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Adhesive's Increasing Role in HVAC Filtration Efficiency

Clean-In-Place Filtration Technology Can Make Refineries Safer and More Productive

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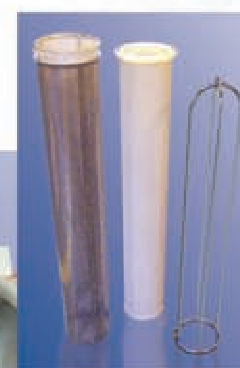
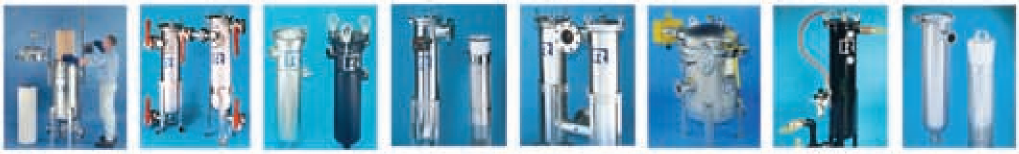


Model 18 shown, housings can hold up to 18 filter elements.



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Phone: +1-704-552-3708
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Internet: www.filtnews.com

Carol and Arthur Brown, Founders
Klaas DeWaal, Publisher and CEO
Antoinette DeWaal, Associate Publisher and Vice President

Editorial Department
Ken Norberg, Editor in Chief, Ken@filtnews.com
Adrian Wilson, Intl. Correspondent
Chen Nan Yang, China Correspondent
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Administration Department
Barbara Ragsdale, Barbara@filtnews.com

Circulation Department
Cherri Jonte, Subscribe@filtnews.com

Advertising Sales Representatives
USA
Joan Oakley, Joan@filtnews.com
Debra Klupacs, Debra@filtnews.com

Europe
Sabine Dussey, sabine.dussey@dussey.de
Martina Kohler, m.kohler@iff-media.ch
Judy Holland, jholland@textilemedia.com
Ferruccio Silvera, ferruccio@silvera.it

China
Zhang Xiaohua, ifj-china@yahoo.com.cn

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Mailing Address for advertising, news releases and address changes:
International Filtration News
International Media Group, Inc.
6000 Fairview Road, Suite 1200
Charlotte, NC 28210 USA
Phone: +1-704-552-3708
Email: info@filtnews.com
Internet: www.filtnews.com

POSTMASTER:
Send address changes to:
International Filtration News
International Media Group, Inc.
6000 Fairview Road, Suite 1200
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Editorial Advisory Board

Industry Experts Join Editorial Board

International Filtration News welcomes three new members to their Editorial Board. Together, Katariina Majamaa from Dow Water & Process Solutions, Richard Jacobs from Eaton Corporation and Robert Burkhead from Blue Heaven Technologies, brings with them vast expertise from their respective areas.

Katariina Majamaa
End User Marketing Manager - Heavy Industry
Dow Water & Process Solutions

Katariina Majamaa is the end user marketing manager at Dow Water and Process Solutions. She is responsible for developing and implementing short to medium term strategies, on a global basis, for growing value to end users and generate pull through demand within the heavy industry market segment with Ultrafiltration, Reverse Osmosis, Nanofiltration, Ion Exchange, and Fine Particle Filtration technologies.

Previously, Majamaa was the global application development leader for Industrial Water & Power Generation and the leader of the North American Application Development team. Here, she was leading technology strategy and new product development projects from concept exploration through market launch based on identification and assessment of market needs, emerging and complementary technologies, products and solutions, as well as developing intellectual property strategy and strategic external partnerships.

Majamaa is currently located in Minneapolis, Minn. She joined The Dow Chemical Company in 2007 as a technical service and development engineer for reverse osmosis, nanofiltration and ultrafiltration membranes in Rheinmuenster, Germany, serving the regional markets of Benelux, Nordic, Baltic, the U.K. and Ireland. She later moved to Tarragona, Spain, to support the expansion of pilot capabilities and the opening of the Tarragona Water Technology Application Center in 2011. Most recently, Majamaa spent time in Shanghai, China, exploring the needs of the greater China market.

In Finland, Majamaa earned her Master of Science degree in Chemical Engineering from Helsinki University of Technology. She also recently completed graduate studies with research in the area of biofouling with Delft University of Technology, the Netherlands, towards her doctorate in Chemical Engineering. She has more than 10 peer-reviewed scientific publications and over 30 conference presentations/alternative publications, and is a certified Six Sigma black belt. FN

Richard Jacobs
Liquid Filtration Technologies
Eaton Corporation

As president of Eaton's Filtration Division, headquartered in Tinton Falls, New Jersey, Richard Jacobs oversees a division considered a leader in liquid filtration that helps companies improve product quality, increase manufacturing efficiency, protect employees and equipment, and achieve sustainability goals. He is responsible for the division's business operations and performance in worldwide markets with manufacturing locations in the U.S., Mexico, Brazil, Germany, Belgium, India and China as well as its worldwide sales offices in 22 countries. He holds several U.S. Patents in manufacturing liquid filtration.

Jacobs joined Eaton in 2004 as vice president, supply chain management for the Fluid Power Group, responsible for a spending budget of $2B globally. He was later promoted to corporate vice president, supply chain management for Eaton globally. There he was responsible for a budget of $7B, purchasing products and services from 87 countries. Prior to joining Eaton, Jacobs was vice president and general manager for Bendix CVS, a former division of Honeywell/Allied Signal, responsible for a $260M business selling desiccant filters and wheel end products. He also served as a corporate director in Honeywell's supply chain function. In addition, Jacobs is a graduate of the University of Tennessee Lean Certification Program as well as a graduate of the Six Sigma Institute.

Earlier in his career, Jacobs spent eight years with General Electric and is a graduate of GE's Manufacturing Management Program. He holds several degrees including a Masters of Industrial Management, Bachelors of Science in Mechanical and Industrial Engineering from Clarkson College in Potsdam, New York, and graduated from the Harvard BMS program and the Columbia General Management program. FN

Robert Burkhead
Air Filtration Product Development and Performance Testing
Blue Heaven Technologies

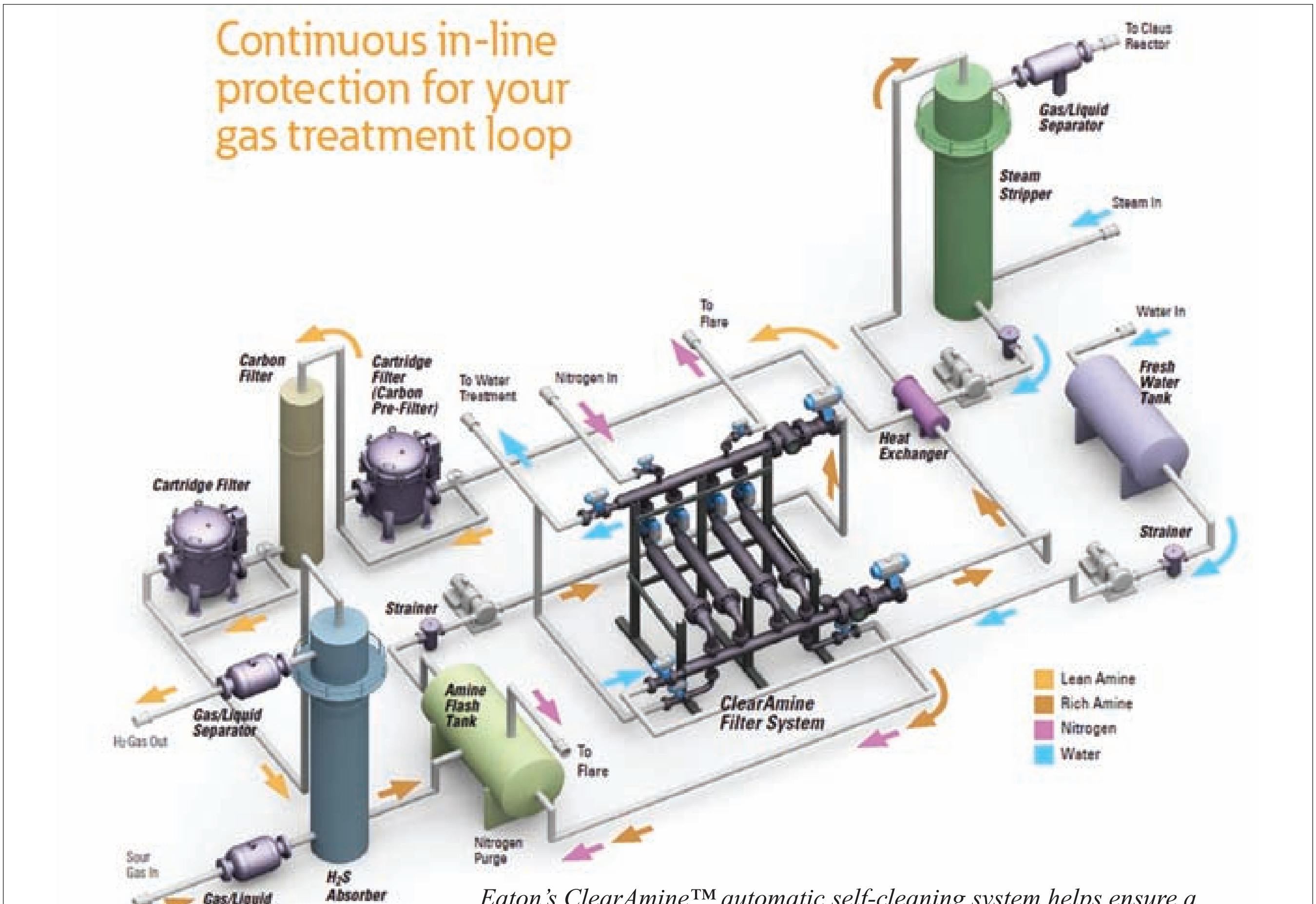
Robert Burkhead is president and founder of Blue Heaven Technologies in Louisville, Kentucky. Blue Heaven is a third party testing laboratory with a focus on air filter product performance assessment testing. In his capacity at Blue Heaven over ten years, he has also instructed and trained a wide range of customer's internal personnel in the technical details of air filtration product and market specifics.

