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## Food Packaging

October 2014

**18 Harris Equipment Helps Food Companies Attain SQF Certification**

**28 NIOSH and OSHA Grade D Standard Review for Supplied Air Respirators**

**32 High Speed Bearing Technologies for Wastewater Treatment Applications**

**12 NESTLÉ BEATS THE HEAT**





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# FROM THE EDITOR

## Food Packaging



The compressed air and blower industry adds value to customers by developing and then advising how to appropriately apply technology to their processes. This issue offers articles highlighting the solid work we know is being done every day in the field.

Energy conservation is the focus, in our lead article, at a Nestlé ice cream factory located in Tulare, California. Nestlé's Project Engineer, Tom Finn, shares the details of an innovative heat recovery project done, working with Lane Hawkinson from Rogers Machinery, on their four 125 horsepower Kobelco oil-free compressors.

SQF (Safe Quality Foods) Certification is recognized by food retailers and food service providers as a rigorous food safety management system. Phil Kruger from Chicago-based compressed air systems company, Harris Equipment, helps his clients create a SQF compliance plan. This involves defining compressed air quality requirements and testing procedures.

Many industrial plants use supplied air respirators (SAR) due to the presence of airborne contaminants in certain processes. Automotive assembly paint shops, sandblasting operations and confined space entry areas in refineries and steel mills are examples. Dan Whyman, from Air and Liquid Systems, provides us with an updated review of the OSHA Grade D compressed air quality and NIOSH respirator standards.

Our industry does not only advise on how to apply products — it also of course innovates and brings new technologies to the market. The Spencer Turbine Company has provided us with an interesting article titled, "High Speed Bearing Technologies for Wastewater Treatment Applications." The report compares the history, basic operation and construction of airfoil and magnetically levitated bearings used in aeration blowers. It also offers a discussion of the advantages and disadvantages of each bearing technology for the wastewater aeration industry.

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### ROD SMITH

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## INDUSTRY NEWS

### Ingersoll Rand to Acquire Cameron's Centrifugal Compressor Division

Ingersoll-Rand announced it has entered into an agreement to acquire the assets of Cameron International Corporation's Centrifugal Compression division for \$850 million. The acquisition is expected to close before the end of the year, subject to regulatory approval.

The division provides centrifugal compression equipment and aftermarket parts and services for global industrial applications, air separation, gas transmission and process gas. Cameron's Centrifugal Compression division generated sales of approximately \$400 million in 2013, has approximately 850 employees and operates from 12 global locations. Upon closing of the transaction, Ingersoll Rand will welcome the Turbo-Air® and MSG® brands into the Ingersoll Rand family of brands.

"Cameron's Centrifugal Compression division offers complementary product, manufacturing and engineering strengths as well as financial synergies that make it a natural fit into our core business and will provide meaningful value to our shareholders," said Michael W. Lamach, chairman and chief executive officer.

"This opportunity expands our Industrial Segment and will be immediately accretive to EPS, EBITDA margins and ROIC."

The acquisition will strengthen Ingersoll Rand's Compressed Air Systems and Services business, which provides a wide range of centrifugal, reciprocating and rotary air compressor products used in a variety of industrial and manufacturing applications. Cameron's Centrifugal Compression division will also expand Ingersoll Rand's compression offerings into areas such as air separation, petrochemical, chemical, and process gas.

"We are pleased at the prospect of our centrifugal air compressor division joining Ingersoll Rand's Compressed Air Systems and Services business to offer expansion into efficiency and flow offerings and enable customers to be better served," said Jack Moore, chairman and chief executive officer of Cameron International Corporation.

Ingersoll Rand plans to fund the acquisition through a combination of cash on hand and debt.

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"We are pleased at the prospect of our centrifugal air compressor division joining Ingersoll Rand's Compressed Air Systems and Services business."

— Jack Moore, CEO, Cameron International Corporation



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## INDUSTRY NEWS

**Atlas Copco Promotes Neil Breedlove**

Atlas Copco Compressors has appointed Neil Breedlove vice president, business line manager for its U.S. oil-free air division. “Neil brings over 28 years of experience in oil-free air, and has worked with many of the industries that require oil-free air for

critical processes, including oil and gas, power generation, steel fabrication, food and beverage, semiconductor, air separation and automotive,” said John Brookshire, president, Atlas Copco Compressors LLC. “His experience in all aspects of the business line will serve him as he works to grow the oil-free air business according to our short- and long-term business goals.”

In his new position, Breedlove will be responsible for continuing the development and growth of the company’s oil-free air business in the U.S. He will also be responsible for maintaining a strong sales and marketing team to develop and implement business development goals in accordance with the oil-free air division’s targets and objectives.

Breedlove was previously the manager of CTS Service Sales — Southern Region and served as the regional sales manager for both the industrial and oil-free air division. He began his career at Atlas Copco as a design assembly and test engineer within the oil-free engineering group and was part of the team responsible for the finished build-out of both the standard and customized oil-free Z series compressor.

Breedlove received his executive Master in Business Administration from Baylor University.

**Atlas Copco Compressors LLC** is part of the Compressor Technique Business Area, and its headquarters are located in Rock Hill, S.C. The company manufactures, markets, and services oil-free and oil-injected stationary air compressors, air treatment equipment, and air management systems, including local manufacturing of select products. Atlas Copco Compressors has major sales, manufacturing, production, and distribution facilities located in California, Illinois, Massachusetts, North Carolina, South Carolina, and Texas.

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**ABB Celebrates 125th Anniversary in Finland**

Predecessor company Strömberg was established in 1889. Today, ABB Finland is a global technology and production hub with more than 5,000 employees in 30 locations.

ABB is celebrating its 125th anniversary in Finland. Founded in 1889 in Helsinki by entrepreneur and inventor Gottfrid Strömberg, ABB Finland is today an innovative automation and power technology company with more than 5,000 employees in 30 locations, with sales of 2.3 billion euros in 2013.

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dynamic and successful country organizations and we continue to invest substantially in innovation and production facilities” said ABB Chief Executive Officer Ulrich Spiesshofer. “I would like to thank our colleagues in ABB Finland for their long standing excellent results and confirm our strong commitment to grow together in the future,” Spiesshofer added.

ABB Finland provides its customers solutions for power transmission and distribution, building technology, sustainable transportation, renewable power as well as industry automation and marine solutions.

ABB Finland has a very important global role within ABB, with several key technologies and businesses being led here.

These include the lead center for energy-efficient Low Voltage drives and the successful Azipod propulsion system for ships, which was invented by ABB Finland. Subsea transformers and grid automation are also further examples of Finnish innovation.

With more than 800 technologists and more than 190 million euros in investment annually, the company is one of ABB’s global research and development hubs and was the second largest research and development investor in Finland in 2013.

The ABB drives business, headquartered in Helsinki, makes a major global contribution to improve energy efficiency and lower environmental impact. In 2013, the energy

savings reached 310 terawatt hours, which is equivalent to the electricity needs of about 90 million households in the European Union.

ABB is a leader in power and automation technologies that enable utility and industry customers to improve their performance while lowering environmental impact. The ABB Group of companies operates in around 100 countries and employs about 145,000 people.

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# Nestlé Beats the Heat: Innovative Air-to-Water Heat Exchanger Recovers Heat from Air-Cooled Compressors

By Compressed Air Best  
Practices<sup>®</sup> Magazine



► When the topic of discussion is making ice cream, the first thing that comes to mind isn't heat, but at Nestlé's Ice Cream factory in Tulare, California, heat is recovered from air-cooled air compressors to heat process water.

Nestlé USA falls under the global umbrella of Nestlé S.A., the world's largest food company. The Tulare plant makes Nestlé, Dreyer's Grand and Häagen-Dazs ice cream products on eight

production lines and compressed air is used in a wide range of applications.

"Right out of the gate, everything is pneumatic," explains Tom Finn, Project Engineer with Nestlé Ice Cream Division. "Air cylinders and air driven motors, the process piping valves which divert, route, stop/start, and mix process fluids, our packaging machinery including rejection, cleaning and vapor removal processes, all

of these rely on compressed air. If we don't have compressed air, we're done. As a food processor we chose oil-free compressors with filtration and drying systems to ensure that our compressed air stream is free of moisture and particulate. What is required is clean dry air to prevent product contamination."

According to Finn, the Tulare plant has four 125-horsepower Kobelco KNW Series oil-



**"As a food processor we chose oil-free compressors with filtration and drying systems to ensure that our compressed air stream is free of moisture and particulate."**

— Tom Finn, Project Engineer, Nestlé Ice Cream Division



free air-cooled screw compressors. Two compressors are typically running 24/7. When demand rises and pressure drops, a third compressor comes on automatically. The fourth compressor allows Nestlé to rotate compressors in service and provide redundancy to ensure a continuous air supply even if one compressor is off-line for maintenance.

Air leaving each compressor passes through a moisture separator, then a regenerative-type dual tower dryer, and then to a dry air receiver tank that serves as a pressure buffer to help minimize compressor cycling. Clean, dry air exits the receiver into the piping network for use as part of the process throughout the plant.

On its own, Nestlé's compressors are fairly typical of oil-free systems used in food processing environments. What makes this compressed air system unusual, however, is its innovative method for recovering and reusing the heat of compression.

### Background

The story begins in the mid-1990s when Nestlé began a phased replacement of its existing oil-free reciprocating compressors, which were experiencing unacceptably high maintenance costs and down time.

"The recipe was old technology in a hot room, which was a bad combination," according to Lane Hawkinson, National Sales Manager Kobelco KNW Series Oil-Free Air

Compressors for Rogers Machinery Company, Inc., of Portland, Oregon. "Nestlé bought their first Kobelco in 1996, then a second in 1998, and two more in 2001. Each Kobelco rejects 11,500 cfm of air at 160 °F with high potential for heat recovery."

An initial cooling plan for the air compressors involved simply ducting the cooling air out the roof. That would dramatically reduce the heat load inside the utilities area, but Nestlé's global commitment to energy efficiency presented Finn with a challenge and an opportunity: instead of just rejecting all that heat, could it be put to work?

