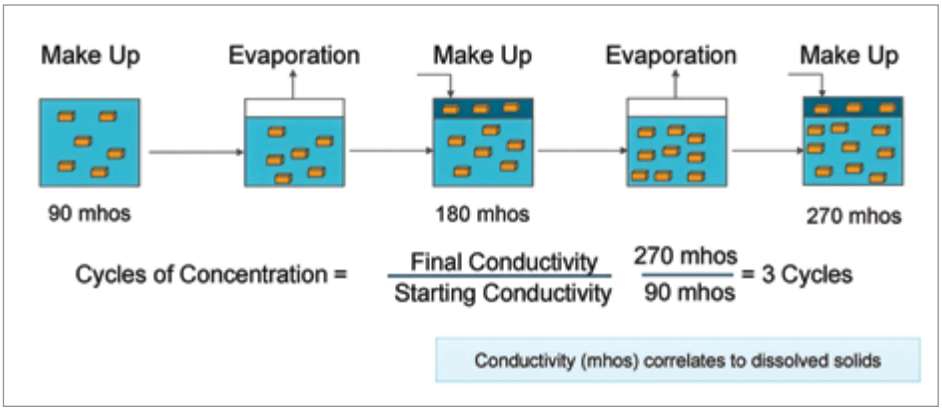
## Alternative Water Sources in Evaporative Cooling

The growing adoption of AWS to supplement or replace municipal makeup requirements in evaporative cooling is a direct response to the cost, availability and consumption challenges outlined previously. As water availability becomes less predictable, and as both water procurement and sewer discharge costs continue to rise, the economics of cooling system operations are shifting. Within this context, AWS is not just a sustainability initiative – it's a practical response to cost, availability and long-term operational resilience. However, each source must be evaluated not only for availability, but for how its chemistry behaves under concentration within cooling systems, and must be engineered deliberately.

**Reclaimed Municipal Wastewater.** Reclaimed municipal wastewater offers one of the most reliable AWS supply streams in terms of volume and availability. Its adoption is often driven by cost and access, particularly in regions where potable water is constrained or cost-prohibitive. However, this reliability in supply is offset by variability in composition. Elevated nutrients, dissolved solids and organic content introduce biological pressure, increased oxidant demand and tighter limits on achievable COC.




*Mass balance of water in an open cooling tower*




*An example of a cooling system operating at three cycles of concentration*

Its successful use depends on designing for these conditions – not assuming they can be corrected downstream. Successful reclaimed water integration typically requires filtration plus disinfection, with additional conditioning or desalting based on target cycles and discharge constraints.

**Harvested Rainwater and Stormwater.** Rainwater and stormwater are attractive from both a cost and sustainability perspective, particularly where capture infrastructure already exists or for facilities with large roof areas. It's often one of the most institutionally supported alternative water strategies, particularly where stormwater management requirements and potable water reduction mandates align.

However, their intermittent nature introduces both supply and quality variability. First-flush contamination, debris and atmospheric deposition can significantly impact water quality. Chemically, rainwater is typically low in hardness and total dissolved solids (TDS), which can support higher achievable COC. However, low mineral content does not eliminate operational risk. These sources can be corrosive and inconsistent without proper conditioning or chemical pretreatment. Roof runoff can introduce suspended solids, organic debris, trace metals from roofing materials and microbial contamination.

Seasonality is a primary design constraint. Rainfall patterns rarely align with peak evaporative demand. Storage systems must be engineered to prevent stagnation, starvation and sediment accumulation during low-turnover periods. As a result, rainwater is most reliable when treated as a supplemental or blended source rather than a sole supply. Additionally, the capital investment and floor space required to properly capture, store and treat harvested rainwater or stormwater can be significant.

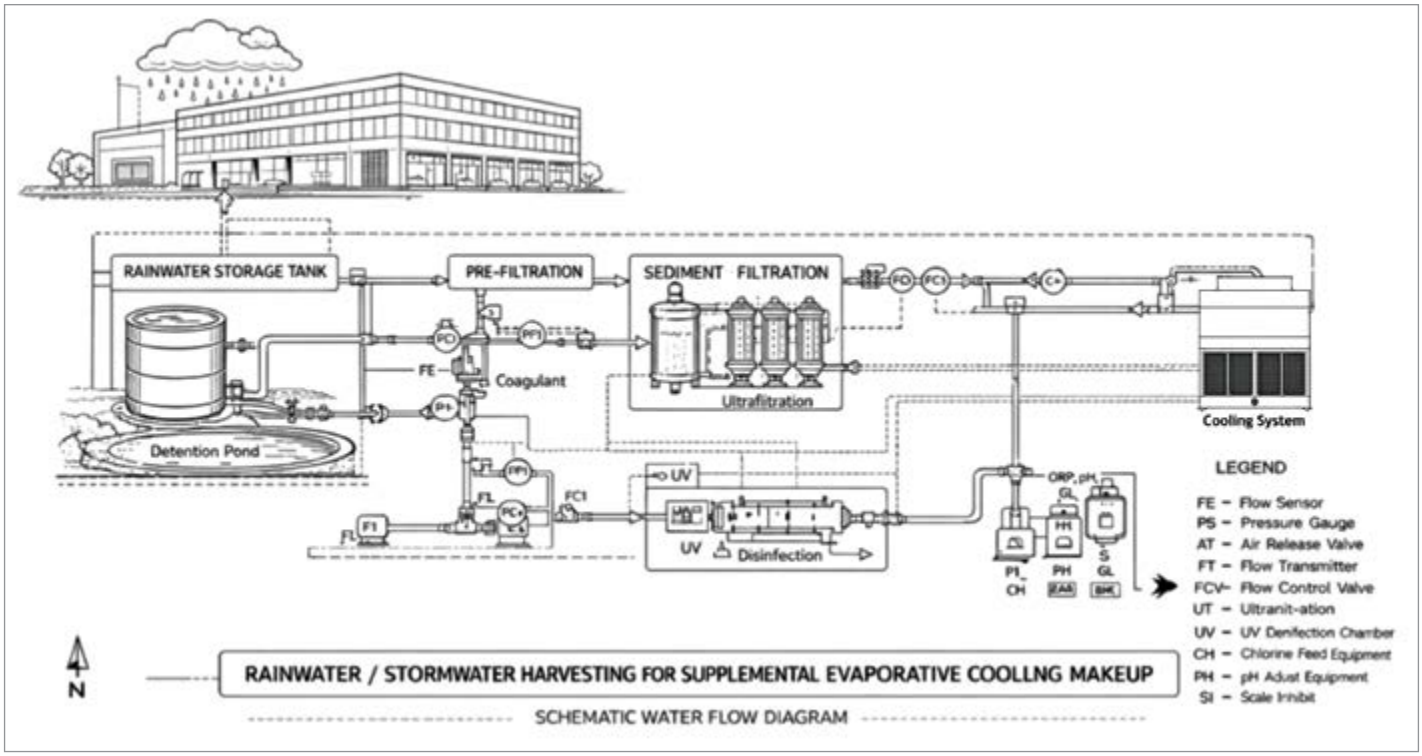
When integrated deliberately, rainwater harvesting can reduce potable water demand without introducing the nutrient variability associated with some reclaimed sources. Its role is often best suited as a supplemental source, supported by storage and equalization to manage variability.