Burkhead has also held engineering management positions at AAF International (for 15 years) and the U.S. filtration business group of Freudenberg Nonwovens (for 10 years). In both these positions he was accountable for overseeing the filtration media/product design and manufacturing as well as laboratory construction and management.

Burkhead has a Bachelor of Science degree in Mechanical Engineering Technology and holds product design awards and patents for various filtration products. He has been actively involved in ASHRAE technical committee activity for 30 years and also remains involved with INDA, AFS, ASTM and Underwriters Laboratory. FN

Clean-In-Place Filtration Technology Can Make Refineries Safer, More Productive and More Environmentally Sustainable

By Richard Jacobs, President, Eaton's Filtration Division



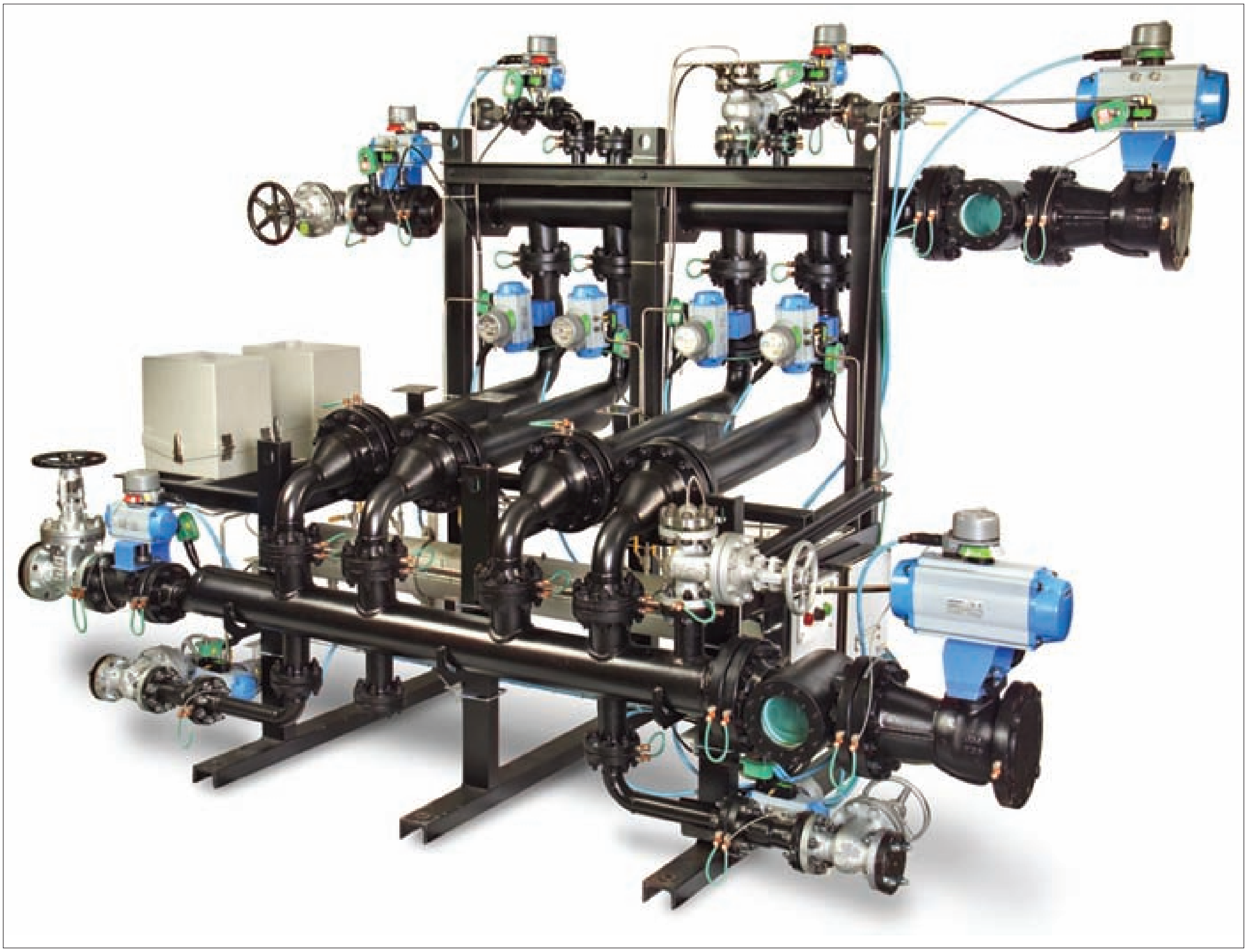
Eaton's ClearAmine™ automatic self-cleaning system helps ensure a continuous supply of pure amine for the removal of acid gas (H_2S and CO_2).

Processing toxic, corrosive and explosive chemicals at high temperatures and pressures creates a uniquely hostile and dangerous environment. The fact that it is safely done every day in refineries around the world is a tribute to the skill and expertise of the engineers who design and operate them, but there is always room for improvement. Modern filtration technologies can make a significant contribution to both operator safety and overall productivity while reducing a refinery's carbon footprint and environmental impact.

That is not conjecture. The safety enhancement and other benefits of modern, "clean-in-place" filtration systems have been proven in hundreds of refineries. The technology is widely used in catalyst protection and coking applications and is now being applied in a growing number of "amine units."

An amine unit is used to remove hydrogen sulfide (H_2S) and carbon dioxide (CO_2) contained in many crude oil feedstocks prior to refining. The process uses an amine, typically diethanolamine, monoethanolamine or methyldiethanolamine (DEA, MEA, MDEA) to remove H_2S and CO_2 from hydrocarbon gases.

As the amine circulates through the process, it picks up contaminants



Pipe scale, rust, iron sulfide, sand and other solids build-up in closed-loop amine systems fouling flash drums, heat exchangers, strippers, re-boilers, and carbon filters. They also attract hydrocarbons, which cause system foaming. Eaton's Clear-Amine™ system provides an efficient method of removing harmful solids to protect and extend equipment life, and maximize amine systems' effectiveness.

including pipe scale, rust, iron sulfide, sand and a variety of other solids. These foul system components include flash drums, heat exchangers, strippers, re-boilers and carbon filters. The amines also attract hydrocarbons, a major cause of system foaming, which reduces process efficiency.