A common method to recover heat rejected from air-cooled compressors is to direct the

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## NESTLÉ BEATS THE HEAT



Heat coming off the air-cooled compressors is ducted through finned coils that transfer more than 350,000 BTUs per compressor per hour to preheat the plant's hot water makeup supply.

warmed air via ductwork to a large space, such as a warehouse or garage, to provide interior heating. The need for low quality heating like this is seasonal, however, and because the heating season in California's Central Valley is short, most of the time the heat still would be vented outdoors. Rather than settle for low quality heat used seasonally, Finn conceived of a system to recover BTUs rejected from the air-cooled compressors to heat water.

"Nestlé is highly tuned into resource conservation," Finn explains. "In Tulare we're already at the stage of the game where we've pulled the low hanging fruit, so we have to be more creative in finding ways to capture energy savings. With heat recovery from the compressors, I was looking at energy we can use year round, so I had to think about what we use year round in a food production facility. The answer was hot water. We have many hot water stations around the plant for washing, sanitary systems, waste systems and a lot more, and demand for hot water is ongoing."

### Concept

It's not unusual to recover heat from water-cooled compressors to produce hot water, but Nestlé's Kobelco compressors are air-cooled. What makes this heat recovery project unusual and innovative is the use of air-to-water heat exchangers.

"To capture energy for heating water, we needed a more specialized approach," Finn recalls. "I believed we could accomplish this by employing air-to-water heat exchangers. When I first discussed the idea, people said, 'You want to do *what*? How is that going to work?' It was one of those times when you



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As Finn explained to plant managers, heat rejected from each operating compressor, amounting to more than 350,000 BTUs per compressor per hour, would be scavenged in an 11,500 cfm air flow and fed via ductwork through a finned coil much like a car radiator. Water from the plant's hot water make-up supply would flow through the coil and pick up heat rejected by compressor. Water exiting the coil would be warmer than when it went in, so less natural gas would be required to raise the temperature of water for the plant's hot water applications. Each compressor would have its own heat exchanger and the heat recovery process would operate, in series, whenever a compressor was running.

Finn developed the make-up water recirculation system and a colleague designed

the air-to-water heat exchanger coils, but some additional system engineering was required. “We determined that the compressor's heat rejection fan, which pushes air across the compressor to cool it, was going to need help moving sufficient air through the coil to maintain the efficiency of the rejection system,” Finn explains. “Our solution was to add an assist fan downstream of each coil to pull the air through. We got in touch with Lane Hawkinson from Rogers Machinery and he and their engineering department helped us by providing some numbers regarding air flow and pressure drop. I estimated how much water runs through each heat exchanger and made adjustments to the flow rate until I reached an optimal setting. A variable frequency drive on the pump made this precise adjustment possible. It runs at 46 Hz to pick up maximum heat.”

Hawkinson points out that he has been involved with many heat recovery projects



One of four Kobelco KNW series oil-free screw compressors at Nestlé's ice cream factory. Note the air-to-water heat exchanger in the ductwork above.



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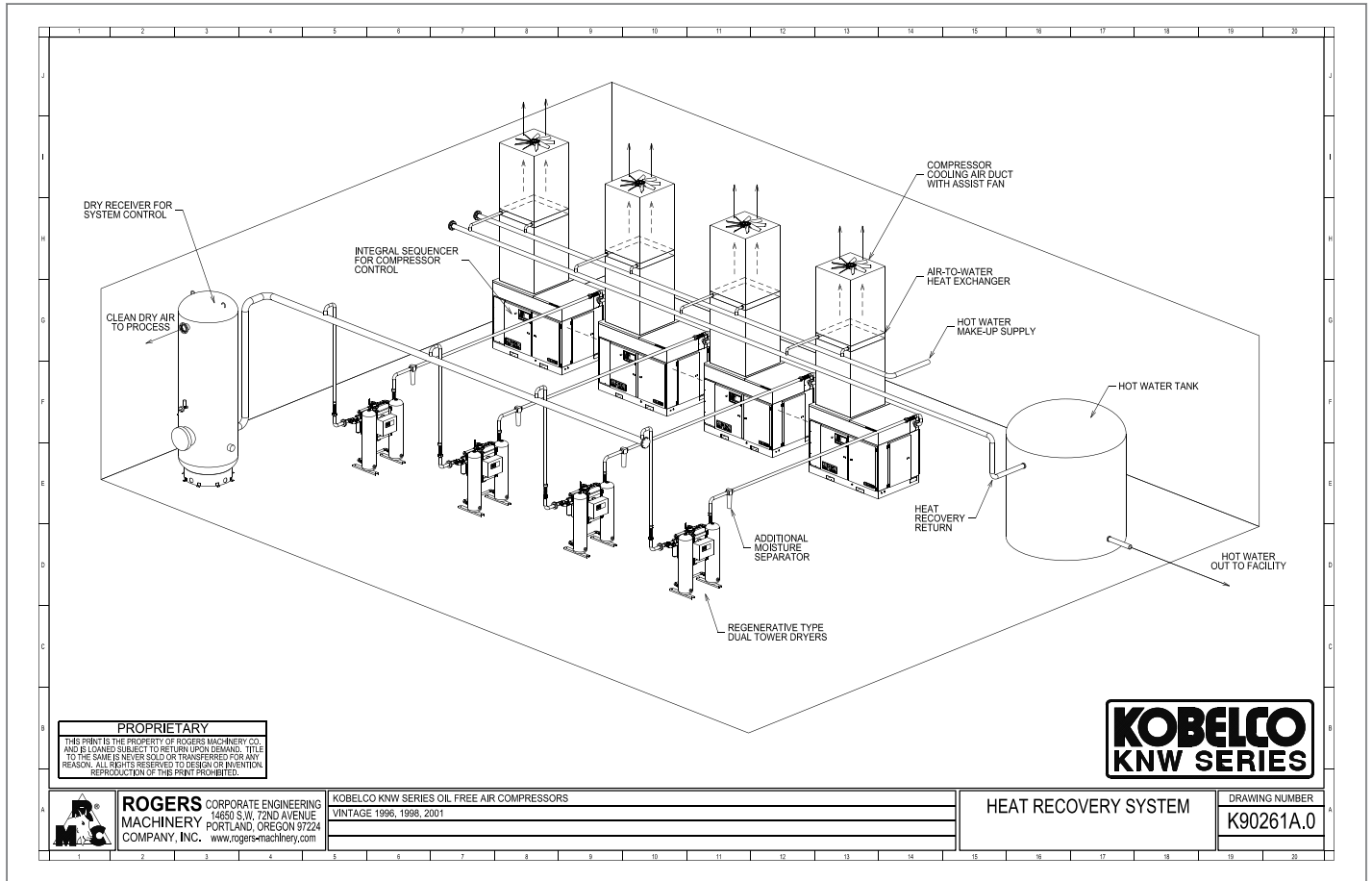
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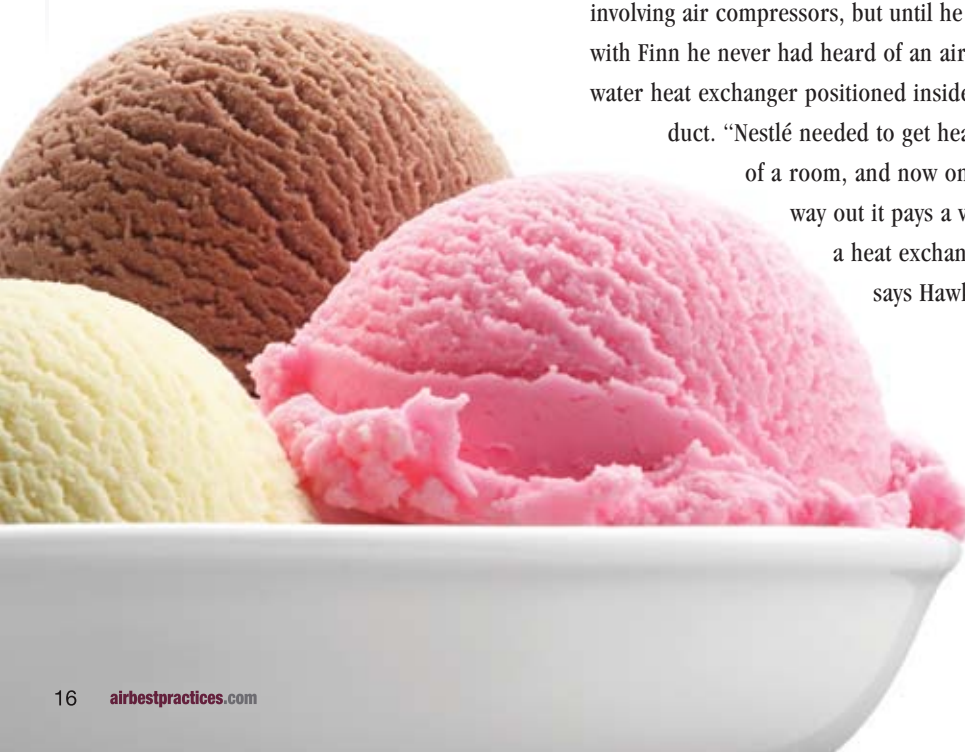
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## NESTLÉ BEATS THE HEAT



Compressed air and heat recovery system overview.



involving air compressors, but until he talked with Finn he never had heard of an air-to-water heat exchanger positioned inside a duct. “Nestlé needed to get heat out of a room, and now on the way out it pays a visit to a heat exchanger,” says Hawkinson.

“It’s a great idea that Tom Finn and Nestlé executed very well. Nestlé has been a customer since 1996 and the machines have been running trouble free for years. We are always glad to provide technical information to help maximize the efficiency of customer installations.”

Finn points out that actual heat gain varies, although on a June day when he checked the water temperature was 80 °F going into the heat exchangers and 107 °F coming out. “Our target for temperature gain was 20 degrees,” says Finn, “so anything we get above that is icing on the cake.”





**“Just because you have an older system, doesn’t mean you’ve missed the boat — It can be retrofitted.”**

— Lane Hawkinson, National Sales Manager, Rogers Machinery Company

### Takeaway

Finn calculates the total cost for the heat recovery system at \$150,000 including touchscreen controls for the pumps and diverter valves. The reduction in natural gas consumption because the intake water is preheated amounts to 309 therms per 24 hours. The project’s payback period was initially estimated at 3.8 years, but that turned out to be too conservative as payback occurred in just over 3 years.