**HVAC Condensate Capturing.** HVAC and process condensates are among the highest-quality AWS available. The low hardness and TDS concentration make condensate attractive as blending streams, reducing blowdown and improving system efficiency. Economically, they represent water that's already been paid for. However, the same low mineral content makes condensate chemically aggressive, requiring robust corrosion control. In cooling applications, condensate is most effective when blended with sources with higher TDS to reduce makeup conductivity and increase achievable COC.

Not all condensate is created equal. While HVAC cooling-coil condensate is typically low in hardness and only mildly acidic, condensate from combustion sources can contain acidic byproducts. These streams present a significantly higher corrosion risk. For this reason, combustion-derived condensate should never be reused without thorough evaluation.

**Graywater.** Graywater reuse can be attractive in facilities with high shower, laundry or process wash loads, particularly on campuses and in large commercial buildings. In practice, however, graywater is one of the most variable AWS options.

## Alternative Water Source Strategies for Evaporative Cooling Systems




*Basic water flow schematic illustrating supplemental rainwater and stormwater integration*

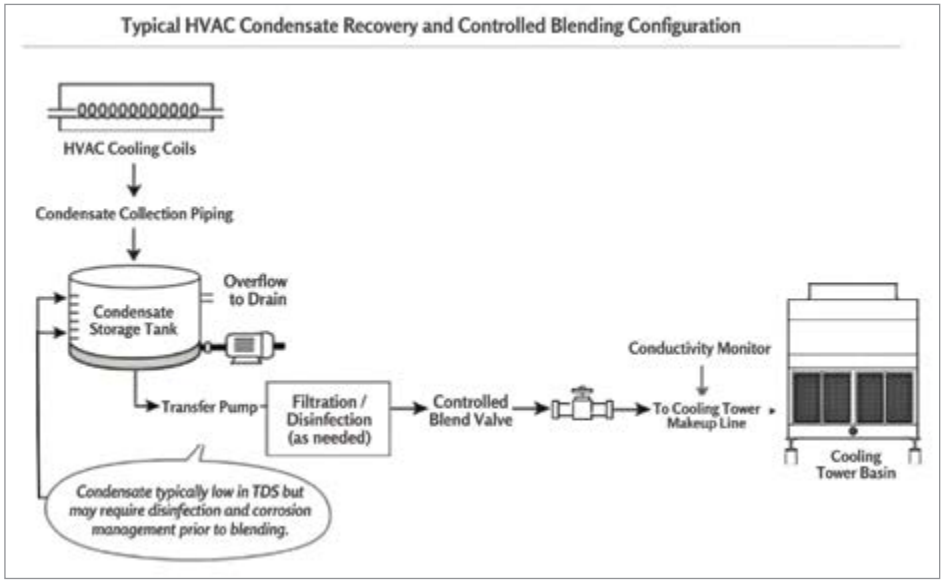
Surfactants, oils and biodegradable organics, combined with intermittent loading, create a highly dynamic water profile. In evaporative systems, this variability can accelerate foaming, fouling and biological growth, while also increasing oxidant demand and treatment complexity. As a result, graywater typically requires robust pretreatment and advanced filtration before it's stable enough for consistent, year-round use for cooling makeup.

While many graywater reuse projects are technically feasible, they're often operationally demanding. Facilities that succeed approach graywater as a managed process stream, not as a passive reuse opportunity.

**Process Wastewater and Internal Reuse.** Process wastewater and cooling system blowdown represent high-impact opportunities for freshwater demand reduction. However, these streams are inherently elevated in dissolved solids and may contain treatment residuals, metals and organic constituents. Absent appropriate conditions, reuse does not eliminate risk – it redistributes it, frequently manifesting as increased deposition potential, corrosion risk or fouling in downstream equipment.

Implementation of blowdown reuse typically necessitates advanced treatment to reliably control constituent levels and stabilize water chemistry. Advanced treatment of these water sources, such as reverse osmosis, is commonly applied. System design must carefully evaluate concentrate management, fouling and scaling potential, pretreatment water use and overall lifecycle costs.

**Brackish Groundwater and Desalination.** Brackish groundwater can be a stable supply in some regions, but high salinity, chlorides, sulfates and silica often cap achievable cycles quickly. Reverse osmosis can produce usable makeup water, but energy consumption, pretreatment needs and concentrate disposal must be evaluated as part of the total system design.




*A basic water flow schematic illustrating supplemental HVAC condensate capturing*

## The Common AWS Constraint: Variability

Across all AWS, the defining characteristic is not a specific contaminant – it's variability. Unlike traditional water supplies, AWS introduces continuous fluctuations in nutrient loading, biological activity, organic content and dissolved and suspended solids. These shifts directly influence fouling potential, microbiological growth and scaling and corrosion behavior within the cooling water system.

Engineering for variability requires a shift in mindset from static design to adaptive operation. Characterization must extend beyond single-point analyses to include ranges, frequencies and rates of change across key parameters. Treatment systems must be selected and sized not only for expected loads, but for peak conditions and transient events. Controls must move beyond fixed setpoints to responsive strategies that adjust based on real-time system feedback. Filtration, chemical feed and monitoring infrastructure must be integrated in a way that allows the system to absorb and respond to variability without destabilizing.

Ultimately, variability is not a secondary consideration in AWS – it's the defining constraint governing system performance. Systems acknowledging and designing around this constraint can operate reliably, even with high dynamic water sources or variable loading profiles. Systems that don't will be continuously reactive to symptoms rather than controlling the underlying process.

## Why AWS Projects Fail More Often than Expected

Most AWS projects fail because variability is acknowledged in theory but not fully accounted for in design and operation.

A common failure pattern includes:

- AWS is characterized by limited or average water quality data
- Treatment systems are sized for steady-state conditions and assumptions
- Control strategies rely on fixed setpoints rather than adaptive logic
- Upset conditions are considered infrequent rather than inherent

*This evaporative, closed-circuit fluid cooler is equipped with a factory-mounted solid water treatment system, designed to improve water management, reduce maintenance requirements and support reliable thermal performance.*

In reality, water quality is dynamic. Seasonal variation, intermittent contamination loading and changing oxidant demand introduce variability that must be anticipated and managed. When systems aren't designed to

## Alternative Water Source Strategies for Evaporative Cooling Systems

handle this variability, operators are forced into reactive control rather than stable operation.

Importantly, scaling, corrosion, microbiological growth and fouling are not inevitable outcomes of AWS use. These risks are manageable with a water treatment program properly designed for both the cooling system and the actual makeup water chemistry. However, as variability increases, so does the need for alignment between system design, control strategies and treatment approaches.

Another common misstep is treating AWS as something only to use when they happen to be available. In evaporative cooling, that approach is fundamentally flawed. These systems are continuous consumers of water, and any alternative source must be integrated with the expectation of a reliable, consistent supply, at whatever level of redundancy and assurance each facility or location requires. Intermittent use without a defined supply strategy introduces instability into both system operation and water chemistry control.

This ties directly into a broader issue: implementing AWS as a water treatment add-on rather than a system-level design consideration. Treatment may be addressed, but hydraulics, storage, filtration, drift control, instrumentation and operational practices remain unchanged. Without the necessary infrastructure – storage, capacity, blending strategies, backup supply integration and controls – systems only meet targets theoretically, but lack resilience under real-world operating conditions.

*Technicians inspect a critical process evaporative condenser at a cold storage facility, equipped with a factory-mounted solid water treatment system designed to provide streamlined water treatment control, improved system cleanliness and optimized equipment operation.*

The reality is straightforward: One plus one does not equal two. Without designing for consistent supply and the infrastructure to support it, AWS introduce variability faster than treatment programs can compensate for it.