The process is continuous, with the "rich" contaminant-bearing amine being regenerated and reused as "lean" amine. The most common amine filtration solution today uses cartridge-type filters to remove contaminants from the lean amine stream after regeneration. This ultimately exposes everything upstream of the regenerator to a full load of contaminants.

Rich-side filtration is a better solution in terms of protecting the equipment, but opening a cartridge-type filter system unnecessarily exposes workers to dangerous and potentially explosive H_2S and other hazards when changing cartridges. The cartridges themselves also represent an inventory expense and must be disposed of as hazardous waste creating both cost and environmental impact issues.

Since clean-in-place filter systems minimize or eliminate the need for operators to open the filter system during operation, the safety impact is obvious. These systems typically use a backflush and purge cycle with a backpressure-sensing control. The filters are installed both as single units with a bypass and as multiple banks to provide continuous protection.

The enhanced operator safety provided by a clean-in-place system makes it much more practical than cartridges to filter the rich amine side of the process. This can extend the life of costly system components

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These are not the only benefits. A clean-in-place filtration system also can significantly reduce a refinery's environmental impact and carbon footprint. Compared to the commonly used disposable media systems, an automated clean-in-place system dramatically reduces the number of bags and/or cartridges that must be purchased, inventoried, handled and eventually disposed.

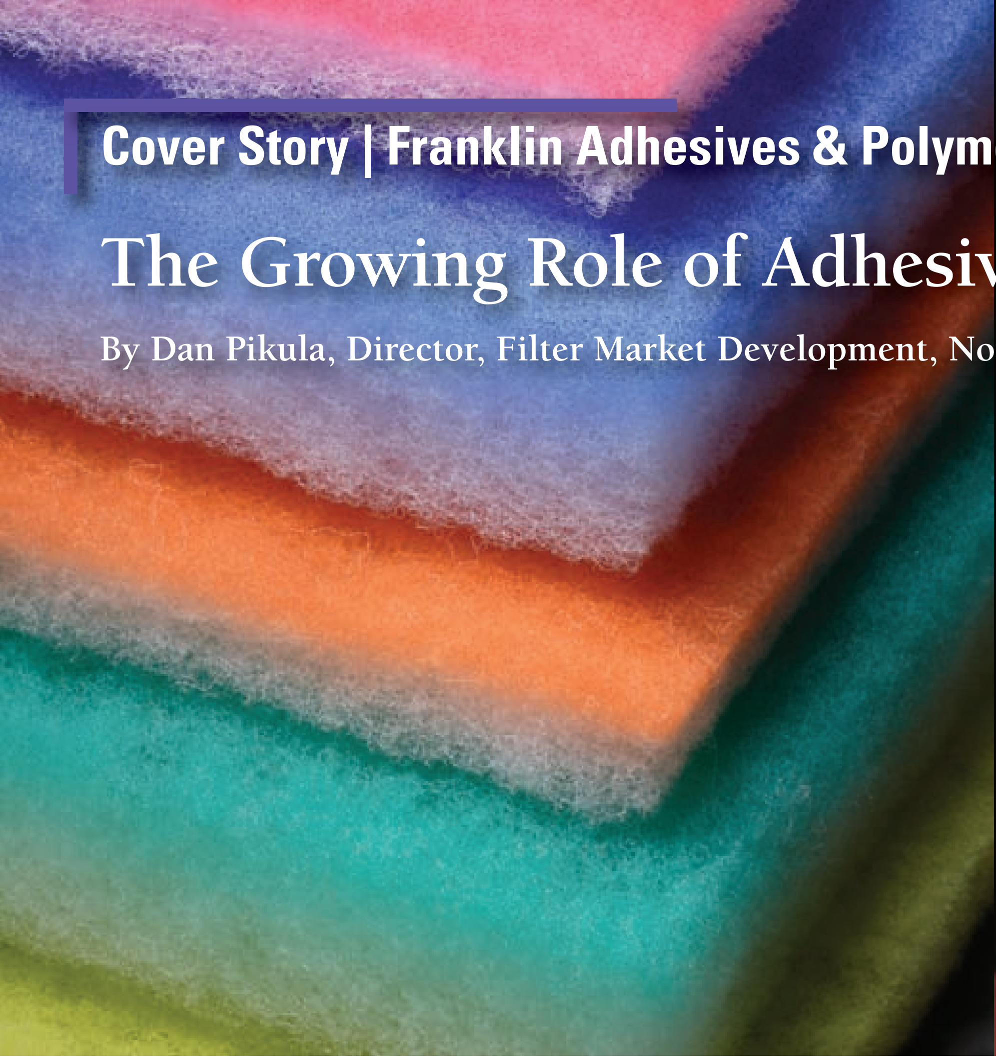
Removing contaminated bags and/or cartridges from the waste stream reduces the gaseous emissions associated with their decomposition as well as the associated hazardous waste landfill fees. Over a ten-year period, these savings can add up to nearly a 60 percent cost reduction compared to today's commonly used disposable media systems.

Making the refineries that fuel our modern, global society more productive, more environmentally sustainable and above all safer than ever before is a huge challenge. Fortunately, it is one the filtration industry is well prepared to help their customers meet. FN

For more information contact:
Richard Jacobs
Eaton
Tel: 1-732-212-4747
Email: richardjacobs@eaton.com
Website: www.eaton.com/filtration

The Growing Role of Adhesives in Increasing F

By Dan Pikula, Director, Filter Market Development, North America



The FilterFAB 3000 series introduces PVA technologies that act as binders.

The adhesives are sprayed directly onto the filter

For years, filter manufacturers have relied on adhesives to put together various components of the HVAC filters they make, so as to assemble the filter media or bond it into a frame or end cap. Now, they are looking to this versatile substance to increase performance of the filter media itself.

The ability of adhesive to bond filter media together or to a frame also enables it to capture and hold in place particles in an air stream during filtration. Atomizers along the production line spray an adhesive formulated specifically to entrap the matter directly on the filter media. The adhesive bolsters filtration efficiency throughout the expected life span of the media.

At least one adhesives manufacturer that serves the filter industry has taken a lead in developing products to meet the growing interest in spray-on adhesives for improved HVAC filtration efficiency. Franklin Adhesives & Polymers recently launched FilterFAB 3000, a series of adhesive technologies for media in residential and commercial air filters. The series offers adhesive technologies designed to increase particle entrapment, including one that also functions as a binder. It also includes an adhesive technology developed strictly for use as a versatile media binder.

The company, which also offers a wide range of adhesives for many other filter assembly applications, plans to broaden the FilterFAB 3000 series over time to meet additional filter media manufacturer specifications. It also is prepared to customize FilterFAB 3000 formulations for specific production equipment, filter media type and manufacturer requirements.

The initial product in the FilterFAB 3000 series draws on technology used for pressure sensitive adhesives (PSAs) – adhesives that typically are coated onto a substrate to make tapes and labels. PSAs can either be removable (such as painter's tape), permanent (a label on a prescription bottle) or repositionable (sticky memo paper). The FilterFAB PSA takes on far different roles in the filter manufacturing facility. As a permanent PSA, this surfactant-stabilized vinyl acrylic adhesive can both laminate layers of filter media together and increase particle entrapment.

The FilterFAB 3000 line also includes water-based surfactant-stabilized polyvinyl acetate emulsions developed as binders to stiffen filter media. The binder is designed to ensure easy pleating and crimping of media and to minimize pore clogging during filtration.

Filter manufacturers get the best of both worlds with the final adhesive technology in the current FilterFAB line-up – a unique combo-adhesive that fuses the above PSA and polyvinyl acetate (PVA) technologies to offer the dual functionality of enhanced particle entrapment and media binding. A single sprayer can simultaneously apply a binder and filtration enhancement PSA, both increasing plant productivity and end-product performance.

Despite their ability to provide specific

HVAC Filtration Efficiency

media.

This digitally altered photo depicts entrapment of particles.

solutions to the filter manufacturer, the technologies that comprise the FilterFAB 3000 series share a number of characteristics that position them to easily meet varied application and production requirements, offer the convenience of easy clean-up in the plant and meet regulations for environmental friendliness.

First, the adhesives manufacturer can easily customize key performance characteristics of any of these technologies to meet specific application requirements. Any of the formulations can be matched to media type, production equipment, end use, viscosity, etc. Customized adhesives will be tested in the lab to ensure ideal performance in the actual production facility. Further, the formulations are compatible with a wide range of conventional additives, increasing their versatility and ability to meet specific manufacturer needs.