Hawkinson points out that practically any existing installation of air-cooled compressors has the potential to benefit from heat recovery. “Just because you have an older system, doesn’t mean you’ve missed the boat,” he says. “It can be retrofitted. Every situation is unique and some solutions will be more complicated than others. The challenge of heat recovery is that sources and uses can be inconsistent. A lot of air-cooled compressors are installed outdoors where heat recovery is harder and makes less sense. But for air-cooled compressors installed indoors, heat recovery via simple ducting or more sophisticated means like Nestlé used are always an option and should be studied.”

Finn attributes his insight into energy savings to his previous work in ship building. “On a ship you have to use every watt,” he says. “I just started thinking that way and never

stopped. This heat recovery project was another application of that kind of thinking. Another project I’m looking at involves the heat recovery system’s assist fans, which are not variable frequency drive. Over time we have found that they don’t need to be running full speed all the time. We have plans to upgrade our evaporator fans with VFD motors elsewhere in the plant, and when we do we will upgrade the assist fans to VFD.”

One of Nestlé’s global goals is to become the most efficient energy user among the food manufacturers and this project is a good step on that journey. **BP**

For more information contact Lane Hawkinson, Rogers Machinery Company at email: [lane.hawkinson@rogers-machinery.com](mailto:lane.hawkinson@rogers-machinery.com) or visit [www.knw-series.com](http://www.knw-series.com)

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# HARRIS EQUIPMENT HELPS FOOD COMPANIES ATTAIN SQF CERTIFICATION

By Neal Lorenzi



► Phillip Kruger, general manager of Harris Equipment Corp., Melrose Park, Ill., is on a mission to help food processing companies achieve SQF (Safe Quality Foods) Certification when it comes to the proper use of compressed air systems. In fact, Harris Equipment acts as a consultant to these companies, helping clarify some of the vague details left out of the SQF directive.

“Basically, we help our clients identify the methods in which they can get approved by SQF,” Kruger says. “By establishing some sort of standards to the directives, we are able to help our clients create a plan that aligns itself with the SQF directives, which, quite frankly, are vague.”

A privately held company, Harris Equipment has been providing industrial service and sales

to the Chicago-area market since 1936. The company’s offerings include a wide range of air compressors.

## Compressed Air in Food Processing

Compressed air is used in a broad range of applications in the food processing industry such as mixing of ingredients, cutting, drying of product, transporting product through



“SQF is recognized by retailers and foodservice providers around the world who require a rigorous, credible food safety management system.”

— Food Marketing Institute (FMI)



processing systems and packaging of final product.

In many of these applications, compressed air comes in direct or indirect contact with food product and the impurities in the compressed air may contaminate the food product. This can result in change of color and taste, reduced shelf life and exposure to bacteria and other microorganisms, which can result in product recalls.

The SQF Food Safety Management System is designed to prevent such problems from occurring. "SQF is recognized by retailers and foodservice providers around the world who require a rigorous, credible food safety management system," the group states on its website. "Administered by the Food Marketing Institute (FMI), SQF benefits from continual retailer feedback about consumer concerns. These benefits are passed on to SQF-certified suppliers, keeping them a step ahead of their competitors."

SQF is a food safety management company that conducts audits and reports its findings on companies that voluntarily subscribe to its services. Once an audit is performed, SQF releases the data; from this data, other companies can determine who they want to use for packaging and manufacturing. To facilitate the process, SQF has released a guide that provides directives for processes used in manufacturing.

### Seeking Quantifiable Standards

However, when it comes to the use of compressed air, SQF does not offer quantifiable standards, says Kruger. "What is clean? What is monitored and how frequent is regularly? This is where Harris Equipment comes in. I've had clients who were tired of feeling pressure due to the ambiguous standards.



Gary Pollack and Phillip Kruger (left to right) of Harris Equipment.

An advertisement for aircOm PIPINGSYSTEM. The top half shows a close-up of blue pipes connected by black fittings. Below this, the text reads: "It's not a pipe dream.... It's a dream of a piping system!". The aircOm logo is prominently displayed. At the bottom, a blue banner contains the text: "QUICK | EASY | RELIABLE", "10-year warranty", "100% all aluminum system", and the website "www.aircom.us.com". On the right side of the banner, contact information for the Head Office and Warehouse, and West Coast Stores, is provided.

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## HARRIS EQUIPMENT HELPS FOOD COMPANIES ATTAIN SQF CERTIFICATION

“Typically a customer is asked to prepare for an SQF audit and has no idea where to begin. That’s when they call us. We start by asking them what it is they want us to help them accomplish. We then take an inventory of their current system and the application. From that stage, we are able to put together a profile and assign it an ISO Quality Class per ISO 8573-1.

“We then discuss the different ISO classes and what they mean. From there, the customer tells us what they would like their classification to be; we then detail out the proper equipment and installation to achieve the desired classification.”

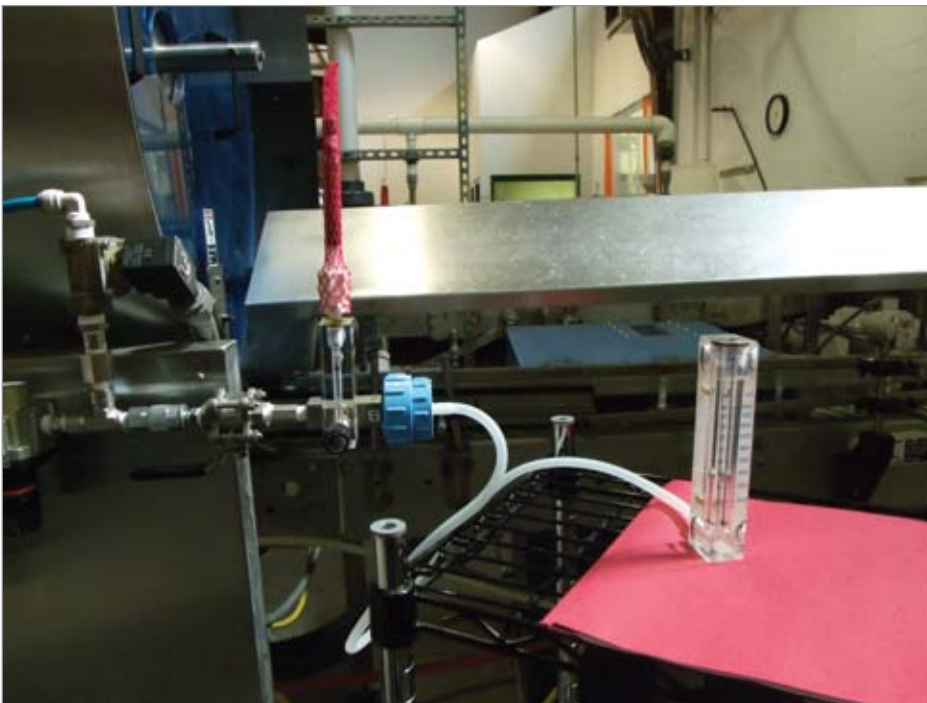
Harris Equipment recommends monitoring equipment and third-party testing and suggests equipment and tests that fit the customer’s

goals. “Some companies are looking for microbiological cultures while others are looking for standard moisture and particulate testing,” Kruger explains. “It is up to the customer and is based on what they want their system tested for. In addition, the customer determines the frequency of testing. I don’t know that what we are doing is the absolute, but it is a start and it helps clients who are facing the SQF challenge.”

Why is it important to help clients achieve an SQF approved status? It helps food processing companies secure additional business in a competitive market.

### Details of the Process

When working with food processing companies, Harris Equipment strives to teach them what can be done to achieve SQF



An air sample is captured before being sent to Trace Analytics for analysis.

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## HARRIS EQUIPMENT HELPS FOOD COMPANIES ATTAIN SQF CERTIFICATION



Jar washer using compressed air.

approved status. There are three major parts of the process:

1. Determine the quality of compressed air the company currently has
2. Determine the quality of compressed air the company wants
3. Plan the equipment selection, installation and implementation phase

“If they’re looking for a certain classification where a 30-degree dew point is acceptable, then we would quote the right piece of equipment. If they are looking for quality of air where a negative 40 dew point is to be their standard, then we would quote the right dryer,” Kruger says.

This all ties into the first SQF directive: compressed air shall be clean and present no danger. Harris Equipment makes sure that the right equipment is chosen, so that it does not create a dangerous environment.

“We look at equipment components such as the food-grade oil compressor and different stages of filtration, and make sure everything is installed correctly and can maximize the mechanical separation of water from air.” This is more of an investigative process: taking inventory, showing companies what they have, finding out what they want and determining what it will take to get them there.

The second part of the process involves regular monitoring. Part of this involves implementing a maintenance program — making sure that food-grade oil is changed according to schedule (it has a shorter life than other oils); making sure the filters are changed on time; making sure timer drains are working properly; making sure that dryers are cycling correctly.

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Harris also implements a remote dew point monitoring system, which ensures that no condensate, which can cause microbial growth, builds up throughout the plant. Kruger and his team initiate a hydrocarbon monitoring system (checking oil to make sure there are no high levels of hydrocarbons). The last part involves documentation — making sure the company documents the testing and monitoring of the process over time. “So what we do, basically, is put together a plan for these food processing companies. This plan helps them prepare for SQF auditing,” Kruger notes.

### Monitoring Equipment

BEKO Technologies Corp., Atlanta, manufactures monitoring equipment that is used by food processing companies, which can help them achieve SQF certification. “Typically, food companies are mandated to monitor their hydrocarbon carryover from the compressed air system because the compressed air could come in contact with the food product or packaging,” says Pam Tetterton, product/project manager. “In years past, this was done by taking a sample and sending it out to a local lab to have it analyzed. This process could take up to two weeks to determine whether a batch of products could be released or needed to be scrapped.”

To fill this need, BEKO Technologies has developed an inline hydrocarbon monitoring system (METPOINT OCV), which continuously monitors and documents the residual oil content of flowing compressed air. Even the smallest amounts of oil are detected, giving early notice of the possible contamination of pipe work and products. When critical points are reached in the system, the user is able to immediately react to deviations in a proactive manner.



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The BEKO METPOINT® BDL monitor and data logger is capable of accepting up to 12 sensors per unit (shown with a flow sensor attached).