### Return on Investment: Fit-for-Use and Economic Alignment

Not all AWS are appropriate for all systems. Successful implementation requires alignment between water quality, system design, treatment capability and economic objectives. While AWS can reduce potable water demand and lower water and sewer costs, it often introduces increased system complexity and higher treatment requirements. The value of any AWS strategy is determined by how well these factors are balanced. When properly aligned, AWS can improve both economic performance and system reliability. When they're not, they can introduce instability outweighing their intended benefits. AWS projects evaluated solely on first cost or short-term water savings often disappoint. A meaningful economic analysis includes capital cost, operating cost, avoided cost and sensitivity to water and price escalation. Just as important, it considers the cost of not having water when it's needed.

Fit-for-use is the technical foundation of this alignment. Cooling systems don't require clean water in an absolute sense. They require water that's predictable and controllable within the limits of the system's materials, hydraulics and treatment program. An alternative source that meets volume requirements but introduces wide swings in quality may satisfy supply objectives while undermining system stability. Conversely, a source that is more complex but consistent – when paired with appropriate pretreatment and control – can outperform a higher-quality but less reliable supply. The evaluation, therefore, is not absolute water quality; it's about compatibility with the system's ability to manage quality over time.

This is where economics moves beyond simple substitution. AWS doesn't replace one water cost with another. It reshapes the entire cost structure of the cooling system. Capital investment often increases, driven by storage, conveyance and pretreatment infrastructure such as filtration, softening or membrane systems. Instrumentation and controls also expand, as variability demands better monitoring and more responsive operation. These costs are often front-loaded and highly visible, which is why AWS can appear unfavorable in early-stage evaluations.

Operating costs, however, tell a more nuanced story. Chemical demand may increase due to higher oxidant demand or deposition potential, but this isn't universally true. Well-designed pretreatment can stabilize influent quality and reduce downstream variability, lowering total chemical consumption over time. Energy costs may rise due to pumping or treatment processes, but can be offset by improved COC or reduced blowdown if water chemistry is effectively controlled. Maintenance costs often increase in systems not designed for variability, but in systems that are, maintenance becomes more predictable and less reactive. The distinction is not the source itself – it's whether the system was engineered to handle it.

### Economic Planning with an Eye to Future Variability

Avoided costs are a critical and frequently underweighted component of AWS economics. Reductions in potable water purchase and sewer discharge are the most obvious, but they're only part of the picture. AWS can mitigate exposure to water restrictions, discharge limitations and future regulatory pressures. In regions where water pricing is escalating or becoming more volatile, AWS acts as a hedge against future cost uncertainty. It also reduces dependency on a single supply, which has both economic and operational value. These avoided costs don't always appear on a utility bill, but they materially affect long-term financial performance.

Lifecycle economics is where AWS decisions are won or lost. A system designed for 20 to 30 years of operation will experience changes in water pricing, discharge regulations and system demand that can't be captured in a simple payback calculation. Sensitivity analysis becomes essential: What happens if water costs double, if discharge limits tighten or if production increases? AWS strategies appearing marginal under current conditions often become favorable under realistic future scenarios. Conversely, systems relying on optimistic assumptions about

water quality, water stability or low operating costs can quickly become liabilities.

Equally important is the cost of unreliability. Cooling systems are not optional infrastructure; they're integral to process stability, production capacity and equipment life. An AWS system intermittently failing to meet demand, or introducing conditions driving deposition, corrosion, biological excursions or fouling, carries a cost that far exceeds water savings. Lost production, emergency maintenance, accelerated asset degradation and increased operator intervention all have measurable economic impact. In this context, resilience is not an abstract benefit, but a quantifiable component of lifecycle cost.

Ultimately, the success of an AWS program depends on designing and operating a system that can reliably manage water quality variability while aligning lifecycle costs with performance and risk tolerance from the outset. Fit-for-use ensures water can be managed within the system. Economic alignment ensures the system can be justified and sustained over its full lifecycle. When both are addressed together, AWS becomes more than a sustainability measure; it becomes a strategic asset enhancing operational stability, reducing long-term cost exposure and providing flexibility in an increasingly constrained water landscape. BP

### *About the Author*

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### *About EVAPCO*

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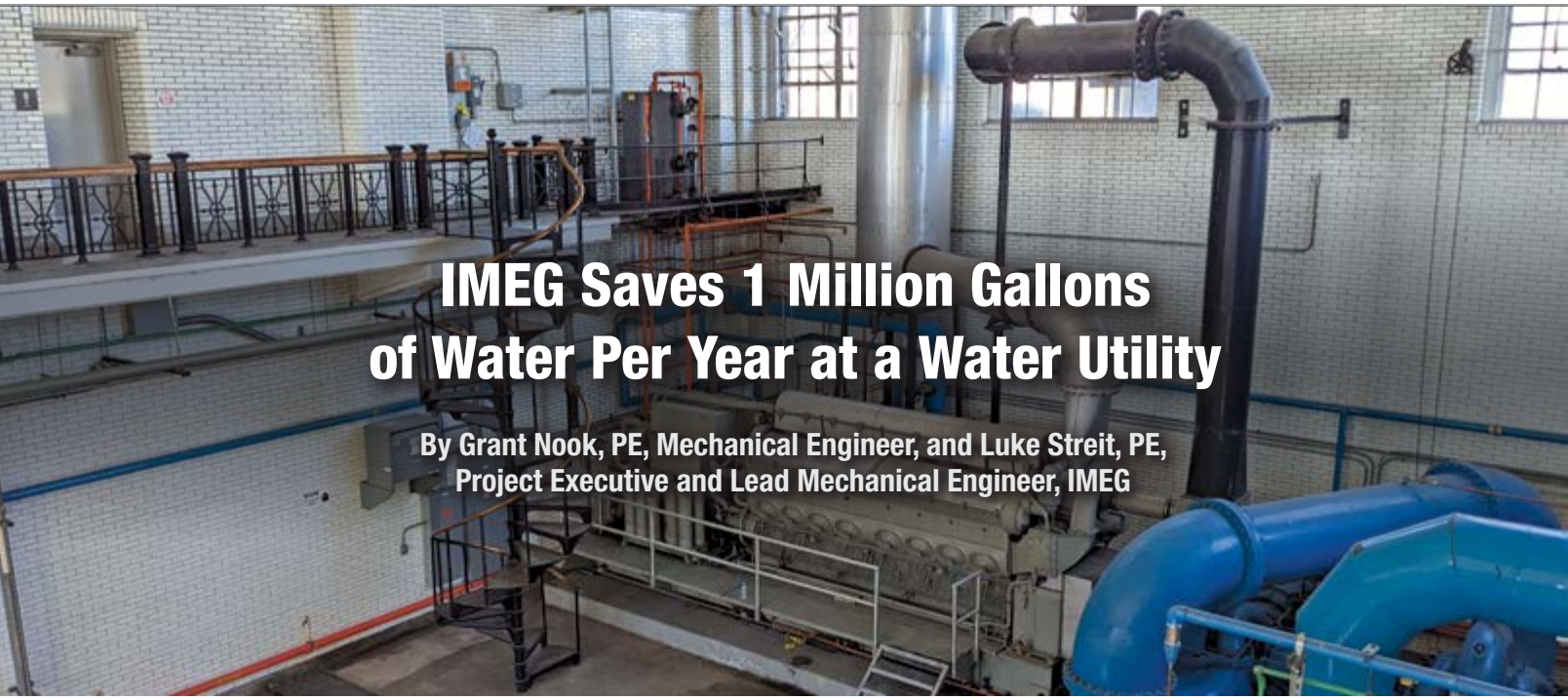

# IMEG Saves 1 Million Gallons of Water Per Year at a Water Utility

By Grant Nook, PE, Mechanical Engineer, and Luke Streit, PE, Project Executive and Lead Mechanical Engineer, IMEG

A pump station for a Midwest water production utility uses two large diesel engines to power critical operations. One of the engines drives a large high-lift pump to boost pressure in the distribution system during extreme hot weather periods when there's an increased demand for water in the community. The other engine is part of an emergency generator package backing up the pump station during power outages. It's also used for curtailment when called upon by the electric utility.