As a group, the FilterFAB 3000 adhesives help filter manufacturers maximize filter efficiency at minimal cost and effort. The application process typically can be incorporated directly into existing media equipment, without need for additional equipment or reduction in productivity. Once sprayed onto the media, the adhesives set and dry quickly, without significant impact on overall production time. And minimal clean-up requirements can increase productivity: The FilterFAB 3000 series easily cleans up with water when wet, decreasing time required to keep equipment clean, free of clogs – and operating smoothly, with minimum downtime or unnecessary maintenance costs.

HVAC filter manufacturers make equipment for customers who require – and value – air purity. Likely, it's important both to the manufacturers and end-users that products used in the manufacture of filters follow guidelines for environmental friendliness. All FilterFAB 3000 adhesives – indeed, all adhesives under the FilterFAB brand – are formaldehyde-free. "Green" formulation ensures that they meet environmental regulatory requirements and are both safe for the plant crew to apply and for use in residential and commercial HVAC systems.

Filter manufacturers continue to seek cost-effective, viable methods to increase filtration efficiency. Recent research and development in the adhesive laboratories strive to provide them easier and better ways to achieve it. Adhesives manufacturers, such as Franklin Adhesives & Polymers, are willing to work with filter manufacturers to develop the best way to produce the highest-quality filtration media for a healthy world. FN

For more information contact:

Franklin Adhesives & Polymers

Tel: 1-800-877-4583
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Smog and Haze Lead to High Demand for Filter Materials in China

By Jason Chen, China Correspondent

Smog and haze is not uncommon around industrial hubs in Northern China, leading to a demand for filter materials.

In the past few months, public concerns over China's severe air pollution forced the government to take a series of new measures to tackle the ever-growing environmental challenges. Production of filtration fibers in the Chinese market will be boosted by the new governmental plans and reach 1,5 million tons by 2020, according to industry experts.

SMOG AND HAZE

The market for air filtration is booming in China as the country has been shrouded for months in thick smog and haze. In eastern China, where most of the country's manufacturers are located, the Air Quality Index (AQI) kept rising during most of 2013. An AQI of 0 to 50 is regarded as excellent, 101 to 150 is considered light pollution, and above 300 is severe pollution. But the AQI in Beijing constantly sat between 400 or 500 during the entire 2013, and in Shanghai, China's commercial center, the AQI even reached 700, a level deemed "poisonous" in early December 2013.

To tackle the hiking air pollution, the Chinese central government set up a series of measures late last year, including limiting car driving according to license plate numbers and phasing out polluted production capacity. They also included a project with a total investment of 1,750 billion RMB ($290 billion), which aims to reduce the smog and haze and improve air quality in the country's three most important economic zones by introducing advanced technologies, new products, and new mechanisms during the next five years. These three zones include Beijing circle (Beijing, Tianjin, and Hebei Province), Shanghai circle (Yangtze River Delta Region), and Guangzhou circle (Pearl River Delta Region). This project will also reach the final goal of eliminating all the heavy air pollution (AQI 251 to 300) in China by 2023. Chinese industry experts expect the investment will boost the growth of the country's filtration industry, especially of those for high-temperature waste gases reduction.

PM2.5 AND FILTER MATERIALS

In China, the main harmful material in the air is particulate matter 2.5 (PM2.5). With a small diameter of only 2.5 micrometers, a PM2.5 spreads through the air and can directly enter the human alveoli of lungs, which can cause severe health problems. PM2.5 mainly come from fossil fuels in vehicles, power plants, and manufacturing industries. Among these sources, high-temperature waste gases from power plants and manufacturing industries such as cement and steel contribute to most of China's PM2.5 emissions, according to the government.

Electrostatic precipitators, bag filters, and electrostatic and bag compound filters are used to eliminate high-temperature waste gases in China. But most of the products currently used in China have a low efficiency, according to Sun Maojian, president of the Yantai Tayho Advanced Materials Co., Ltd. (Tayho).

"Electrostatic precipitators (used by Chinese manufacturers) can only catch around 60% of the particulate matters, which diameters are smaller than 10 micrometers. On the other hand, most of the Chinese companies still use traditional materials such as glass fibers as the main materials in bag filters, which have problems such as short life span, low accuracy, low abrasion resistance, and wastes pollution," said Sun.

Professor Liu Jingxian of the Filter Materials Testing Center (FMTC) of Northeastern University also admitted electrostatic precipitators can't catch PM2.5 effectively, though they can catch 99% of the dust. He said bag filter had become the main stream in China's high-temperature filtration efforts.

According to recent research from FMTC, main filter materials currently used in China to eliminate PM2.5 emissions include:

FOR COAL-FIRED POWER PLANTS

Currently, more than 80% of China's power consumption is supplied by coal-fired power plants. The main filter material in these plants is polyphenylene sulfide (PPS) needle punched felt. A PPS needle punched felt filter can catch around 78% of the PM2.5 in the waste gases, according to the FMTC research. Some filter companies use spunlace process to increase the efficiency. A filter made of spunlaced PPS felt can catch up to 85% of the PM2.5 in a coal-fired power plant.

As the government seeks to tighten the PM2.5 emission limit, polytetrafluoroethene (PTFE) membrane PPS felt will be more widely used by power plants. PPS needle punched felt is dipped, laminated, or coated with PTFE to improve high temperature resistance, corrosion resistance, and the ability to catch small particulate matters. The PTFE-laminated filter material can catch more than 99% of the PM2.5.

FOR CEMENT PLANTS

Bag filters have been used in China's production of cement since early 2000 and have dominated the market since early 2010. The main filter materials for the cement industry include polyimide fibers, also known as P84 fibers. China-made P84 filters can effectively catch PM2.5 in the environment of high temperature, according to a recent report of the Jiangsu Aoshen Advanced Materials Co., Ltd.

But today most of the Chinese cement producers still have dust emissions of much more than the national standard, which is 10mg per cube meters of gases emissions. This means many cement producers still don't use bag filters made of P84 fibers and other advanced materials to reduce gases emission.

FOR THE STEEL INDUSTRY

In China, more than 90% of the filtration products in the steel industry are bag filters, according to Liu. Main filter materials include glass fibers and their composites with other fibers such as P84 fibers and aramid. Glass fiber-based bag filter can catch up to 97% of the PM2.5 emissions in steel production.

ARAMID FILTERS

Comparing to most other products for high-temperature waste gases filtration in China, aramid bag filters have better performance, according to Sun. He said a bag filter made of aramid fibers could catch 98% to 99% of the particulate matters, with diameters as small as one micrometer. But currently only 5% of the filtration products for high-temperature waste gases are made of aramid in China. As the governmental efforts to tackle air pollutions will force the manufacturers to use more efficient filters, Sun estimated China would consume 50,000 metric tons of aramid fibers for producing new bag filters to replace the current electrical precipitators and glass-fiber bag filters in the next few years. This would be a billion-dollar market, said Sun.

But the high cost of aramid fibers will still be the main obstacle to slow this replacement process. Currently China's supplies of aramid fibers are dominate by global brands such as Du Pont and Teijin, and most of the Chinese manufacturers prefer to use the relatively cheaper filter materials such as glass fibers.

The government's 1,750-billion-RMB investment could help Chinese manufacturers reduce the aramid cost. Chinese government subsidizes domestic companies for technological innovation and other efforts that fit the government's plan. The subsidies could reduce the cost of usage of aramid bag filters.

Another possible momentum will be the decrease of aramid prices. As Chinese aramid fiber manufacturers have started to expand their production capacity, the prices of aramid fibers are expected to decline, and aramid bag filters will have better cost performance in the market. Currently, Tayho is China's largest para-aramid producer, with an annual capacity of 1,000 metric tons. China's total para-aramid capacity was only 1,500 metric tons by 2013. But the capacity will reach, respectively, 5,000 metric tons in 2015 and 16,000 metric tons in 2020, according to Ye Yongmao, chief consultant of the China Chemical Fibers Association (CCFA).