“If the food processing company wants oil-free air, BEKO Technologies offers a hydrocarbon removal system (BEKOKAT),” Tetterton adds. “Unlike activated carbon towers that adsorb the vapors, this system cracks the molecular structure of the hydrocarbon chain, so you are left with  $H_2O$  &  $CO_2$ .” The end user can save money by purchasing an oil flooded compressor along with a BEKOKAT hydrocarbon removal system and the METPOINT OCV hydrocarbon monitoring unit.

### Laboratory Analysis

Trace Analytics LLC, Austin, Texas, an A2LA-accredited laboratory that specializes in the analysis of compressed air and gases, also provides equipment that is used in achieving SQF certification. The company offers the rental or purchase of compressed air sampling equipment. Its K8573 AirCheck Kits are based on ISO 8573 and are used in conjunction with Trace’s laboratory analyses for particle count and size beginning at 0.5 microns, water vapor, and total oil including oil aerosol and oil vapor, and optional gases.

“Some of our customers require particle sizing to the smallest range of 0.1 micron,” says Laura Gunn, marketing director. “For them, we offer the rental of a laser particle counter for immediate onsite results of all three particle size ranges specified in ISO 8573.

“Our impaction sampler is used for microbiological sampling. This method allows for reporting of colony forming units (CFUs) as low as zero and further identification if requested by the customer. We can arrange analyses by an A2LA-accredited laboratory or the samples can be analyzed by the customer’s preferred micro lab.”



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Available from BEKO Technologies, the METPOINT<sup>®</sup> OCV is capable of monitoring the presence hydrocarbons in compressed air.

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“Some of our customers require particle sizing to the smallest range of 0.1 micron. For them, we offer the rental of a laser particle counter for immediate onsite results of all three particle size ranges specified in ISO 8573.”

— Laura Gunn, Marketing Director, Trace Analytics

Trace Analytics encourages its customers to work with reputable distributors such as Harris Equipment. “Working with professional service companies is crucial to maintaining the quality of compressed air. Regular maintenance, proper filtration and using dryers appropriate for the application are all important to maintaining clean compressed air.”

### Conclusion

SQF is only a small part of the international food safety initiative, experts agree. It is just one of many organizations that work under the GFSI umbrella. The goal of all of these organizations is to ensure a safe food supply across the world. Determining how to apply those standards to the safe use of compressed air in food processing is still a work in progress — a goal that Harris Equipment is striving to achieve. **BP**

For more information please contact: Harris Equipment at <http://www.harrisequipment.com>, BEKO Technologies Corp. at <http://www.bekousa.com> and Trace Analytics LLC at <https://www.airchecklab.com>

### AUTHOR BIO

Neal Lorenzi is a freelance writer based in Mundelein, Ill. He has covered a wide range of industries during his 25 years as a writer and editor.

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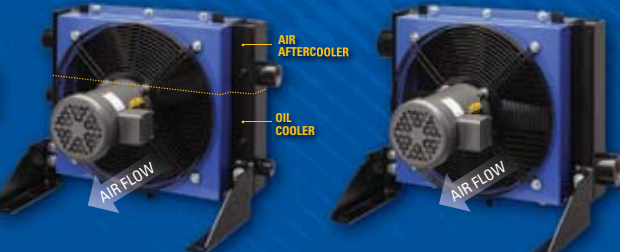
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# NIOSH and OSHA Grade D Standard Review for Supplied Air Respirators

By Dan Whyman, Compressed Air Division  
Manager, Air and Liquid Systems, Inc.

► Compressed air is the most common utility used in a typical industrial facility. It encompasses most operating aspects of the plant. The compressed air system can end up being the most expensive utility due to the focus that if production is running — then leave the system alone. Processes and machines are added and as long as the compressor can handle the increasing load — all is good. This brings us to our subject matter. The plant adds a process, a specialty coating line, requiring respirator protection. The plant determines supplied air respirators are the best choice. They want to be responsible and do the right thing so they start by reviewing what OSHA has to say on the subject.

This article is the report that could have been produced by the plant/facilities engineer, safety engineer and/or industrial hygienist. One of the least understood uses of compressed air is for breathing air. This report will cover the OSHA requirements for Grade D breathing air.

## Supplied Air Respirators Explained

Supplied air respirators (SAR) are used to reduce exposure to airborne contaminants present in many industries. Automotive assembly plant paint shops use respirators to control exposure to specialty coatings. Refineries and steel mills use SAR for confined space entry. Mobile sandblasting operations use SAR for worker

comfort and protection. The applications are many and cross over almost all manufacturing sectors.

Supplied air respirators are defined as an atmosphere-supplying respirator that supplies the respirator user with breathing air from a source independent of the ambient atmosphere.<sup>1</sup> Compressed air is commonly used as a source of air for SAR. This source can be low pressure, medium pressure or high pressure. We will limit our discussion to a medium pressure (75-125 PSIG) source from an air compressor.

## What OSHA Says

The Occupational Safety and Health Administration (OSHA) regulates the quality of compressed air used for SAR under OSHA 1910.134 Subpart (i).<sup>2</sup>

TABLE: OSHA 1910.134 COMPRESSED AIR QUALITY <sup>3</sup>	
Oxygen Content (v/v)	19.5 - 23.5%
Hydrocarbon (condensed)	5 mg/m <sup>3</sup>
Carbon Monoxide	10 PPM
Carbon Dioxide	1000 PPM
Lack of Noticeable Odor	
Moisture	Dewpoint 10 °F below ambient

The obvious objective of the standard is to provide a safe environment for the worker. Most users spend their efforts on the above chart but miss the other requirements within the standard. We will spend our remaining time on some of the more important issues.

### Air Compressor Intake Concerns

Subpart (i) of OSHA 1910.134<sup>4</sup> states that “the employer shall ensure that compressors used to supply breathing to respirators are constructed and situated so as to prevent entry of contaminated air into the air-supplying system”. This has everything to do with the air compressor intake location. The compressors in a large industrial facility are often located in a dedicated room or separate building nowhere near the actual SAR use. The safety engineer normally concentrates on the hazard and the facility engineer concentrates on getting the compressed air to the needed area. Typically, no one looks at the compressor intake location. You do not want the intake(s) near the ground where truck/vehicle exhaust has a high concentration. Intakes located on the roof should be checked for proximity to process exhaust stacks.

### Sorbent Beds and Filtration

Next on the list is suitable in-line compressed air purifying sorbent beds and filters.<sup>5</sup> Here it becomes more open to interpretation. We will dive head first into the technologies for compressed air filtration/purification that are commercially available in a future article. For now, let's review some basics on what this part can mean.

Compressed air by nature becomes saturated during the compression process. Any drop in the compressor discharge temperature causes condensation to occur in the pipe. The dew point must be at least 10 °F below the lowest ambient temperature to avoid condensation formation in the respirator. Remember to survey the entire piping system to determine if any piping is outside where temperatures are the lowest. Ice can actually form on some types of respirators (flooded hoods) if the compressed air is not properly dried. This subpart of the OSHA Standard allows some flexibility in selecting what is most appropriate for conditions in a specific workplace.



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*Supplied air respirator disconnect manifold meeting NIOSH requirements*

### High Temperature and CO Monitors

There are two generic types of air compressors that OSHA covers; oil-lubricated and oil-free compressors. Carbon monoxide (CO) can be the most harmful contaminant produced by an oil-lubricated compressor. Compressor fires produce lethal amounts of CO instantaneously. A compressor fire can occur from any number of equipment failures. They are rare but do occur. One case occurred when the compressor was started with no cooling water, causing an explosion from the superheated air and oil. The compressor had no high temperature cut-off and did not monitor water flow.

OSHA requires oil-lubricated compressors to have a high temperature and/or CO monitor. If only a high temperature alarm is used, the supply air must be tested at intervals sufficient to prevent CO in the breathing air from exceeding 10 PPM.<sup>6</sup> However, no one can predict when a catastrophic event, like a compressor fire or any high CO event will occur, making periodic CO testing meaningless.

In the same light, no one can predict when or if a rare high CO event will occur at



*CO monitor panel with oil and odor removal filters*

the intake of an oil-free compressor. The practical response to this portion, of the OSHA Standard, is to install a CO monitor on any compressed air system used for breathing air. Typically the CO monitor is installed near the worker(s) wearing the respirator(s). Most CO monitors will have an audible alarm set to trigger at the 10 PPM level. This audible alarm may or may not be adequate protection. The user must be able to hear the alarm while the respirator is in use. A remote alarm may be required for confined space and paint booths where the user is separated from the CO monitor by a wall.

### NIOSH Approval for SAR's

Respirators need to be approved by the National Institute of Occupational Safety and Health (NIOSH). NIOSH uses an extensive test protocol to test respirators. The respirator and related items gain a Test Certification Number (TC#) upon approval. Most respirator manufacturers will require that Grade D or better air be supplied to their respirators.

One of the most important items that most facilities are clueless about is incompatible disconnects. The respirator manufacturer will



## AIR RESPIRATORS

generally offer several different disconnect coupling manufacturers. The employer must ensure that the respirator user cannot connect to the standard plant air system or worse yet, to an asphyxiate such as nitrogen or oxygen.

### Compressed Air Testing

The frequency of compressed air quality testing is not specified. It is recommended to test on a regular basis for liability reasons. There are many third party testing labs dedicated to compressed air testing and even specializing in breathing air standards. Remember, testing only gives a sample at one point in time. Nothing will ensure worker safety more than a properly designed system from start to finish.

All maintenance items must be documented and stored in a designated area. OSHA 1910.134 also deals with respiratory selection, fit test program, maintenance, etc. — topics outside the scope of this article.