Both engines are located inside the pump station building and use finished water (water treated and prepared for domestic, potable use) for cooling in a once-through configuration: Warm water from the engine heat exchangers is discharged to a drain and eventually reprocessed at the water treatment plant. The water utility engaged IMEG to assist in developing options for both engines to reduce cooling water use and help avoid potential environmental risks associated with the current method.

The high-lift pump engine is rated at 1,864 kW (2,500 horsepower [hp]) and was installed around 1960. The engine produces nearly 4,000,000 BTUH of heat at full load and requires approximately 220 gpm of cooling water during operation. The generator engine, installed around 1990, has a 12-cylinder block and is rated at 3,810 kW (5,105 hp). The engine produces about 6,450,000 BTUH of heat at full load and uses about 425 gpm of cooling water during operation. Combined, the engines use approximately 1,000,000 gallons of potable water each year for cooling purposes. The temperature of the finished water was approximately 55°F (13°C). The implementation of the closed loop cooling system described here eliminates the need for nearly 1,000,000 gallons of water per year to cool the engine systems.

*Above: The high-lift diesel pump engine before construction began*

## The Engineering Design Process and System Selection

The original pump station building was constructed in the 1920s. The owner had copies of some of the original design drawings, but it was clear changes had been made over the years. The design team used a 3D scanner to capture features of the existing building and site around the pump station. The point clouds generated by scanning were used to develop a 3D model of the existing structure and utility systems for design coordination purposes.

As part of the design process, the design team evaluated several different options for engine cooling. Open cooling towers were briefly considered but quickly discarded. The presence of many cottonwood trees, potential wintertime

*A fluid cooler installation showing piping connections and the control panel*

operation, water use due to evaporation and blowdown, large footprint and weight, redundancy (or lack thereof), chemical treatment and maintenance requirements were all deterrents. While these systems would work, they would be a maintenance challenge to the staff and consume water through evaporation cooling, which we were trying to limit. Chillers, either water-cooled or air-cooled, would be relatively expensive to purchase and require substantial electrical infrastructure. The engine cooling systems are typically cooled with warmer water, which would not require a refrigerant compressor cooling system like a chiller. Radiators and fluid coolers with closed water loops appeared to be more viable options but would require glycol for freeze protection and piping system corrosion prevention. Both types of equipment could be selected with multiple fans, which would provide some level of redundancy; however, radiators would require a large footprint, which was at a premium at this site as explained in more detail in the later sections. Based on all of this analysis, a dry fluid cooler option was selected for further design analysis as it fit the project needs and requirements the best. Energy efficiency was considered but ultimately did not drive the decision for the selected system. The main decision points were maintenance, footprint, cost, redundancy and saving water.

Selections from two different fluid cooler manufacturers were requested for comparison. Criteria such as ability to turn down, quantity of fans, fluid pressure drop, materials of construction, footprint, height, weight, electrical power, cost, lead time and local representation were considered and evaluated. A spare fan, motor and controller were ordered with the final equipment selection for the owner to have on hand in case of an emergency.

Having a large quantity of fans was important as they provide a better level of turndown for when ambient temperatures aren't at peak design temperatures and redundancy if a fan were to fail. Due to the nature of our engine systems, our closed loop system needed to be flexible and adaptable to the heat load on the system from the engines. Having these options available at the fluid cooler equipment ensured our system would be able to adapt to changes in the environment.

Fluid pressure drop was also an important item to evaluate. Due to fluid coolers not having refrigerant compressors, the main way to save energy is by reducing pumping losses through the heat exchanger. Higher pressure drop likely means a smaller footprint and smaller tubes, but eats up pump energy and requires a higher electrical load on the system.

## Fluid Cooler Sizing and Location

Both fluid cooler systems were sized to operate at up to 105°F (41°C) ambient temperature, based on ASHRAE design conditions for the location and because the equipment would inherently be required to operate when the outdoor temperature is the hottest. The generator engine cooling loop was designed for 427 gpm, taking warm water from the engine heat circuit at 157°F (69°C) and pushing through the fluid cooler heat exchanger for a return/discharge water temperature of 122°F (50°C) – a 17°F (9°C) approach above ambient. The existing internal engine heat exchanger was bypassed (more about this later), and the cooling water was circulated directly through the entire engine circuit. The original connections to the potable water system were left in place (with lockable valves) as a backup option should the fluid cooler ever need maintenance when the generator was called to operate. The fluid cooler for the high-lift pump engine was designed with a new heat exchanger, creating independent loops for the engine-side and the fluid cooler-side. The fluid cooler loop was designed to provide 330 gpm of 120°F (49°C) cooling water to the heat exchanger and return 148°F (64°C) to the cooler. On the engine-side of the heat exchanger, 450 gpm of water was circulated with supply and return temperatures of 155°F and 175°F (68°C and 79°C), respectively.

## Cooling Water Pumps Selection and Location

The next step was selecting circulation pumps for the closed loops. Redundancy was desired; therefore, each system would require at least two pumps. Both independent pumps and pre-packaged pump skids were considered. Although a higher initial equipment cost, the packaged skid option resulted in a smaller footprint and simplified the installation of piping and controls. The final pump skid selection included three individual pumps with variable-frequency drives (VFDs), each sized for 50% of the required capacity. The onboard controller for the pump skids is capable of operating based

## IMEG Saves 1 Million Gallons of Water Per Year at a Water Utility

*A glycol fill station, expansion tanks and piping equipment in the basement*

on constant system differential pressure or flow rate, and can lead/lag/alternate pumps to equalize run time. It also calculates the most energy-efficient operation and adjusts individual pump speed on-the-fly.

Pump skids for both systems, along with air separators, expansion tanks and glycol fill stations, were placed in a basement area of the pump station building. Each of these systems was selected based on the fluid parameters, temperatures and volume we were using in each system.

### Fluid Cooler Piping and Controls

Piping for the fluid cooler systems was sized to limit pressure drop and conserve pumping energy: 4-inch steel piping was used for the high-lift pump engine, and 6-inch for the generator. The pipes were sized based on velocity, pressure drop and routing space availability. The piping for both systems was sized around 4.5-5.5 ft/s at their respective flow rates. Glycol also had to be accounted for, as it directly affects the density of the fluid. As described later on, the diesel pump system required the addition of a separate heat exchanger and required us to increase the flow rate to 330 gpm to reject heat adequately. This flow rate was determined on site by increasing the speed of the pumps and evaluating the flow capacity the pumps had with the current pipe routing, in order to provide the maximum amount of flow available for the new heat exchanger.