FILTRATION FIBERS

In China, the main filtration fibers include polyester, nylon, polypropylene, polyacrylonitrile, PTFE, aramid, glass fiber, P84, and PPS. Polyester fibers account for around 70% of China's filter materials consumption, but it can't be used in a high-temperature environment. For high-temperature filtration, the main materials are PTFE, aramid, glass fiber, P84, and PPS.

China's production of filtration products consumed 740,000 metric tons of fibers in 2012, a 14% growth rate from the 2011 level, according to China Nonwovens & Industrial Textiles Association (CNITA). CNITA estimates that the annual growth rate will continue at double digits in the following eight years, which means the country's consumption of filtration fibers could overtake 1.5 million metric tons by 2020.

The market of each fiber is described in the following:

Polyester fiber will continue to be the largest sector. China's consumption of polyester for filtration purposes was about 500,000 metric tons in 2012. By 2017, the annual consumption of filtration polyester fibers could reach 760,000 metric tons.

Aramid will be one of the fastest-growing sectors. In 2013, more than 60% of China's annual para-aramid consumption of around 8,400 metric tons was imported from the United States, Japan and Europe. Para-aramid will remain an average annual growth rate of around 15% between 2012 and 2020. According to Ye Yongmao, by 2015 domestic fiber manufacturers will supply half of China's annual para-aramid fiber consumption of 10,000 metric tons; by 2020 domestic fiber makers will supply 80% of the annual para-aramid consumption of 20,000 metric tons in China.

PPS fibers will welcome a strong growth in the next few years. China's capacity of PPS resins and PPS fibers reached, respectively, 30,000 and 20,000 metric tons by middle 2013. The demands from bag filters in power plants have started to boost the consumption of PPS fibers. Zhang Daming, CEO of China Lumena New Materials Corp. (Lumena) expected China's annual PPS fiber consumption will remain at more than 20,000 metric tons in the next few years. Lumena is one of China's largest PPS fiber suppliers, with an annual capacity of 30,000 metric tons of PPS resins and 5,000 tons of PPS fibers. Zhang said Lumena had high gross profits and strong bargain power for their PPS fibers, as sales were good since 2012. On the contrary, China's PPS fiber sales were weak before 2011, while PPS fiber manufacturers' operating rate was usually below 50%.

China's output and consumption of glass fibers reached, respectively, 2.9 million and 1.7 metric tons in 2012, according to the China Composites Industry Association (CCIA). CCIA estimated 11% of the domestic glass fiber consumption was for industrial textiles, including filtration. FN

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Progressive Dilution for Cleaning Metalworking Coolants

By James J. Joseph

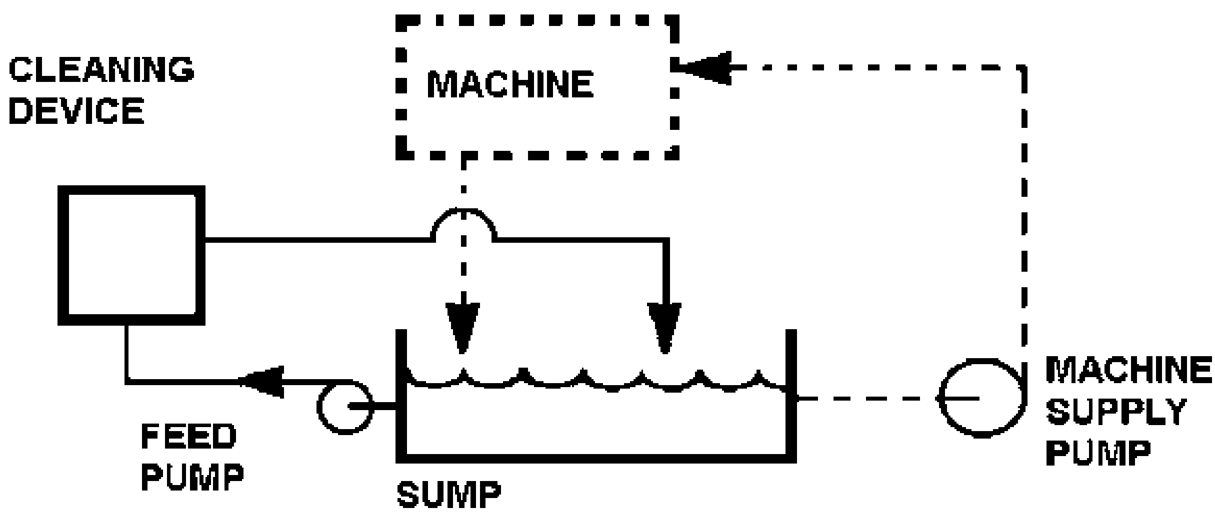


Figure 1: Sidearm Sump Cleaning

Sump-side cleaning of metalworking coolants is growing in popularity because of all the advantages of cleaning at the machine without all the extra handling. There are two basic concepts:

- Remove the total volume to a portable cleaning device, which has its own holding tank. Then send the cleaned fluid back to the sump. This is a remove, repair and replace maintenance procedure.

- Constantly recirculated a portion of the sump's volume through a portable cleaning device without removing the total volume at one time. This is a progressive dilution procedure.

The remove and repair concept is easy to understand. However, the progressive dilution concept has many subtle fundamentals, which influence its success in cleaning a sump. Many believe that all they have to do is to hook up a sidearm cleaning device to a machine's sump and let it run for a short time to clean the fluid; usually the quicker the better. However, the importance of the cleaning time is a major component to successful performance. This article explains the nuances of progressive dilution.

Figure 1 shows a simple schematic of a sidearm device connected to a sump.

Figure 2 shows a typical bag filter with a pump designed to work as a sump-side cleaner on a sidearm concept. Almost any transportable device can be used and the range of possibilities includes centrifuges, most filter designs and typical separators such as magnetic, settling and hydrocyclonic. Of course the selection and size must be in keeping with the application and flow rate.

The success of the progressive dilution cleaning function depends upon many factors, but the two most important parameters are the efficiency of the cleaning device and turnover rate of the volume in the sump.

EFFICIENCY

In this industry the term "efficiency" is a difficult parameter to measure while a unit is working. A filter's efficiency changes as it loads with the contaminants. Centrifuges have a high and fairly consistent efficiency but it could change when the ratios of solids to liquids vary. Other separators have a lower efficiency, which is also dependent on the ratio of solids to liquids.

All of this is treating the suspended material, which can be drawn into the pump's suction. Another part of sump cleaning is to take the steps to remove settled and floating material if they can not be drawn into the feed pump.

TURNOVER

Turnover is defined as a point where the entire volume of liquid passes through a cleaning device at its designed flow rate. For example, a filter flow rate of ten GPM, working on a tank with 100 gallons, will turn over the volume every ten minutes.

PROGRESSIVE DILUTION

Progressive dilution is when a portion of the volume of liquid in a sump, with a fixed amount of suspended material, is continuously recirculated through a cleaning device and returned to the tank. As it is recirculated, the just cleaned portion mixes with the balance of the fluid to dilute the concentration of remaining contaminants. The fluid is progressively being cleaned as long as no other contaminates are introduced during the cleaning period.

The phenomenon of progressive dilution has an axiom that a 100 percent efficient cleaning device will remove over 99.9 percent of the original suspended material after the flow rate through the cleaning device has achieved seven turnovers. This statement has a direct applicability to actual practice, but caution is advised to recognize the practical limits of this thinking. There is more on this in the book Coolant Filtration 2nd Edition- Additional Technologies.

Obviously, the 100 percent efficiency factor is the ultimate accomplishment and there are few devices, which are economically justified to achieve this target. Less efficient devices attempt to reach the 99.9 percent goal, but they need more than seven turnovers to accomplish the task. Regardless of the efficiency, the majority of the contaminants are removed at seven turnovers.

Figure 3 is a family of curves that reflects the amount of contaminants remaining in the fluid versus time at four different device-efficiency levels: less than 25 percent, 25 to 50 percent, 50 to 75 percent, and 75 to 100 percent. The unit for operating interval is one turnover of the reservoir. The title uses the term "clarification" to cover all cleaning devices regardless of their mode of operation. These curves are developed with established models from filtration studies on a wide range of applications. They are prepared to fit known factors found in typical applications and to compensate for some of the realities of data collection and interpretation.