### Conclusion

The idea here is that a properly designed compressed air SAR system requires an integrated effort including multiple engineering/plant disciplines. Everyone from the powerhouse, plant engineering and safety must come together in the planning stages. The end result everyone wants is to protect the worker, from the hazard, with equipment meeting OSHA requirements in a properly designed system. <sup>BP</sup>

For more information contact Dan Whyman, Compressed Air Division Manager, Air and Liquid Systems, Inc., tel: 248-656-3610 Ext 405, email: [dwhyman@alsys.biz](mailto:dwhyman@alsys.biz), [www.alsys.biz](http://www.alsys.biz)

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#### ENDNOTES

1 OSHA 1910.134 Subpart (b)  
2 OSHA 1910.134 Subpart (i)

3 CGA 7.1 Table 1  
4 OSHA 1910.134 Subpart (i)(5)(iii)

5 OSHA 1910.134 Subpart (i)(7)  
6 NFPA CO Fact Sheet

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# High Speed Bearing Technologies for WASTEWATER TREATMENT APPLICATIONS

By Aleksandra Irving PE and Joseph Ibets PE, The Spencer Turbine Company

## ► Introduction

High speed bearing technology is applicable for aeration blowers operating at much higher speeds than the typical 60 Hz, 3600 RPM for cast multistage units. High Speed Turbo (HST) units are usually single stage (though some utilize multiple cores) and rotate from 15,000 to 50,000 RPM. At such high speeds, standard roller bearings cannot offer the industry standard L10 bearing life. Two types of bearing technologies have come to dominate the wastewater treatment market for these types of machines: airfoil and magnetically levitated. Often the two technologies are compared as equals, however, in many significant ways they are not. This paper explores history, basic operation, and construction of the airfoil and magnetic bearings. Furthermore, a discussion is offered on advantages and disadvantages of each technology for the wastewater aeration industry.



The Spencer Turbine Company's AyrJet® high-speed turbo blowers feature magnetic bearing technology.

## Brief History Of Technologies

### 1. Airfoil Bearings

Airfoil bearings originally substituted rolling element and journal bearings in high speed Air Cycle Machines which are at the heart of Environmental Control Systems on gas turbine powered aircraft. Other common applications include bleed air turbo compressors and turbo expanders. These applications typically have light loads and constant speeds. The image below shows the evolution of the airfoil bearings since the Multipad Foil Journal Bearing (Fig. 1a) was introduced in 1960's by Garrett AiResearch (now Allied Signal). Numerous companies such as Honeywell, Hamilton Standard, Mechanical Technology Inc (MTI), ABG-Semca, Sunstrand, British Aerospace, Tupolev and others, made improvements to the basic design. Current research efforts are focused on increased damping and load capacity, advanced anti-friction foil coatings, simplified manufacturing techniques, and improved stability under shock loads.

### 2. Magnetic Bearings

Passive magnetic levitation including patented systems dates back over a century. However, passive systems are inherently unstable. Today, active systems employing electromagnets, sophisticated controllers and algorithms are used almost exclusively. First investigations of active magnetic bearings began in the 1930s for use in ultracentrifuges, which assist in research in molecular biology, biochemistry, polymer science, etc. Today, magnetic bearings are a time-tested technology in the oil and gas industry, sub-sea applications, chillers, high-precision instrumentation, vacuum energy storage, etc. The image below shows a typical magnetic bearing stator. Early research was done at the University of Virginia, with the introduction of the magnetic bearing to the turbo machinery industry in 1988. Further development was done by Magnetic Bearing Inc. and improved upon by NOVA Gas Transmission Ltd. NOVA later created a separate magnetic bearing company - Revolve Technologies Inc. (now part of SKF of Sweden). Current research efforts are focused on improving simulation techniques, increasing stability,



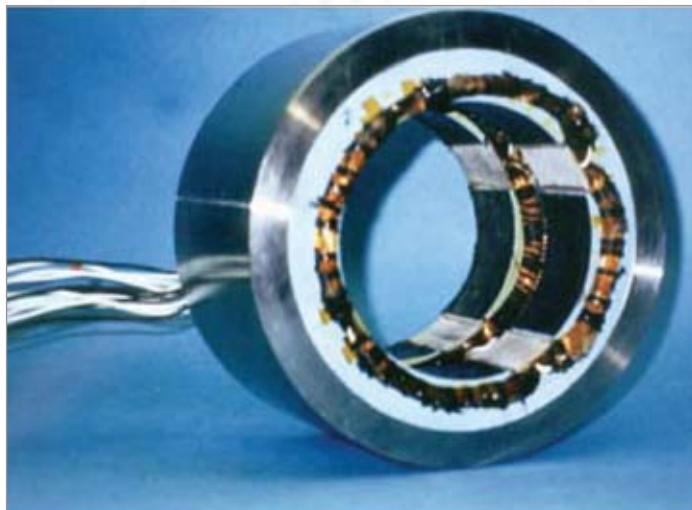


Fig 2 — Stator of a typical magnetic bearing

and even reducing reliance on feedback systems (such as the Halbach magnetic bearing).

## Principles of Operation

### 1. Airfoil Bearings

Airfoil bearings operate similarly to an oil bushing or a journal bearing, but with air as the working medium. Before start-up, a small amount of preload exists between the shaft and the bearing. Additionally, in machines with horizontal shaft orientation, the shaft rests against the bearing due to gravity. Consequently, some of the foils are in direct contact with the shaft while it is stationary. This contact results in friction as the shaft begins rotation relative to the foils before lift off.

The rotating assembly lifts off the bearing due to hydrodynamic pressure that is generated between the shaft and the bearing. In any fluid system (air, water, oil) the velocity of the fluid directly at the surface of a solid boundary will always be zero, even if the fluid stream is moving on a larger scale. Therefore the velocity of the fluid stream increases at some rate with distance from a solid boundary. This velocity difference means that some shear is applied to the fluid. The airfoil bearing takes advantage of this small scale shear to produce hydrodynamic pressure and levitate the shaft. After levitation the shaft becomes non-contacting at around 2,000 to 5,000 RPM. The image below shows an oil lubricated journal bearing operating on the same principle as the airfoil bearing.

To mitigate negative effects of the sliding friction during slow rotation at start up (such as heat generation and wear) solid lubrication is applied to the surfaces. Common types of coatings used as lubricants of the bearing surfaces are Teflon-S and Korolon (chromium oxide). Some

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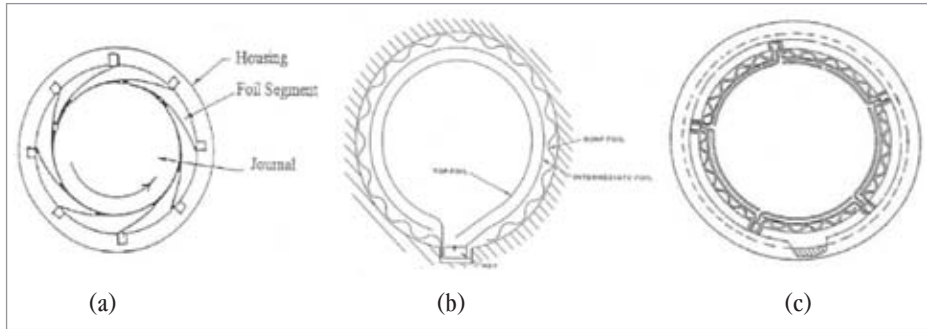


Fig 1 — Evolution of the airfoil bearing technology.

(a) Multipad Foil Bearing concept developed by Garrett AiResearch; (b) Reversed Multilayer Foil Journal Bearing concept developed by Hamilton Standard; (c) Reversed Multipad Foil Journal. Bearing concept developed by R&D Dynamics

military applications use a polyimide coating developed by NASA. Other coatings include aluminum oxide, titanium nitride, titanium carbide and various boron nitride mixtures. Though studies show excellent wear resistance

of the coatings, wear of the foil coating is not well tolerated by the bearing. Once solid lubricant is worn to the substrate, increased friction can cause galling and seizure of the machine. Any contaminants in the air stream

of the bearing such as dust or sand will cause accelerated wear.

### 2. Magnetic Bearings

Active magnetic bearing systems rely on dynamically actuated electromagnets for levitation. If compared directly to an oil journal or an airfoil bearing, the working medium of a magnetic bearing is electrical current as opposed to oil or air, and the shaft is supported by an active magnetic field as opposed to an oil film or air pressure. As the bearing is turned on, the electromagnets push the rotating assembly toward the center of the bearing. The system is called active because sensors that are part of the bearing detect the actual location of the center of the rotating assembly and pass the information

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to a Magnetic Bearing Controller (MBC). The controller decides if the power going to any of the magnets must be adjusted to achieve a more centered position and does so accordingly. A system schematic is shown in Fig 4.

Once the shaft is levitated, rotation can begin with essentially no friction. During normal operation the position of the shaft is monitored thousands of times per second and electromagnets are adjusted accordingly. The active adjustment allows for automatic corrections of small irregularities of the rotating assembly such as imbalances. While operating, a variety of performance characteristics can be monitored and recorded by sensors that are a natural part of the bearing assembly. This gives insight into the temperature, vibration, thrust loads, proximity to surge and system stability of the equipment. The data can be further statistically analyzed showing condition and health of the machine, operating trends, and any early warning signs for the system.

In the event of a power outage, it is standard industry practice to include fail-safe mechanisms as part of the design of the bearing. One such mechanism is a simple UPS that continues to supply power to the magnetic bearing system until shaft rotation has stopped. In wastewater

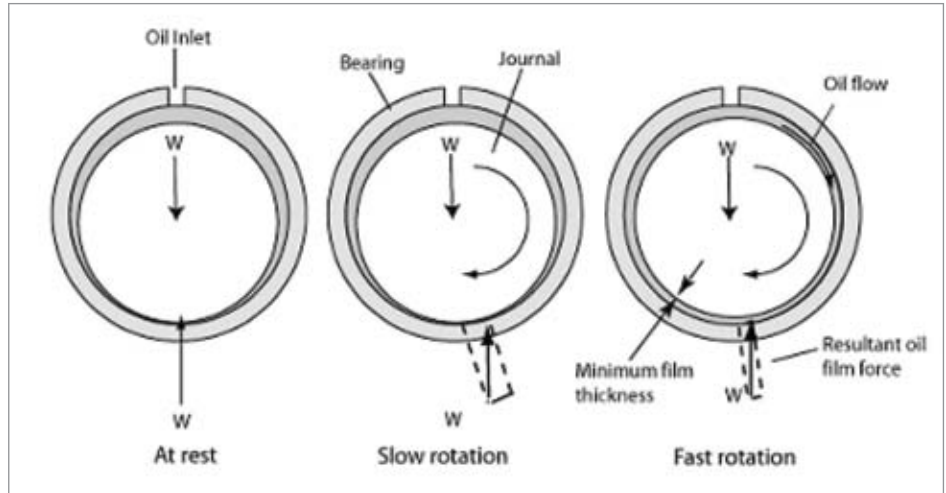


Fig 3 — Oil journal bearing operates on the same principles as the airfoil bearing.

treatment applications, shaft rotation will slow very rapidly due to the discharge backpressure, and will come to a stop within a few minutes at the most. Another method of bearing protection

does not require a UPS. At the time of the power outage, the motor is turned into a generator and the harvested power is then used to levitate the rotating assembly.