The fluid coolers and pump skids were supplied with factory controls. Flow meters and temperature and pressure sensors installed in the piping network provided signals to equipment controllers to modulate fluid cooler fans and pumps in order to maintain the needed loop water temperatures for each engine. Both engines have thermostatic valves with onboard controls modulating to a setpoint for the entering water temperature to the engine. This will reduce the load on fluid coolers when peak demand isn't required. Basic information and alarms from the fluid cooler systems were linked to the existing SCADA control system for the pump station so operators could monitor and react to any issues.

### Lessons Learned by the Engineering Team

In this story's introduction, we noted both diesel engines are relatively old, especially the high-lift pump engine. Therefore, knowledge of the existing systems and documentation from manufacturers and representatives was minimal and difficult to attain. Initially, it was assumed the existing high-lift pump engine-side shell-and-tube heat exchanger was adequate to remain, and engine water temperatures and flow rates were estimated for design. During initial system startup and commissioning, however, the engine water loop could not reject heat quickly enough, and the engine had to be shut down before it overheated. It was later determined the engine-side heat exchanger no longer had enough capacity due to the warmer water temperatures delivered from the fluid cooler (compared to potable water). Therefore, a new plate-and-frame heat exchanger was selected, ordered and installed. The original heat exchanger was removed. The next iteration of startup and commissioning proved to be successful.

For the generator engine, the original integral heat exchanger proved to be undersized with the different water temperatures, as well. To

*The diesel pump engine heat exchanger*

remedy the issue, IMEG worked with the local generator factory representative to develop a solution bypassing the heat exchanger and allowing fluid cooler water to flow directly through the engine circuit. In doing so, the glycol fluid had to be changed to meet the manufacturer's requirements, and additional system expansion volume was added. A second, separate glycol feed station had to be installed for the generator system.

Through the course of construction, the decision was made to install change-over piping for both engines to allow connection back to the finished water in case either fluid cooler was disabled. Since the pump station was considered critical infrastructure, this flexibility put operators and stakeholders at ease.

## Water Savings

The main driver for this project was reducing water usage for the two engine cooling systems. With the existing operation consuming nearly 1,000,000 gallons of water per year, IMEG had to evaluate which systems would adequately cool the engines without using as much water.

The water utility provided IMEG with estimated operating hours per year for each of these systems. This data showed the high-lift pump operated for two to four hours every month, as well as during emergencies. At 220 gpm of flow, this totaled 26,400-52,800 gallons per month, or 316,800–633,600 gallons per year to cool one engine. The data also showed the generator engine operated for approximately 12 hours per year, although this could be higher depending on emergencies. At 425 gpm, this was approximately 306,000 gallons per year.

The closed loop cooling system was selected because it didn't require a constant supply of water. Once the system is filled, no additional water is required during operation. Water is heated by the engine, then cooled by the fluid cooler before going back through the system. The closed loop cooling system uses glycol to provide freeze protection and chemical treatment, but reduces the requirement for a large amount of water, saving 1,000,000 gallons of potable water per year.

## Conclusion

Adding closed-loop cooling water systems to existing industrial equipment can reduce water use, minimize potential environmental risks and provide more reliable operation. However, careful research and planning are required to ensure correct system design, avoid installation delays and minimize system outages and disruption to services or products provided by the operation. BP

### *About the Authors*

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### *About IMEG*

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# Cleveland Thermal Modernizes Cooling Infrastructure for the Future

By Troy Dreier, Senior Editor, *Compressed Air & Cooling Best Practices Magazine*

For more than a century, a district energy system has powered some of the most important buildings in downtown Cleveland, OH. Today known as Corix Cleveland Thermal, the system provides steam and chilled water to approximately 90 buildings encompassing 20 million square feet of space. Its customers include government facilities, hotels, educational institutions, apartment buildings and convention facilities relying on the system for heating and cooling.

The district energy network traces its roots to 1894, when the original steam system was established. Chilled water service followed nearly a century later in 1993. Since acquiring the system in 2015, Corix has continued operating and investing in the infrastructure. Today, the company is preparing a major modernization effort focused on the chilled water plant, ensuring the system remains reliable and expandable for decades.

## Serving Downtown Cleveland with Steam and Chilled Water

Corix Cleveland Thermal serves a broad range of customers throughout downtown Cleveland. Major buildings connected to the system include Cleveland City Hall, Public Hall, Cleveland State University, the Hilton Cleveland Downtown, The 9 Hotel, the Huntington Convention Center of Cleveland, the Cuyahoga County Justice Center complex, the county administration building, the Drury Plaza Hotel, the Crowne Plaza and the downtown Cleveland Public Library.

Some customers receive steam, others receive chilled water and several receive both. Previously, the system included a second facility, but operations have since been consolidated into one plant capable of meeting the district's heating and cooling requirements.

On the cooling side, the plant's major assets include two 5,000 ton electric centrifugal chillers, a 2,000 ton steam-driven chiller and a 1,500-ton electric chiller. Together, these chillers provide the capacity needed to support cooling demands across the downtown network.

## Seasonal Chilled Water Operations

The chilled water system operates under two seasonal modes. During the winter season, which runs from November 1 through May 1, the system maintains chilled water temperatures between 39°F and 48°F (4°C and 9°C). Contractually, water temperatures must remain below 50°F (10°C). During the summer cooling season, from May 1 through October 1, temperature requirements become tighter. Operators maintain supply temperatures between 39°F and 42°F (4°C and 6°C) to meet customer obligations during peak cooling demand.

Weather conditions can complicate operations. Rapid swings between summer-like and fall-like temperatures are common, forcing operators to anticipate changing loads and adjust production accordingly.

The chilled water loop typically returns water from customers at roughly 50°F (10°C). The chillers then remove heat and return water to the distribution system at temperatures of 39°F to 42°F (4°C to 6°C). Typical system delta-T values range from 10°F to 12°F (6°C to 7°C) during peak summer conditions.

## Centrifugal Chillers and Cooling Towers

The cooling plant relies heavily on its two 5,000-ton electric centrifugal chillers. The evaporator side cools the district chilled water supplied to customers; the condenser side rejects heat to multiple large cooling towers. Two original induced-draft crossflow cooling towers using mechanically-driven fans with dual-speed operation are located on the plant roof, 80 feet

*Above: Corix Cleveland Thermal provides steam and chilled water to approximately 90 buildings in downtown Cleveland, OH, encompassing 20 million square feet of space.*

*Rapid temperature swings force operators to anticipate changing loads and adjust production accordingly.*

above street level. Each contains three cells and was field-erected. Unlike many conventional cooling towers using standard basins, these towers were constructed with suspended concrete basins.

"They were built strong," said Joel Bolanos, Operations Manager, Corix Cleveland Thermal. "The cooling tower system originally installed was meant to operate in the winter, as well."

A newer cooling tower located in a nearby parking area represents a significant modernization effort. This field-erected cooling tower contains four cells. Unlike the older cooling towers, the newer cooling tower uses direct-drive fans and variable-frequency drives.

"Now, we don't need to run the fans and all the cells at all times," Bolanos said. "We can control our leaving water temperature to a tight set point."

The newer design offers several advantages. Direct-drive reduces maintenance requirements by eliminating mechanical linkages and gear-driven components. Variable-frequency operation improves efficiency by matching fan output to actual cooling requirements rather than relying on simple high-low control.

The cooling tower system operates with a target leaving-water temperature of 75°F (24°C). Depending on ambient conditions and load, the towers achieve temperature reductions of 10°F to 15°F (6°C to 8°C).