The curves are not absolute because of the many other factors and unknowns which take place during the recirculation of liquid through a cleaning device. They are not really smooth since most devices will react differently as the amount of suspended material in the fluid changes in concentration. However, it is possible to use these as guides to project a feasible performance

Figure 2: A typical bag filter with a pump designed to work as a sump-side cleaner on a sidearm concept.

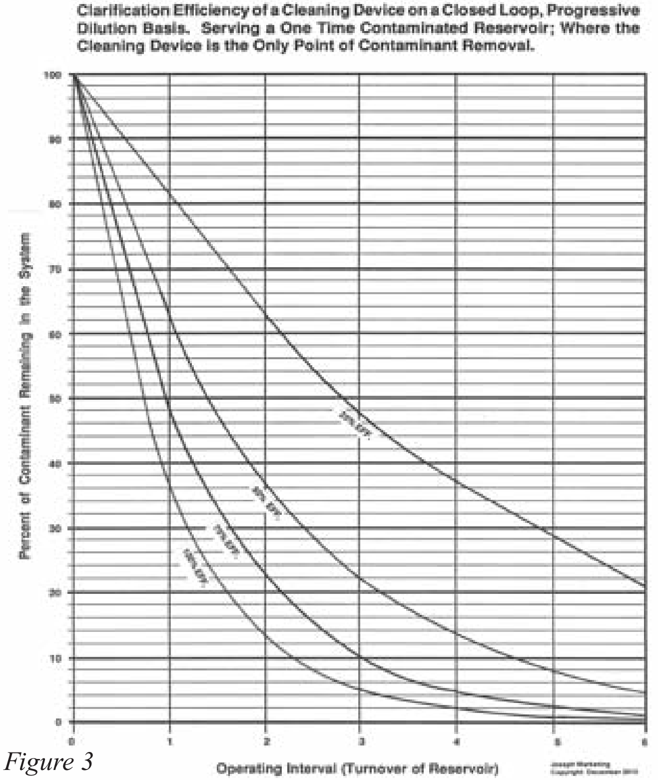


Figure 3

or make flow rate adjustments to achieve better turnover-rates. Also, it can be seen that a device with low efficiency could be "acceptable" for an application.

APPLYING PROGRESSIVE DILUTION

Knowing that seven turnovers is a key factor, here are points to consider:

1. Initial thoughts should be to see what is needed to approach seven turnovers.
2. A large sump should have a higher flow rate than a small sump.
3. Time to reach a turnover is an important parameter for machine downtime.
4. Sump cleaning is intended to extend the fluid's life; not keep it totally clean.
5. The machine can operate with some contaminants; it does once it starts working.
6. Seven turnovers may be too long and not really needed.
7. Time to service the device, as needed, during the cleaning cycle.
8. Note the different turnovers at a given level of contaminants left in the system.

9. A small increase in flow rate could make a significant difference in turnover rates.
10. There are four factors: sump size, downtime, device selection and flow rate.

Of the four factors in the progressive dilution concept, two are fixed: sump size and maximum time the machine can be down. The other two, device selection and flow rate are flexible within a reasonable range of options.

The following typical scenario reveals some thought processes.

Given:

- Sump capacity of 250 gallons
- Filter selected for 20 GPM and has been properly sized for the application
- Turnover every 12.5 minutes
- Seven turnovers would have the machine down for about 1.5 hours

If downtime is too long for the machine's production schedule, here are some options to reduce the time:

1. Select a higher capacity cleaning device for a flow greater than 20 GPM. Probably this step is the most practical; i.e., if bag filters are used, add more bags in parallel. Or, with centrifuges use a larger unit.
2. Use the most efficient device possible; most of the time a filter or centrifuge is already at the best level. The filter must be sized for the application to avoid frequent stopping to change the media.
3. Run it at the number of turnovers the machine's downtime can tolerate and see if the clarity level is acceptable. For example, the curves show what can be achieved if 20 percent left in the system is acceptable; 1.5 to 3.3 turnovers.
4. If none of the above is feasible, drain the sump, transport the fluid to a remote cleaning operation, and refill with cleaned fluid from the remote operation.

CAUTION

Since progressive dilution is a complex phenomenon, it is important to understand that the information offered here is presented in good faith as a guide to understanding the basics of sump cleaning. All factors should be evaluated by everyone involved to make sure there are no unknowns, which could influence the selections of equipment and time. FN

James J. Joseph is a consultant who has also written the book Coolant Filtration 2nd Edition, Additional Technologies.

For more information contact:
Joseph Marketing
120 Richmond Hill Court
Williamsburg, Virginia 23185
Tel/Fax: 757-565-1549
Email: josephmarketing@verizon.net

Testing and Evaluation of Liquid Bag Filters

By Dr. Ernest Mayer

Liquid filter bags are universally used in a variety of industries particularly for paint, ink jet, chemicals, pigments and wastewater filtration. Needle-punched felt bags are primarily used, and a discussion of the needled-felt punched process can be found in various texts. More rigorous micron-rated media are becoming more prevalent today. In addition, multiple geometries are now offered for greater surface area per individual bag. Another issue with bag filtration (other than simplicity and low cost) is the lack of uniformity between manufacturers and their confusing micron ratings. This paper addresses how Capillary Flow Porometry (CFP) and to some extent NIST Glass Bead challenge testing can be used to unambiguously assess micron ratings; how actual ISOCTD challenge testing can be used; and how full-scale testing can be done to assess efficiency and life.

NIST GLASS BEAD CHALLENGE TESTING

Glass bead challenge testing with NIST certified glass beads was pioneered by Whitehouse Scientific in the U.K. and further developed by DuPont to provide a rigorous method to determine the cut-point efficiency of primarily flat sheet media, including felts. This method was also compared to conventional Capillary Flow Porometry (CFP) where some interesting correlations were found. Almost all flat sheet media that were tested by both NIST glass bead challenge testing and CFP showed excellent comparisons by both Whitehouse and DuPont's instruments except for needled felts. Apparently, the dry glass beads were trapped in the felt depths by static effects, which resulted in erroneous efficiencies.

As a consequence, a wet method had to be used, but then significant deviations occurred from the dry

TABLE I

FLAT-SHEET ISOCTD CHALLENGE TESTING OF BAG FILTER MEDIA*

Media	Flux * (gpm/ft^2)	CFP Values ** B.Pt. (µm)	CFP Values ** B.Pt./1.65 (µm)	(1) Initial Efficiencies at (µm) 50%	(1) Initial Efficiencies at (µm) 98%	(2) Life (mins)	(3) DHC (g/Size #2 Bag)	Comments
P050	8	252	150	>70	>70	105	101	Standard P050 needled felt has high CFP values, high >70µm 98% efficiency (but 125µm by vendor) and reasonable life and DHCs); higher vendor flux reduces DHC
P050 (Vendor data w/later sample)	12	208	126	~70	125	100	92	
9096	8	142	86	>70	>70	120	54	Thin DuPont #9096 media, has short life and low DHC
9097	8	115	70	60	70	83	93	Thick DuPont #9097 media exhibits similar DHC to P050, slightly shorter life, but is much more efficient (i.e., 70µm final 98% efficiency)

** A small 0.1 ft2 Millipore filter holder was challenged with a 200ppm water solution of ISOCTD at stated flux, and both turbidity (NTU) and particle counting determined on samples collected.*

*** PMI Capillary Flow Porometer (CFP) values for Bubble Point (B.Pt.) sizes in microns including the typical B.Pt./1.65 correction for the universal tortuosity factor based on dry media challenge testing.*

(1) The 50 & 98% initial efficiency ratings are listed in microns based on samples collected for turbidity & particle counting. Note that >70 µm values result because the particle counting instrument only went up to 70 µm maximum (except for the vendor data).

(2) Media life in minutes to 30 psid.

(3) Dirt Holding Capacity (DHC) in grams at end of cycle and 30 psid (expressed as grams/full size #2 bag & based on efficiency and grams ISOCTD fed over cycle).