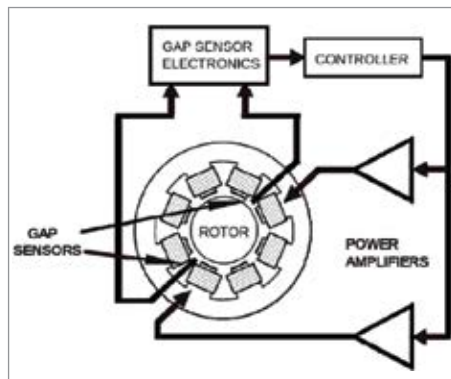


Fig 4 — Magnetic bearing schematic. Gap sensors detect position of the rotor and send the information to the controller. Controller adjusts the power to the electromagnets to re-center the rotor.

## Save Energy with FPZ Blowers

FPZ high performance regenerative blowers are capable of producing air flows over 1,200 cfm, vacuums to 17"Hg, and pressures over 12 psi. FPZ blowers are an efficient alternative to plant air and can provide significant electrical savings.



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Both protection methods are supplemented by one other protection system — the “back-up” bearing. In case of a UPS failure or other problem, the rotating assembly will land on an inner race of a roller bearing installed within the system. Under typical conditions, the rotating assembly does not make contact with the roller bearing because the roller bearing ID is slightly larger than the OD of the rotating shaft. Axial back-up bearings are also a standard component of the magnetic bearing and operate on the same principle.

### Discussion

Airfoil and magnetic bearings both offer a viable method of supporting high speed rotating assemblies for centrifugal compressors in wastewater treatment applications. However, given the great differences in features and price points, the choice is not always obvious. The simplest comparison is shown in Table 1. Key differences become obvious for airfoil and magnetic bearings respectively:

- Bearing control — passive vs. active
- Bearing health monitoring — passive vs. active
- Contacting — at start up and low speed vs. never
- Failure modes — fewer paths, but catastrophic vs. complex self-protecting system
- Cost — low vs. high

### Bearing control

Bearing control is completely passive for the airfoil bearings. Because there is no actuation or control loops, the stability of the bearing will depend solely on the design of the mechanical components and operating environment. Variability in viscosity, density, thermal conductivity and heat capacity of

the bearing operating gas will contribute to bearing stability and must be considered during machine design.

Magnetic bearing control is performed with the control loop of the controller. Position of the rotating assembly with respect to the center of the bearing is determined on the order of 10,000 times per second using the position sensors integral to the bearing. Position information is then passed to the MBC, which performs calculations and adjusts power sent to the electromagnets of the bearing. Stability of such closed loop systems is easily controlled. The ability to dynamically adjust bearing characteristics allows for a wide stability range, self-protective algorithms, and collection of data for health trending purposes.

For wastewater treatment applications, the advantages offered by the active control of magnetic bearings are significant. Aeration blowers must be designed to handle ambient conditions varying with seasonal changes, day-to-day variation and intraday diurnal cycle. Continuous self-monitoring by the magnetic bearings provides an assurance against catastrophic failure, and gives insight into overall health of this essential equipment.

### Bearing Health Monitoring

Only passive temperature monitoring is easily possible with airfoil bearings. Thermocouples can be installed as a specified extra in some cases onto the exterior of the stationary components in the bearing to monitor local temperature. In theory, in the case of localized heating problem on the bearing, if the problem is identified quickly enough, the machine may be turned off to protect itself. However, temperature monitors for the airfoil bearing are not common practice in the field as the response time of such devices must be fast enough to capture the near instantaneous temperature rise. No other health monitoring is available for the airfoil bearing.

Unfortunately, this leaves the machine vulnerable to catastrophic failure, as the condition of the shaft coating, imbalances, and center of rotation are not monitored.

Magnetic bearings have active control of the rotating assembly. The bearings continuously offer a detailed picture of the bearing condition. Shaft position can be related to vibration, dynamic imbalances, and internal diagnostics of the bearing. Temperature sensors detect overall condition of the bearing and the control circuitry. Additionally, the above data can be used to analyze system resonances, gyroscopic effects, and overall system stability. If a problem is detected, the machine will automatically shut down to protect itself from costly damage. Finally, the collected data can be retrieved via an internet connection anywhere in the world and analyzed further to see large scale trends, comparison to other machines, etc.

Aeration equipment is a significant investment for any wastewater treatment facility. The ability of the blower to detect any impending damage and to protect itself has the potential to save downtime, repair and replacement costs. Even if a blower fails during a warranty period, a lengthy shutdown can be a serious disruption for the plant operation. Having the capability to shut down the machine automatically before any damage occurs is a significant long term cost advantage for the plant owner and operator. Additional understanding can be gained from the data being collected by the machine. Maintenance staff for the plant can begin to analyze a machine fault without being on site.

### Contacting

Soft polymer coatings such as Teflon on the foils of an airfoil bearing will tend to wear at the contacting point with the journal at start, stop and low speed operation (typical liftoff speeds of 2000 to 5000 RPM). A better

# HIGH SPEED BEARING TECHNOLOGIES FOR WASTEWATER TREATMENT APPLICATIONS

performer is a hard solid lubricant applied on to the surface of the rotating journal. This eliminates localized wear and distributes it randomly over the circumference of the journal. Endurance tests on PS304 (Korolon) coating have shown the number of start/stop cycles at 5.0 PSI load and 352 °F to be in excess of 100,000. However, under room temperature conditions, the number of start/stop cycles is reduced by over 50%. Additional consideration must be given to the typical loads seen by the bearings in the wastewater industry. Of the radial and thrust airfoil bearings, thrust bearings are typically more vulnerable to high loads. To minimize loads and extend airfoil bearing life, blower designers will often use thrust balancing lines or employ a “double-ended” motor design in which mirrored blowers are assembled onto both ends of the motor. It should be noted that balancing lines will reduce the overall efficiency of the machine as it reroutes some of the process air to the bearing. Double-ended designs have a larger wetted surface area, and consequently have higher surface drag, compared with typical single stage machines.

Magnetic bearings do not experience contacting under normal operation and therefore do not have physical wear. Contacting is only possible if no power is provided to the bearing. This may happen during a power outage or internal component failure. Back-up systems are typically built-in to commercial magnetic bearings to prevent damage in either scenario. In case of a power loss, the rotating assembly will slow down within seconds and come to a full stop in less than 2 minutes due to the load provided by the back-pressure of an aeration system. For that duration the rotating assembly can be supported in two ways. One commonly used option is a UPS unit which provides power to levitate the bearings until full stop. In case of a UPS failure, the rotating assembly will land on a set of back-up roller bearings. Back-up roller bearings are specially designed to have an internal diameter slightly larger than the diameter of the rotating shaft.

During normal operation there is no contact between the rotating assembly and the roller bearings. Additionally, the roller bearings are designed and tested for multiple shaft

landings at full load and RPM. Another method of protection against power failure is using the inertia of the rotating assembly after a power loss as a power source for the bearing levitation. With this option, the back-up roller bearings are also employed.

Machines utilizing airfoil bearings are capable of many starts and stops; however, shaft coating will degrade with repeated cycles, ingestion of dust and other contaminants. Coating condition is not easily inspected. Further study may end speculation on the longevity of the airfoil bearing coatings in wastewater treatment applications. Until then, magnetic bearings offer a reliable, long-term solution for aeration blowers.

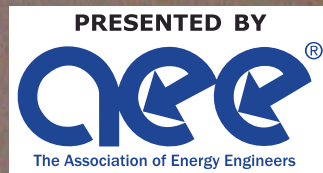
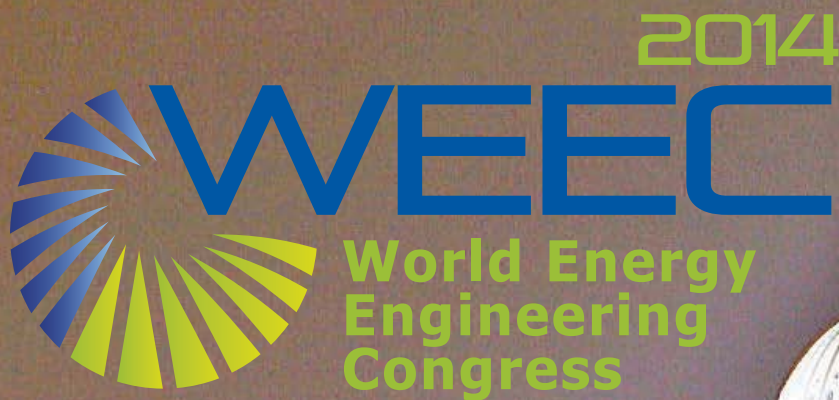
## Failure Modes

It has been demonstrated by the scientific community that many airfoil bearing failures occur as a result of a thermal run-away effect. Because the air bearings rely on viscous shearing of the operating fluid, some heat is generated as part of normal operation. If left unchecked, heat build-up can cause localized

TABLE 1 — SIMPLE COMPARISON OF OIL JOURNAL, AIRFOIL AND MAGNETIC BEARINGS

	OIL JOURNAL BEARINGS	AIR BEARING	MAGNETIC BEARING
Working medium	Oil	Air	Electric current
Shaft supported by	Oil film	Air pressure	Magnetic field
Medium delivered by	Oil pipes or sump	Ambient air source	Wires and cables
Bearing stability and characteristics defined by	Oil film stiffness	Air gap stability, foil stiffness and configuration	MBC algorithms
Bearing stability control	Passive	Passive	Active
Key support component	Oil pump	Shaft speed	Controller amplifier
Support component back up	None	None	Backup rolling element bearings and UPS battery back up
Bearing health monitoring	Passive temperature sensor	Passive temperature sensor	Active position sensors, multiple temperature sensors, remote monitoring
Contacting	At start up and low speed	At start up and low speed	Never
Inherent monitoring	None	None	Temperature, vibration, proximity to surge, system stability
Cost	Not applicable to wastewater industry	Low	High





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## HIGH SPEED BEARING TECHNOLOGIES FOR WASTEWATER TREATMENT APPLICATIONS

hot spots and uneven mechanical heating and may lead to bearing seizure. Failures of this type tend to occur rapidly with little to no warning. Amount of preload between the inner foils of the bearing and the shaft as well as bump foil designs will contribute to this condition. Careful consideration and simulation of these factors is required during machine design as they will affect overall machine longevity. Other failure causes include ambient environment. Ambient dust and salt water moisture can cause significant damage to the coatings on the shaft or foils and can even initiate a catastrophic failure. Typical designs try to limit particulate ingestion with reverse pitot cooling air intakes for the bearings. The working fluid in the radial bearings will not typically circulate and the positive pressure inside the bearing will naturally limit particulate ingestion. However, the thrust bearing tends to accelerate the working fluid radially and will naturally have some flow between the foil and the thrust flange. To eliminate the possibility of damage and extend life of the machine, the air supplied to the bearing must be properly filtered.