## Winter Cooling and Condensate Recovery

One of the plant's most interesting operational strategies involves winter cooling and condensate recovery. Although some chillers were designed with free cooling capability, the system has not used that feature. Winter cooling loads occasionally exceed available free cooling capacity, and operators determined conventional chiller cycling offered greater reliability. Instead, operators closely monitor system temperatures and cycle chillers on and off as needed.

Typically, when distribution temperatures rise into the mid-40°F (7°C) range, operators start a chiller and reduce loop temperatures to 39°F (4°C) before shutting the machine down again. This approach conserves energy while protecting equipment.

Condensate recovery plays a role in the facility's water conservation strategy. Because the system operates both steam and chilled water systems, condensate generated by steam-driven equipment can be repurposed for cooling tower makeup.

"The bulk of our condensate return load comes from the steam-driven chilling," said Masen Sudduth, Plant Engineer. "We take all that condensate, collect it in a tank and basically have it set to a float switch."

The recovered condensate is clean and reduces dependence on municipal water supplies. "In the wintertime it can provide all of our cooling tower makeup," Bolanos said. "So much so that I have to redirect the water sometimes because I end up overfilling the cooling towers."

The utility estimates average chilled water plant water consumption at 1.36 million gallons per month. Makeup requirements account for less than 5% of system volume most days.

*The district energy system runs two three-cell induced-draft crossflow cooling towers located on the roof, and a newer four-cell cooling tower with direct-drive fans and variable-frequency drives in a parking area.*

The utility partners with ChemTreat to manage its treatment program. Each cooling loop receives a combination of corrosion inhibitors and biocides tailored to seasonal conditions. Sodium hypochlorite is the primary biocide, while corrosion inhibitor formulations vary depending on operating mode and system requirements. The cooling towers operate at four cycles of concentration. The use of recovered condensate helps maintain water quality because the condensate is cleaner than incoming municipal water.

## Cooling System Modernization and Future Growth

The next chapter will focus on replacing the two 5,000-ton chillers, which use refrigerants that are becoming difficult to support. The modernization project aims to reduce refrigerant risk, improve efficiency and enhance system flexibility.

Rather than replacing the existing units with identical chillers, engineers are evaluating multiple smaller chillers in the 2,500-ton range. This approach will allow them to better match cooling production with demand while increasing redundancy and flexibility.

"The main reason we're doing it is because our two largest pieces of equipment use R-22," Sudduth said. "That's been phased out. It can no longer be imported into the United States."

Planning and design work are already underway. Equipment selection has not yet been finalized, but future refrigerant choices will emphasize long-term sustainability and regulatory compliance. Equally important, the project will restore expansion capability lost through decades of modifications.

"We're trying to set it up to where we can grow and make it easier for people in the future," Bolanos said. "I want to make tomorrow easier." BP

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# OSHA-Compliant Air Guns: Safety, Performance and Industrial Cleaning

*By Troy Dreier, Senior Editor, Compressed Air Best Practices® Magazine*

➤ Among the simplest but most widely used compressed air tools are air guns used for industrial cleaning. Found in a wide range of manufacturing plants and facilities, air guns provide a fast and effective way to remove debris from equipment, conveyors, floors and production areas. Yet despite their simplicity, air guns present safety considerations many plant operators overlook.

The difference between OSHA-compliant and OSHA non-compliant air guns can have major implications for worker safety and corporate liability. Properly designed air guns, known as safety air guns, use nozzles engineered to limit hazardous output pressure while still delivering the thrust required for industrial cleaning. Facilities that understand OSHA requirements and train employees on proper air gun use will be better positioned to avoid injuries and reduce compliance risks.

## A Legacy of Air Gun Safety

The history of Guardair Corporation closely parallels the evolution of air gun safety in the United States. Founded in 1942 in Bridgeport, CT, the company manufactured air guns for industrial cleaning applications long before modern workplace safety regulations were established.

When OSHA was created in the 1970s, Guardair helped formulate regulations governing the use of compressed air for industrial cleaning. Concurrently, the company developed and patented what Tom Tremblay, President, Guardair, described as the industry's first safety air gun.

*Above: Safety air guns quickly and effectively clean metal chips and shavings off machined parts.*

Since then, the company has expanded through organic growth, acquisitions and ongoing product development. Today, the company manufactures a wide range of safety air guns designed for different industrial applications.

"We're proud of our engineering and product design capabilities," Tremblay said. "They represent a pretty significant portion of our total sales. If you look at our company today, we're the largest manufacturer of safety air guns in the U.S. and perhaps the world."

*Tom Tremblay, President, Guardair*

## Compressed Air Cleaning Applications

Air guns perform a critical role wherever production processes generate excess waste materials and debris that must be removed quickly and efficiently. According to Tremblay, air guns are commonly used to clean metal chips in metalworking facilities, deal with crumbs and flour in food processing plants, blow off sawdust and shavings in woodworking shops and clean vehicle interiors in transportation maintenance facilities, as well as for general cleanup in grain mills, pulp and paper operations, sawmills and lumber processing facilities.

In many of these applications, cleaning via traditional methods is either impractical or inefficient. Equipment may operate continuously, dirty surfaces may be difficult to access or sanitation requirements may limit the use of brushes and brooms.

"Using compressed air is an effective and efficient way to clean," Tremblay explained.

"It's especially useful where machinery needs cleaning but also needs to be in continuous operation."

Because applications vary dramatically, air guns have evolved into specialized tools designed for different cleaning requirements. Some generate low thrust and are meant for delicate, close-in bench-top work including electronic equipment or precision machinery. Others are designed to generate maximum thrust to move heavy debris. The company's air guns meet these varied needs, Tremblay said.

"We have high power, we have low power, we have air guns that are used for close-in work. We have air guns that are used for distant work. We have air guns which make a lot of noise. We also manufacture safety air guns with noise-silencing features where noise suppression is a concern."

## OSHA 1910.242(b) Requirements for Air Guns

The key OSHA regulation governing air gun use is OSHA Standard 1910.242(b), which addresses the use of compressed air for industrial cleaning purposes. This regulation focuses on a specific hazard associated with compressed air, namely output pressure. Industrial compressed air systems commonly operate between 80 and 120 psig (5.5 to 8.3 barg). While this pressure range is useful for cleaning applications, serious injury can result if compressed air were to enter the human body.

"OSHA Standard 1910.242(b) states the output pressure of an air gun must be limited to less than 30 pounds of pressure when the tip is blocked," Tremblay said.

The phrase "when the tip is blocked" is critical to understanding the standard. Some people incorrectly assume the plant compressed air system should be regulated down to less than 30 psig (2.1 barg). In reality, industrial air guns may use full plant air pressure during normal operation. However, when the output nozzle becomes blocked, OSHA has determined 30 psig (2.1 barg) represents the maximum safe pressure under these conditions.

"During operation, if an air gun nozzle tip is pressed against the surface of exposed skin, compressed air could enter the bloodstream through a scratch or cut," said Tremblay. "This could cause an air bubble or air embolism. Should it travel to your brain, it could be fatal."

As a result, OSHA-compliant safety air guns incorporate pressure-limiting features to ensure the output pressure when blocked remains below the 30 psig (2.1 barg) threshold.