TABLE II - FELT BAG PAINT FILTRATION – PLANT TRIALS*

Bag Used	Porometer Results* Value	New	Used	Δ % Decr.	Water Flux (gpm/ft^2) ** New	Used	Δ % Decr.	Avg. % Decr. (1)	Comments
PE10	MFP (μ)	36.8	28.5	23	1126	814	28	30	PE 10 bag appreciably blinded
	B.Pt. (μ)	153	112	27					
	Frazier (cfm)	35	21	40					
9097/9096	MFP (μ)	31.7	26.6	16	937	792	15	17	9097/9096 dual-layer bag much less blinded as well as lower ΔP at end of batch (see Fig. 1)
	B.Pt. (μ)	126	114	10					
	Frazier (cfm)	24	18	25					
PE 25	MFP (μ)	46.2	51.7	-12	1129	1081	5	-3	PE 25 bag has some life left but the felt media actually opened up upon use
	B.Pt. (μ)	186	207	-11					
	Frazier (cfm)	33	31	6					
9097/9096	MFP (μ)	38.5	38.9	-1	937	1008	-7	+2	9097/9096 bag shows little blinding with very little opening of the basic pore structure
	B.Pt. (μ)	133	130	3					
	Frazier (cfm)	24	21	12					

** The used filter bags were soaked in solvent for 24 hours to remove residual paint resin; and nine 25mmD. samples were cut from each bag and evaluated via a PMI Capillary Flow Porometer (CFP) for Bubble Point (B.Pt.), Mean Flow Pore (MFP) size, and Frazier permeability (cfm/ft2). The results were then averaged and compared to new samples from similar bags; and the % Decreases (Decr.) calculated, which has been shown to be a measure of media blinding.*
*** Water Flux (gpm/ft2) obtained on these same 9-25mmD. samples by filtration of 0.2 μm filtered DI water at 5 psid pressure.*
(1) Average of all four parameter % Decreases.

method. This wet method combined with glass bead particle counters proved to be accurate, but CFP results for these thick needled-felts were still fairly high compared to glass bead efficiency values such that actual ISOCTD testing became necessary along with some full-scale testing.

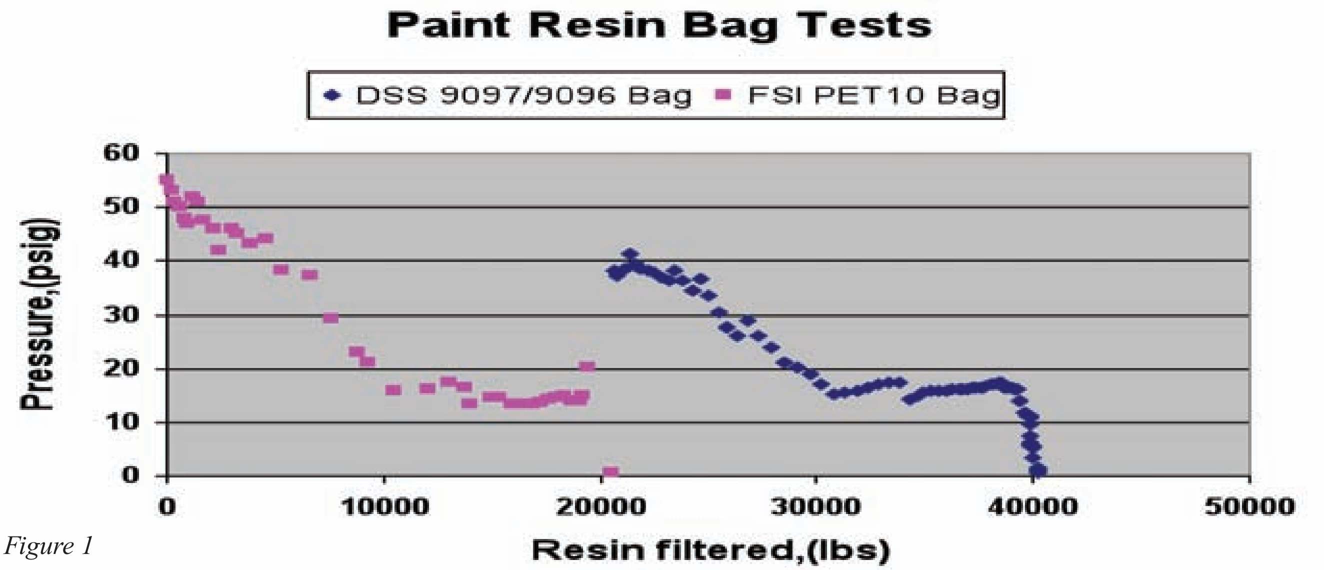


Figure 1

TABLE III

FULL-SCALE SIZE #2 ACTUAL PLANT TESTS*

Bag	Avg. Turbidity, (NTU) ** In	Out	% Eff.	Approx. *** Area (ft²)	(1) Term. ΔP (psid)	(2) Life (Hrs)	(3) DHC (g)	Comments
P050 (control)	6.6	5.0	25	14	45	1:15	100	Control bags at high dirt load exhibited similar 25% efficiency and DHC, but very short 1:15 hour life
9096	3.7	2.8	26	14	49	2:00	63	9096 bags are inferior to P050 bags by all criteria (except perhaps life)
9097	6.6	4.6	31	14	45	1:40	92	9097 bags exhibit longer life & higher efficiency at similar DHC
P050 (control)	3.4	2.6	25	14	35	3:57	92	Control bags exhibited normal ~4 hour life under normal operating conditions
9096 (Pleated)	4.5	3.4	25	60	0.6	3:15	107	Pleated #9096 bags had similar DHC but at only 0.6 psid ΔP at the same efficiency
9097 (Pleated)	3.6	2.2	39	60	1.5	16:00	453	Pleated #9097 bags had significantly more DHC & Life at increased 39% efficiency
BOSG (molded-depth)	~3.8	~2.5	35	14	20	9:00	217	Molded BOSG bags also exhibited long 9:00 hours life at higher efficiency & life

** Actual plant tests were conducted with the various bag media evaluated in a 4-around Size #2 Pall vessel at a constant 150 gpm flow which translates into the normal ~11 gpm/ft2 flux for 4 standard Size #2 bags (as well as for the molded BOSG bags); and ~2.5 gpm/ft2 for the ~60 ft2 pleated bags.*
*** Turbidities determined on collected influent and effluent samples across the bag filter, and averages over the entire bag life to terminal ΔP, (i.e., at least 7 and up to 28 sample pairs collected depending on bag life and averaged).*
**** Approximate filter area for the 4 bags tested;*
(1) Terminal ΔP depending on plant operation and/or bag limitation;
(2) Bag life in minutes to 30 psid.
(3) Dirt Holding Capacity (DHC) in grams at end of cycle at 30 psid (based on actual grams contained in bag by weighing dry dirty bag – new bag weight).

SMALL-SCALE FLAT-SHEET BAG MEDIA

Table I details a few tests with typical bag filter media challenged with ISOCTD at a nominal 8 gpm/ft2 bag filter flux and shows:

• Standard P050 felt has higher CFP values compared to DuPont's 9096 and 9097 and a poor >70 µm 98% ISOCTD efficiency, but reasonable life and 101 g DHC (corrected to a Size #2 bag area, which agrees very well with actual plant tests – see Table III).

• A vendor test of P050 results in a 125 µm 98% efficiency, which agrees very well with the CFP B.Pt./1.65 value, albeit they used a somewhat higher 12 gpm/ft2 flux. However, their life was somewhat shorter at 100 mins; and DHC also lower at 92 g (which could be attributed to the higher flux). The lower DHC could also be attributed to slightly higher ISOCTD ppm loading used (i.e., see plant evaluations in Tables III & IV)
.

• Both DuPont 9096 & 9097 media exhibit lower DHCs (except perhaps for 9097, which has similar 93 g DHC to the 101; 92 DHCs to P050), but both are significantly more efficient (i.e., 86 µm and 70 µm 98% efficiencies).

Thus, these small-scale 0.1 ft2 ISOCTD challenge tests demonstrated that P050 has reasonable life and DHC but poor 125-150 µm 98% efficiency; that DuPont's new 9096 felt media has much better 86 µm 98% efficiency but poor life and DHC; and that 9097 has some potential since its life and DHC are similar to P050, but at much better 70 µm 98% efficiency.

PLANT FULL-SCALE RESIN FILTRATION

Table II (and Figure 1) details the ~110°C resin filtration trials with actual size #1 bags; and shows:

• The 9097/9096 dual-layer bag blinds much less than the corresponding PE10 bag with low DP increase (see Fig. 1) and equivalent filtrate quality (as indicated by plant grit tests not shown here). Note that both of these two bags were tested on the same tank of resin to terminal DP so the comparison would be valid. It is believed that this lower blinding of the DuPont spunlaced media is due to greater uniformity and the absence of needle-punched holes.