Magnetic bearings are much more complex compared to the airfoil bearings and, consequently, have more failure modes. However, the self-protection mechanisms virtually eliminate the possibility for a catastrophic failure. For most problems, the machine will shut down before a failure occurs. Dusty and moist environments do not affect the magnetic bearings as the clearances between the rotating and stationary components are generally large enough to accommodate some particulates. Furthermore, the performance of the bearing is not affected by the particulates in the air as the working medium is electric current.

Protection is offered against costly catastrophic failure by magnetic bearings; however, a simpler system such as the airfoil bearings offers fewer methods to fail. The choice of the bearing technology lies with the plant designer, owner and operator. It is important to consider effects of failure, time to repair or replace the equipment, cost of the event, and the reputation of the equipment provider before making this key decision.

### Cost

Cost is often the deciding factor in technology selection. The initial cost of blowers with airfoil bearings is typically significantly less than magnetic bearings. This is due to the complex system the magnetic bearings need for proper operation. However, direct comparison of the technologies shows that the two are **not equal**. The added cost of blowers equipped with magnetic bearings offers significant long term advantages over the life of the machine. Selecting airfoil bearings for blowers for your plant will offer a lower upfront cost, and fewer failure modes. However, should something go wrong during the typical expected 20 year life span, the possibility of a catastrophic failure and high repair and replacement costs can be expected to be much higher with the airfoil designs. Selecting the bearing technology for your application should take into account capital equipment cost, long term management and maintenance, and considerations for failure modes.

### Conclusions

Finally, we can easily point to the significant differences between magnetic and airfoil bearing technologies. Though both bearing types are acceptable for the wastewater

treatment industry, they are not equal and should not be compared as such. The simplicity and low cost of the airfoil bearings mean that comprehensive monitoring, active control, and self-protection of the blower is limited at best and in some cases not possible. However, the advantages of remote access to check status and health of the machine, data trending, multiple fail-safe mechanisms, and many other features come with a higher up-front cost with magnetic bearings.

In some cases airfoil bearings will be the preferred choice for a particular plant design. These may be designs with very low horsepower requirements, continuous operation (few start/stop cycles), and a clean air supply. However, it is possible that in most cases magnetic bearings will be the preferred technology due to long term advantages of the technology. **BP**

For more information contact The Spencer Turbine Company at [www.spencerturbine.com](http://www.spencerturbine.com)

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### Further Reading

"An Overview of Magnetic Bearing Technology for Gas Turbine Engines", D. Clark et al. NASA/TM-2001-213177

"Magnetic Bearings at Draper Laboratory", A.Kondoleon et al. NASA-CP-3336-Pt-1

"Performance and Durability of High Temperature Foil Air Bearings for Oil-Free Turbomachinery", C. DellaCorte, NASA/TM-2000-209187

"Remaining Technical Challenges and Future Plans for Oil-Free Turbomachinery" C. DellaCorte NASA/TM-2010216762

"Foil Bearing Starting Considerations and Requirements for Rotorcraft Engine Applications", K. Radli et al. ARL-TR-4873

### Figure Credits

Fig 1 a,b,c – "Foil Air/Gas Bearing Technology - An Overview" by Giri L. Agrawal, published by The American Society of Mechanical Engineers, Publication 97-GT-347

Fig 2 – <http://spinoff.nasa.gov/spinoff1996/images/114.jpg>

Fig 3 – [www.wikipedia.com](http://www.wikipedia.com)

Fig 4 – [www.wikipedia.com](http://www.wikipedia.com)



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# RESOURCES FOR ENERGY ENGINEERS

## TECHNOLOGY PICKS

### New Kaeser Secotec TF Refrigerated Air Dryers

Kaeser Compressors, Inc. is proud to announce their latest advancement in air treatment technology. The Secotec TF models push the boundaries of compressed air refrigerated dryer performance further than ever before thanks to a game-changing thermal storage system. Compared to previous designs, these models are more efficient, have lower pressure drop, and a reduced footprint.



The extremely efficient Secotec TF units handle flows up from 520 to 1060 cfm. Kaeser's innovative Secopack LS thermal storage system contains a phase-changing material (PCM) that is 98% denser than conventional storage media. Thermal energy is stored as the PCM cycles from a solid to a liquid state. This makes the Secotec TF units up to 60% lighter than other thermal storage dryers.

These dryers also include Sigma Control Smart, a micro-processor based controller which controls the thermal storage process. It has an alarm and service message memory, as well as remote on/off control capability. An optional Ethernet interface for connecting to a master control system is also available.

The dryers' internal design also makes it possible to reduce pressure loss across the dryer to 2.2 psi (compared to 2.9 and higher for conventional models). Air-cooled and water-cooled versions are available.

To learn more about the new Secotec TF dryers, visit [www.kaesernews.com/Secotec\\_TF](http://www.kaesernews.com/Secotec_TF). To be connected to your local representative for additional information, please call 877-586-2691.

#### About Kaeser

Kaeser is a leader in reliable, energy efficient compressed air equipment and system design. We offer a complete line of superior quality industrial air compressors as well as dryers, filters,

SmartPipe™, master controls, and other system accessories. Kaeser also offers blowers, vacuum pumps, and portable diesel screw compressors. Our national service network provides installation, rentals, maintenance, repair, and system audits. Kaeser is an ENERGY STAR Partner.

### Michell Oxygen Analyzer Receives Certifications

The Michell Instruments XTP601 Oxygen Analyzer has cCSA<sub>US</sub> certification making it approved for use in both hazardous and general purpose areas in the US and Canada. The instrument also carries ATEX and IEC Ex certification, broadening its global hazardous area coverage.

The XTP601 uses thermo-paramagnetic technology to make accurate and stable measurements of oxygen in background gases such as hydrogen, nitrogen, carbon dioxide and air as well as hydrocarbon gases. It is capable of measuring oxygen ranges from 0-1% up to 0-25%. Typical hazardous area applications include monitoring of inert or blanketing gases in refining, chemical and pharmaceutical industries. General purpose applications include inert gas generators and breathing air.

The analyzer, which is housed in a tough metal case, is available in three versions: a blind transmitter, a unit with status LEDs or a full-display unit. The full display version has a touch-screen interface which allows through-the-glass interaction eliminating the need to remove the analyzer cover to actuate its functions.

All versions are supplied with two 4-20mA outputs, two concentration alarms, Modbus RTU over RS485 protocol and application software as standard.

Visit [www.michell.com](http://www.michell.com)

#### About Michell Instruments

Michell Instruments Group is a worldwide leader in the field of moisture and humidity measurement solutions. With over four decades experience, Michell designs and manufactures a wide range of sensors, instruments and customized systems capable of measuring dew-point, humidity and oxygen in applications and industries as diverse as compressed air, power generation,



## TECHNOLOGY PICKS

petrochemical, oil and gas, food processing and pharmaceutical. Michell's innovative products make processes cheaper, cleaner, more energy efficient and safe.

The Group has multiple manufacturing locations with their international headquarters located in Ely, UK and a North America sales and service headquarters located in Rowley, MA. It has its own facilities in 10 countries with an extensive network of factory trained application and service engineers, subsidiaries and distributors stretching across 56 countries.



### New HOBOMeter® Plug Load Data Logger

According to the U.S. Department of Energy, plug loads — or energy used by equipment plugged into an outlet — can account for up to 50% of a building's total electrical load. While minimizing plug loads can be an effective energy reduction strategy in buildings, it is often difficult for energy auditors and building management professionals to determine how much energy individual pieces of equipment such as computers, monitors, printers and other devices consume. This, in turn, makes it difficult to prove out the return-on-investment for energy management and control strategies, or even educate building occupants on the impact of equipment shut-down best practices.

To help solve these issues, Onset, a world leader in data loggers, has announced the HOBOMeter Plug Load Logger, a high-accuracy, easy-to-deploy data logger that measures and records the power and energy

consumption of 120V plug loads from office equipment, vending machines, and other devices.

Capitalizing on the HOBOMeter reputation for reliability, the logger offers a number of key advantages:

- 0.5% measurement accuracy enables more reliable plug load energy use data
- “Meter Mode” provides instant viewing of real-time plug load variables
- Large memory enables faster logging intervals for more comprehensive plug load profiles
- Battery backup ensures logged data remains intact in the event of a power outage or load failure
- Full-featured LCD display provides visual diagnostics for easy deployment
- Accompanying HOBOMeterware® software for graphing and analyzing plug load data

“As plug load analysis has become a more integral part of identifying savings opportunities in commercial office spaces, the need for a plug load monitoring tool of professional grade that can provide accurate, reliable data to the energy auditing professional is very strong,” said Herman Gustafson, Onset product marketing manager. “The HOBOMeter Plug Load Logger meets this need head on, and will help energy professionals determine opportunities for energy savings on plug loads and confirm these savings once plug load controls are implemented.”

### Reliable, Accurate Performance

The HOBOMeter Plug Load Logger provides 0.5% measurement accuracy with a measurement resolution of 1 watt, making it an ideal choice for building audits where detailed energy use data is required. The logger can measure up to six parameters — True RMS Voltage, True RMS Current, Watts, Watt-hours/Kilowatt-hours, Apparent Power, and Power Factor — to provide a comprehensive plug load profile. And its rugged housing is designed to withstand the rigors of real-world handling, providing reliable performance despite bumps, drops, and use under desks.