## Air Gun Nozzle Engineering and OSHA Compliance

Modern OSHA-compliant safety air guns achieve compliance through specially engineered nozzle designs rather than reducing the pressure of the plant compressed air system. Manufacturers use nozzle designs allowing full cleaning performance during normal operation while limiting output pressure under blocked conditions.

One example is the venturi nozzle. Under normal operation, air exiting the nozzle creates a venturi effect that draws additional ambient air into the output stream, thereby increasing cleaning power. If the nozzle becomes blocked, air escapes through the side ports and limits the pressure below 30 psig (2.1 barg).

Another approach uses nozzle designs that physically prevent blockage at the outlet. Since the tip cannot be fully blocked, dangerous pressure conditions cannot develop. Other designs incorporate active mechanisms releasing excess pressure when blockage occurs. These engineering solutions allow operators to maintain cleaning effectiveness while meeting OSHA requirements.

## Understanding Air Gun Thrust vs. Pressure

Besides meeting OSHA-mandated dead-end compliance, one of the most important technical specifications in air gun selection is thrust developed by the air gun.

"Thrust is the ability to clean surfaces and move debris," Tremblay explained.

Air gun thrust is measured in pounds. High-thrust air guns move heavy materials and large pieces of debris. Lower-thrust models used in bench-top applications are appropriate for lighter cleaning tasks and delicate equipment. They typically use a ¼-inch airline, consume 6 cfm and generate 0.4 pounds of thrust. At the opposite end of the spectrum, heavy-duty industrial models use a ¾-inch airline, consume 185 cfm and generate up to 13 pounds of thrust.

Heavy-duty, high-thrust models are intended for construction sites or sawmills where operators must move significant amounts of heavy debris. The appropriate choice depends on the cleaning application.

"Use the right tool for the application," said Tremblay. "You don't need 13 pounds of thrust to clean a computer circuit board."

## OSHA Noise Exposure Standards

In addition to OSHA's compressed-air cleaning requirements, facilities must also consider OSHA Standard 1910.95, which addresses occupational noise exposure. Air guns can contribute to high workplace noise levels. High-thrust models often generate substantial noise, particularly when operating continuously. To address this issue, manufacturers offer silencer nozzles, reducing noise and maintaining OSHA compliance.

OSHA's noise regulations involve monitoring workplace exposure over extended periods and evaluating cumulative decibel levels throughout an employee's shift. Because air guns can contribute to total facility noise exposure, selecting quieter equipment is an important part of compliance efforts.

*This handheld vacuum gun is connected to a 5 gallon storage container for collecting debris such as metal chips, shavings, sand, powders or sawdust.*

When selecting air guns, plant operators should evaluate whether workers require hearing protection, if air guns are operating in close quarters or if nearby coworkers might be affected by cleaning activities.

## Common Air Gun Misuse and Abuse

Although OSHA-compliant air guns are designed with safety in mind, improper use can still create significant hazards, with horseplay being the most serious misuse issue. Workers occasionally misuse compressed air by directing it at co-workers, pressing nozzles against bare skin or misusing air guns in other dangerous ways. Compressed air can damage hearing, rupture

# OSHA-Compliant Air Guns: Safety, Performance and Industrial Cleaning

*Ergonomic air guns provide high-powered chip removal, along with operator comfort.*

eardrums or cause severe internal injuries if directed into body cavities.

Another common problem involves modifying air guns. Some workers remove nozzles or alter safety features to try to increase performance. Others tape over venturi ports because they mistakenly believe air is escaping through the openings. Venturi ports actually increase thrust and are an essential safety feature.

"Sometimes workers cover the venturi ports with duct tape thinking air is escaping," Tremblay said. "In fact, venturi ports draw in outside air to deliver more power. Covering these ports essentially turns the safety air gun into a non-compliant and potentially dangerous open pipe."

Another frequent misuse involves self-cleaning. At the end of a shift, workers often use compressed air to remove dust, chips or debris from clothing and skin. Environmental health and safety professionals discourage this practice because airborne particles can become embedded in the skin or enter the eyes.

## Homemade Air Guns and Their Hazards

Among the most concerning violations encountered during OSHA inspections are homemade air guns. These improvised devices often consist of little more than a pipe or tube connected to compressed air through a shutoff valve. Because they lack OSHA-compliant nozzle technology, they deliver full system pressure directly from the outlet.

"They're just an open pipe and are very dangerous," said Tremblay.

Homemade devices create two significant hazards. First, they exceed OSHA output pressure requirements. Second, if dropped while in use, they can violently whip and cause injuries. Commercially available safety air guns address these concerns through OSHA-compliant nozzles and spring-loaded trigger mechanisms that automatically shut off airflow when released.

## What OSHA Air Gun Audits Involve

Compliance audits involving air guns are straightforward. EHS personnel walk through the facility, workstation by workstation, and assess air gun condition and compliance. They look for non-compliant nozzles, modified or homemade air guns, missing safety features and damaged equipment.

The company offers an OSHA Compliance Kit designed to help users evaluate air gun compliance before OSHA inspections occur. The kit includes educational materials, a training video and a pressure-testing gauge. The gauge measures blocked-tip pressure from 0 to 100 psig (0 to 6.9 barg) with green markings indicating compliance below 30 psig (2.1 barg), while red markings indicate non-compliance.

"Pressing the gauge inlet against the tip of the air gun measures the output pressure," Tremblay said. "Compliant air guns will register less than 30 psig."

## OSHA Penalties for Air Gun Non-Compliance

Facilities operating non-compliant air guns may face OSHA warnings or financial penalties. According to Tremblay, fines commonly fall in the range of $8,000 to $10,000 per occurrence, although actual penalties vary based on circumstances.

Several factors can influence enforcement actions, including the number of violations, previous inspection history, severity of hazards, the presence of injuries and overall safety compliance.

"If an OSHA inspector discovers non-compliant air guns, we're talking an OSHA penalty of some sort," said Tremblay.

Repeated violations may receive increased scrutiny, particularly if inspectors identify broader safety management deficiencies. Facilities may also face deeper investigations if inspectors determine unsafe practices are widespread or the facility has a history of injuries.

## Selecting the Right Safety Air Gun

Choosing an OSHA-compliant safety air gun involves more than simply verifying regulatory compliance. Operators should begin by evaluating the cleaning application itself. Key selection factors include required thrust, debris type, cleaning distance, compressed air line size, ergonomics, noise levels, chip flyback protection, and OSHA compliance.

*Designed for quiet operation, this safety air gun is effective in noise-sensitive environments.*

Some applications require compact bench-top tools while others benefit from extended-reach designs. The company's Long John models, for example, are available in lengths ranging from 12 inches to 72 inches, with longer custom versions available.

Ergonomics also play an important role. Users can choose pistol-grip or thumb-actuated models depending on worker preference and workstation layout. Chip flyback protection helps prevent debris from being directed back toward operators. Silencer nozzles reduce occupational noise exposure.

Regardless of configuration, the nozzle remains the most important compliance component. Plant operators should verify any air gun they purchase incorporates technology designed to satisfy OSHA requirements.

## Conclusion: Air Gun Safety Education Remains Critical

Even the best-designed air gun cannot eliminate risks created by poor practices on the shop floor. Tremblay emphasizes the importance of training and education: Employees must understand why homemade or modified air guns are dangerous, why horseplay is prohibited and how OSHA standards apply to everyday cleaning activities.

Facilities combining OSHA-compliant safety air guns with ongoing safety education are more likely to maintain safe operations and avoid costly violations.