## RESOURCES FOR ENERGY ENGINEERS

### TECHNOLOGY PICKS



#### Fast, Easy Deployment

The HOBOnet Plug Load Logger streamlines energy auditing applications in a number of ways. For example, it features an easy-to-view LCD that visually confirms logger operation and battery status, and displays real-time plug load variables without having to connect the logger to a computer to view the information. The logger's large memory capacity is capable of storing 1.9 million measurements, enabling faster logger intervals for more comprehensive plug load profiles, as well as longer deployment periods between offloads. And the logger's "Meter Mode" allows users to quickly get a read on the current energy use of a particular area of interest with zero software setup; this can be very useful for walk-through audits or to identify which equipment is the best candidate for longer-term monitoring.

#### Graphing and Analysis Software

Once load data has been recorded with the HOBOnet Plug Load Logger, it can be easily viewed in graph form and analyzed using Onset's HOBOnetware® graphing and analysis software for Windows and Mac. The software makes data readout hassle-free, provides powerful plotting tools, and enables plug load data sets to be easily combined with data from other types of HOBOnet data loggers commonly used in building energy audits, including Onset's HOBOnet UX90 Occupancy/Light loggers and HOBOnet UX100 Temperature/Relative Humidity loggers.

#### Pricing and Availability

The HOBOnet Plug Load Logger (model HOBOnet UX120-018) is available immediately from Onset and is priced at \$239. Please visit <http://www.onsetcomp.com/products/data-loggers/ux120-018> for complete pricing details and technical specifications, or sign up for a free live webinar to learn more.

#### About Onset

Onset is a leading supplier of data loggers. The company's HOBOnet data logger and weather station products are used around the world in a broad range of applications, including building energy performance monitoring, water resources management, and ecological and agricultural research. Based on Cape Cod, Massachusetts, Onset has sold more than 2.5 million data loggers since the company's founding in 1981.

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#### Sierra QuadraTherm® 640i/780i Air Flow Meters Win Suite of Global Agency Approvals — cFMus, ATEX and IECEx

Sierra Instruments, a leading global mass flow meter manufacturer, is pleased to announce its evolutionary QuadraTherm® 640i/780i air flow meters have received global approvals for the following standards of safe operation in potentially hazardous environments: cFMus (USA and Canada), ATEX (European Union) and IECEx (International). This signifies that the QuadraTherm is certified as flame-proof and protected from dust ignition sources and meets all design criteria for electrically-powered flow meters used in areas where combustible gases may be present.

The IECEx and ATEX certification programs ensure explosion-proof and hazardous area compliance in the European Union and international destinations. The cFMus certification program ensures explosion-proof and hazardous area compliance in the United States and Canada. With approvals, QuadraTherm is approved for applications in hazardous plant areas like facilities management, chemical processing, oil & gas, wastewater, and



## TECHNOLOGY PICKS

natural gas throughout the European Union and international communities.

“We designed and tested the QuadraTherm air flow meter for safe operation in heavy industrial applications. The global approvals are a recognition that years of hard work in design and testing were right on target. Now our customers can use the QuadraTherm in even more heavy industrial application across the globe,” says Scott Rouse, Product Line Director.

The QuadraTherm thermal mass flow meter’s approvals are as follows:

### cFMus

Class I, Division 1, Groups B,C, and D

Process Temperature Range: -40 °C to 200 °C (-40 °F to 392 °F)

T3C Ta = -40 °C to 60 °C (-40 °F to 140 °F)

Type 4x

### ATEX and IECEx Approvals

II 2 G Ex d IIC T3 Gb

II 2 D Ex tb IIIC T200°C Db

Ta = -20 °C to 60 °C (-4 °F to 140 °F)

Process Temperature Range: -40 °C to 200 °C (-40 °F to 392 °F)

With these global approvals, Sierra’s QuadraTherm air flow meter can be used throughout the world where hazardous or explosive environments may be present, expanding the market for our customers.

The QuadraTherm provides the best accuracy +/- 0.5% of reading above 50% of full scale for flow meter air measurement and other gases; built-in flow conditioning (inline version); multivariable outputs; flow ranges up to 60,000 sfp (305 smps); qTherm®, Dial-A-Gas®, Dial-A-Pipe™; and Hazardous Area approvals. The QuadraTherm is available in two models: the 640i insertion and 780i inline. The QuadraTherm family has a no-drift sensor with lifetime warranty; has multivariable output: mass flow, temperature, pressure (optional); measures all inert and all non-condensing clean gases; flammable gases (methane, propane, hydrogen, and digester gas); repeatability for mass flow rate is +/- 0.15% ; ValidCal™ Diagnostics to validate calibration in the field; and gas accuracy is +/- 1 °C (1.8 °F).

### About Sierra

A global leader in flow measurement and control for over 40 years, Sierra instruments designs and manufactures high performance flow instrumentation for gas, liquid and steam applications commonly found in the pharmaceutical, scientific research, health, energy and semi-conductor industries. With over 150 offices in 50 countries, Sierra is uniquely positioned to provide their innovative products and lifetime support for the leading companies of today and the growth enterprises of tomorrow and lifetime support for the leading companies of today and the growth enterprises of tomorrow.

Visit [www.sierrainstruments.com](http://www.sierrainstruments.com)



### FCI ST50 Air Flow Meter

Engineers who need to reduce the energy cost of air compressor systems will find the precision ST50 Air Flow Meter from Fluid Components International (FCI) helps them more accurately measure compressed air and detect system inefficiencies or expensive leaks.

Plants that depend on point-of-use compressors will find the ST50 Flow Meter is a cost effective mass flow monitoring solution that is ideal for compressed air flow measurement. It provides precision flow measurement to reduce the consumption of pneumatic air, helping manufacturing, assembly and process plants reduce air consumables and the energy required to support compressed air systems.

## RESOURCES FOR ENERGY ENGINEERS

### TECHNOLOGY PICKS



The installation of ST50 Flow Meters in large facilities with multiple air compressors allows the operators to compare compressor usage and adjust them for optimum efficiencies. In addition, the use of mass flow meters at the point of compressed air output helps to ensure peak performance at a given flow rate. Comparing the performance of multiple air compressors is also useful in predictive maintenance applications where higher flow rates may indicate leaking valves or seals in one unit versus other units operating under similar conditions.

The ST50 Flow Meter utilizes FCI's highly accurate thermal dispersion mass flow sensing technology to provide highly effective direct mass flow measurement at a lower cost. With the ST50, there is no need for the temperature sensors, flow computers or other devices required with orifice plates, Venturis, Vortex shedding and other meters. The ST50's unique design also provides built-in temperature compensation for reliable measurement over a wide temperature range with almost no pressure-drop.

The ST50 Flow Meter features a wide flow range from 0.75 SFPS to 400 SFPS (0.23 to 122 NMPS) for air, compressed air or nitrogen. Flow meter accuracy is +1% of reading, +0.5% of full scale, with repeatability of +0.5% of reading. The meter operates at temperatures from +40 to 100 °F (4 to 38 °C).

The ST50's flow range can be field-configured in either standard mass flow or volumetric engineering units. It features dual analog outputs, 4-20 mA and 0-10 Vdc, which are field assignable as flow

rate or temperature and an RS232C I/O port. A 0-1kHz pulse output for totalizing flow is also available as an option. All configurations are easily user set in the field with any standard laptop to the RS232C port and/or via the wireless IR link/PDA.

The ST50, featuring a rugged stainless steel sensing element with Hastelloy-C tips, is designed for endurance and maximum performance in outdoor and field installation conditions. Its electronics are housed in an all-aluminum, epoxy-coated enclosure that is NEMA 4X (IP66) rated and it withstands operational pressures up to 500 psig [34 bar (g)].

Three process connections are available for the new ST50 high-accuracy flow meter: 1/2-inch MNPT or 3/4-inch MNPT with a stainless steel or Teflon ferrule. It is available in three field adjustable U-length probes, 6, 12 and 18 inches (152, 305, and 457mm) to accommodate pipe sizes 2 to 124 inches (51 to 610mm). Instrument powering options include both DC (18-36V) and AC (85-265V). The ST50 comes with a 1-year standard warranty.

The versatile ST50 offers the best value in its class, featuring superior performance, low maintenance, ease of installation and a long-life. Whether adding flow measurement to improve the process or replacing high-maintenance flow meters, the ST50 provides an accurate, fast response and no-maintenance solution for compressed air, gas and nitrogen flow measurement. For smaller line sizes under 2 inches (51 mm), FCI's ST75 air/gas flow meter is an ideal choice.

To ensure optimum accuracy, performance and quality, FCI owns and operates a best-in-class test and NIST traceable calibration laboratory. FCI product developments are subject to rigorous testing and calibration integrity validation using high-speed data acquisition systems and precision flow calibration equipment.

Fluid Components International is a global company committed to meeting the needs of its customers through innovative solutions to the most challenging requirements for sensing, measuring and controlling flow, level and temperature of air, gases, and liquids.

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## TECHNOLOGY PICKS

### New Siemens AC Power Modules for Sinamics G120 Drives

A new line of PM240-2 power modules is now available from Siemens, extending the use of the popular Sinamics G120 drives family. A significant change is the addition of 230V 3-phase line supply units. Featuring a smaller footprint and higher power density than the current PM240 generation, these new power modules can also be mounted side-by-side without derating.

A push-through version is also available with the heat sink extending out the rear of the cabinet. As a result, the new PM240-2 power modules will reduce the overall required cabinet size and, when used with the optional external mounting bracket, achieve an IP55 (NEMA 12) seal. Standard IP20 open-type versions are also available.

Quick-connect connectors on the motor and cable sides simplify the commissioning and maintenance in the field. Removable terminals for line supply, motor and braking resistors also mean faster replacement whenever service is required.

Overall frame size reduction is further provided, despite the significantly higher power density ranges; for example, Frame size A now has a maximum rating of 3 kW Low Overload (LO) vs. 1.5 kW LO in the PM240 version.

Among the unique, new features of the PM240-2 power modules is the variable speed fan, controllable to run based upon actual conditions vs. simple on/off operation, thereby reducing both the noise generated and the power required when in use.

The PM240-2 power modules are suitable for use with general-purpose and servo-drive styles. Options on these PM240-2 power modules include braking resistors, input reactors, output reactors and sine-wave filters.

*For more information about this new line of power modules, please visit: [www.usa.siemens.com/sinamics-g120](http://www.usa.siemens.com/sinamics-g120).*



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