Properly engineered safety air guns demonstrate productivity and safety don't have to be competing priorities. By understanding OSHA requirements, selecting application-specific equipment and enforcing safe operating practices, users can achieve effective cleaning performance while protecting workers and maintaining compliance. BP

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BETTER PLANTS INSIGHTS

# Better Plants Energy Bootcamps Teach Practical Skills

By Alex Botts, Research Associate, Oak Ridge National Laboratory

From my experience, one of the biggest energy efficiency challenges facing industry today isn't technology; it's knowledge transfer and general system education. Don't get me wrong, new technology advancements will push industry forward, but the fundamentals are what keep facilities operating efficiently and reliably.

Almost every site I visit faces the same challenges: retirement of experienced personnel, smaller maintenance and engineering teams, staff turnover, limited interest from newer workers, increasing energy performance expectations and the general pressure to do more with less. In compressed air alone, I've seen facilities lose decades of system knowledge when a maintenance manager retires or an experienced operator moves on. To address this challenge, the Better Plants program developed an interactive training course focused on workforce development from the maintenance room to the boardroom. Thus, the Energy Bootcamp was born.

The Better Plants Energy Bootcamp is a hands-on, weeklong course covering major industrial energy systems. The course is taught by a team of world-class experts, each with developed expertise in various systems. Naturally, I teach the course and hands-on demo about compressed air. Don't worry, I make great jokes about being full of hot air and talk about the real-world scenarios I see at sites with pictures to back them up.

*At Better Plants Energy Bootcamps, participants learn system principles through hands-on demonstrations.*

## What Makes the Energy Bootcamp Different

What separates the Energy Bootcamp from many training programs is its emphasis on practical application. The bootcamp is designed for individuals new to energy management roles, junior staff or seasoned professionals who need a refresher on the fundamentals. Everyone walks away with a new nugget of information.

The bootcamp combines classroom lectures and hands-on system demonstrations. Each session starts with the basics and advances through engineering principles. For example, I start my session with, "This is a block diagram of a compressed air system," and by the end of the session participants can complete a detailed diagram for themselves.

Each major system has a supporting hands-on demonstration, during which we break into smaller groups to gather system data and illustrate key principles. My personal favorite is demonstrating the effect of pipe diameter on system pressure drop. We also showcase diagnostic equipment available for partners to borrow, including acoustic imagers, which are always a crowd favorite.

The bootcamp covers energy management fundamentals and major industrial systems including utility bill analysis, motors, compressed air, process heating, water systems, making a business case and much more. To date, we have held eight Energy Bootcamps, training 504 individuals with 91% saying they would recommend the training to a colleague or friend. While the curriculum spans many industrial systems, the most effective compressed air professionals I've worked with aren't just compressed air experts; they understand how compressed air fits into the broader manufacturing system.

## Upcoming Better Plants Energy Bootcamps

Fortunately, the Energy Bootcamp is not exclusive to the Better Plants program; anyone is able to join. The next Bootcamp will be held September 28 - October 1 at Oak Ridge National Laboratory in Knoxville, TN, with an optional day dedicated to touring the national laboratory on October 2. Professional development hours (PDHs) are available to those who may be interested. Registration is $215 and includes lunches and snacks. Don't forget to try our famous East Tennessee Banana Pudding. Registration and additional details can be found at: https://energybootcamp.ornl.gov. BP

*About the Author*

*Alex Botts, CEM, is a Research Associate at Oak Ridge National Laboratory, serving as a Technical Account Manager for the DOE's Better Plants Program. She supports industry partners with data analysis, Energy Treasure Hunts and software, guiding them to achieve energy savings and developing training programs.*

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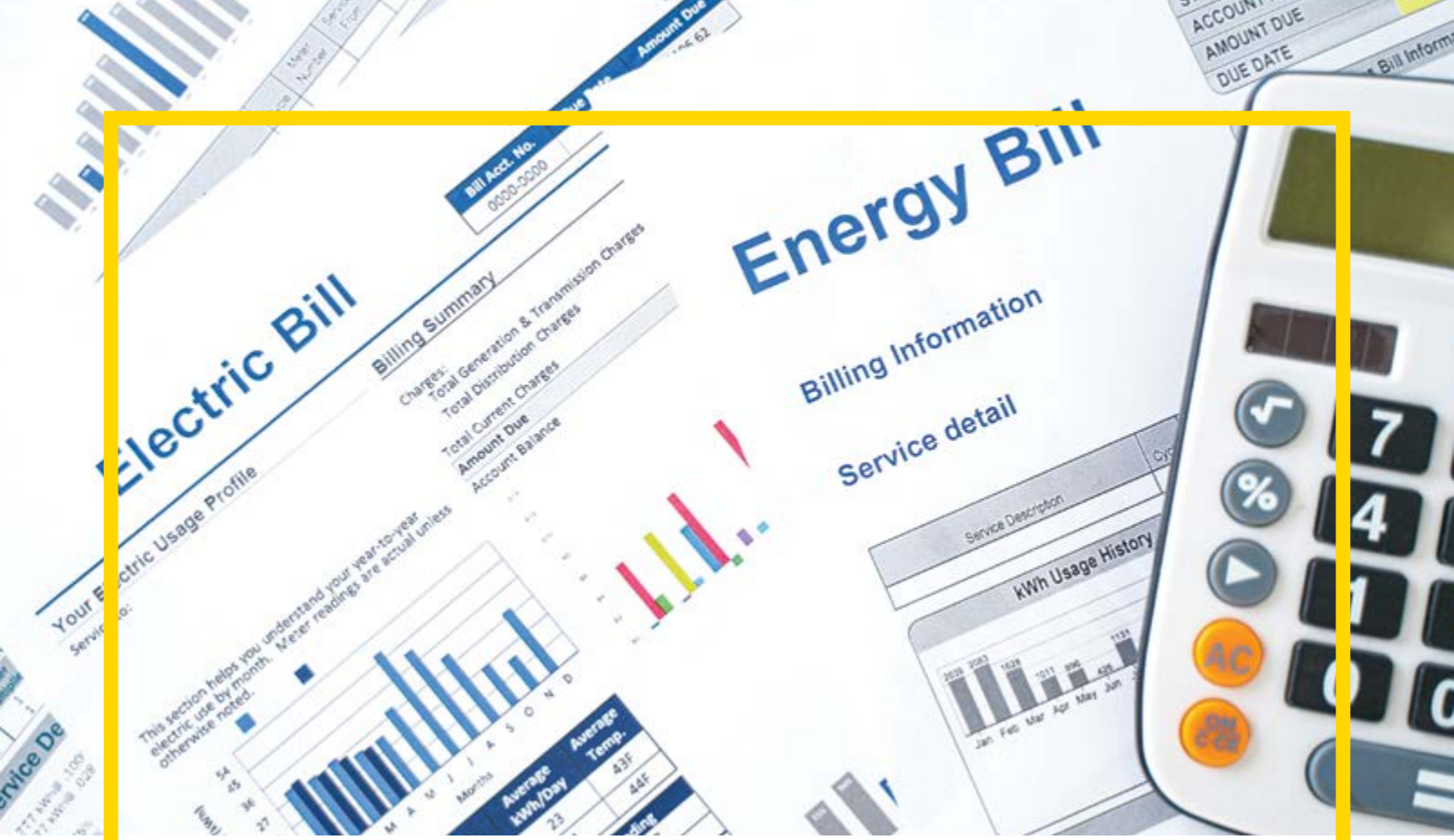


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