• The 9097/9096 bag also opens up less than the corresponding PE25 needle-punched felt bag in another test at equivalent filtrate quality. Note that this test wasn't taken to completion (e.g., 30 psid) because the batch ran out. Nevertheless, the 9097/9096 bag showed about a 13.7 psig DP compared to about 18.9 psig for the PE25 bag; and the 9097/9096 bag has even lower MFP and B.Pt. suggesting better filtration.

• Both spunlaced bag media

TABLE IV

FULL-SCALE SIZE #2 ACTUAL PLANT TEST – SECOND ROUND*

Bag	Avg. Turbidity, (NTU) ** In	Out	% Eff.	Approx. *** Area (ft^2)	(1) Term. ΔP (psid)	(2) Life (Hrs)	(3) DHC (g)	Comments
P050	2.2	1.6	28	14	40	3:15	100	Control bags again during normal operation
"	3.9	2.1	46	14	35	1:32	68	High turbidity upset conditions
9096	3.9	1.7	55	14	35	1:00	54	Under high turbidity feed conditions both 9096 & 9097 bags result in short life at slightly higher efficiency
9097	5.3	~2.7	49	14	35	1:30	52	
BOSG (molded depth)	4.4	1.2	72	14	25	7:25	289	Improved BOSG bags have much longer life than standard Size #2 bags at comparable inlet feed turbidity but at very good 72% efficiency and DHC
80 gsm (pleated)	6.0	1.2	78	60	40	9:30	675	80 gsm pleated bags at very high inlet feed turbidity exhibit very long 9:30 life, high 78% efficiency, and very high DHC [i.e., more than (60/14 x 68-100 = 292-429 g) for area correction]. Thus, a very efficient bag media and construction

** Actual plant tests were conducted with the various bag media evaluated in a 4-around Size #2 Pall vessel at a constant 150 gpm flow, which translates into the normal ~11 gpm/ft2 flux for 4 standard Size #2 bags (as well as for the molded BOSG bags); and ~2.5 gpm/ft2 for the ~60 ft2 pleated bags.*

*** Turbidities determined on collected influent and effluent samples across the bag filter, and averages over the entire bag life to terminal ΔP, (i.e., at least 7 and up to 28 sample pairs collected depending on bag life and averaged).*

**** Approximate filter area for the 4 bags tested.*

(1) Terminal ΔP depending on plant operation and/or bag limitation.

(2) Bag life in minutes to 30 psid.

(3) Dirt Holding Capacity (DHC) in grams at end of cycle at 30 psid (based on actual grams contained in bag by weighing dry dirty bag – new bag weight).

showed less blinding after water flux tests were conducted on dried used bags (after solvent soaking overnight to remove entrapped resin) compared to new bag media, (i.e., 15 vs. 28% for 9097/9096 spunlaced vs. PE10; and -7 vs. 5% for 9097/9096 spunlaced vs. PE25.).

Thus, these actual plant paint resin trials demonstrated the superiority of the new spunlaced media compared to typical needle-punched liquid felts.

PLANT FULL-SCALE 4-AROUND SIZE

Table III details a series of full-scale plant tests with their 150 gpm wastewater stream (flux ~11 gpm/ft2) using four (4) Size #2 bags, and shows:

- The standard P050 bag exhibited a short 1:15 life but a similar 100g DHC compared to the small-scale ISOCTD challenge tests (Table I), but poor 25% NTU efficiency under abnormal operating conditions, (i.e., high inlet feed turbidity).

- DuPont's 9096 and 9097 bags exhibited higher efficiencies, longer lives, but lower DHCs. However, 9097's DHC was reasonably close to that of P050, (i.e., 92 vs. 100g); thus 9097 bags are worthy of further consideration.

- Pleated 9096 and 9097 bags have significantly longer lives and higher efficiencies and DHCs than the standard P050 bags. Note that operating problems limited the DPs to 0.6 and 1.5 psid before the tests had to be terminated. Even so, their performance merited further study because of their higher efficiencies and DHCs that simply could not be accounted for by the area increase.

- FSI's new B0SG bags also have merit due to much longer 9-hour life, increased DHC, and improved 35% efficiency (vs. 25% for P050).

Thus, these full-scale bag tests demonstrated that 9097 bags compare quite favorably to P050 bags (i.e., longer life and similar ~100g DHC, at higher efficiency); that a pleated 9097 bag of ~60 ft2 area has much longer life at higher efficiency and DHC; and that FSI's new molded

B0SG depth bags also have significant merit.

FINAL PLANT FULL-SCALE 4-AROUND

Table IV details the final round of 4-around bag trials with similar bags (except that insufficient 9097 media was available to make pleated bags so a similar 80 gsm spunlaced media was substituted); and that all bags were run to terminal DP. Basically, Table IV shows

- The standard P050 bags exhibit a slightly shorter 3:15 life, a similar 28% efficiency and 100g DHC like previously, but a much lower 1:32 life and 68g DHC (but higher 46% NTU efficiency) at upset conditions of high inlet feed turbidity.

- Under similar upset conditions, the 9096 bags exhibit much shorter life and lower DHC even though its NTU efficiency was 55%. On the other hand, the 9097 bags have similar life at lower DHC but increased 49% efficiency. However, the 9097 inlet feed turbidity was even higher (5.3 vs. 3.9 NTU), which could explain the shorter life.

- The B0SG bags exhibited a very long 7:25 life, an excellent 72% efficiency, and good DHC despite the fact that they had similar area as the P050 bags.

- The DuPont 80 gsm pleated bags (60 ft2 area) exhibited an even longer 9:30 life at even higher 78% NTU efficiency, and an excellent 675g DHC. This very high DHC cannot be accounted for by the increased area, [i.e., 60/14 x (68-100) = 292-429g vs. 674g actually removed]; hence, these pleated 80 gsm bags have significant merit for this application.

Thus, these final full-scale bag tests demonstrated the utility of pleated and molded depth bags for extended life, increased DHC, and increased efficiency with much less operator changeouts.

SUMMARY

The extensive bag filter trials conducted here both with ISOCTD challenge and full-scale plant tests demonstrated that Capillary Flow Porometry (CFP) analysis can predict bag filter media efficiencies (or micron ratings) such that ambiguous vendor ratings can be compared. In addition, full-scale tests must be done to validate ISOCTD tests since efficiencies and DHCs can vary significantly depending on the particular application. Furthermore, the test program here demonstrated the viability of pleated and molded-depth bags for increased efficiencies at much longer lives and DHCs.

For more information contact:
Dr. Ernest Mayer
E. Mayer Filtration Consulting, LLC
Tel: 1-302-981-8060
Fax: 1-302-368-0021
Email: emayer6@verizon.net

Determining Filter Cut Points and Pore Size Distributions Using Microsphere Standards

By Dr. Graham Rideal and Abi Stewart, Whitehouse Scientific Ltd., Chester, U.K.

Porometry is probably the most well known method of measuring pore size distribution. This involves using air pressure to expel a wetting liquid from the pores of a filter. When the gas pressure is applied, large pores offer less resistance and so are cleared first.

The appearance of the first bubble (the "Bubble Point") reflects the largest pore size but different instruments use different methods of detection. For example, in the Coulter Porometer, incremental "bands" of pressure are applied and the fixed band within, which the bubble first appears, is used for the calculations of maximum pore size. There therefore tends to be very good instrument-to-instrument agreement.

In other instruments, there is a continuous increase in pressure and a parallel measure of flow. Deviations from a linear pressure/flow relationship are theoretically more precise but the difficulty here is defining the exact position of the divergence. In simple terms, how much must the bubble be inflated before it is deemed significant?

The exact determination of the Bubble Point, and from it, the maximum pore size is critical as it is the benchmark from which the pore size distribution is calculated. As the pressure on the wetted filter is increased, interpolation of the pressure versus flow rate can then be used to determine the pore size distribution.

The alternative method of measuring filter cut points (a defined "maximum", pore size) and pore size distribution is the Challenge Test. In this method, a range of particles, either as solids or liquids (aerosols) are presented to the filter and the particle size of the penetrating particles measured.

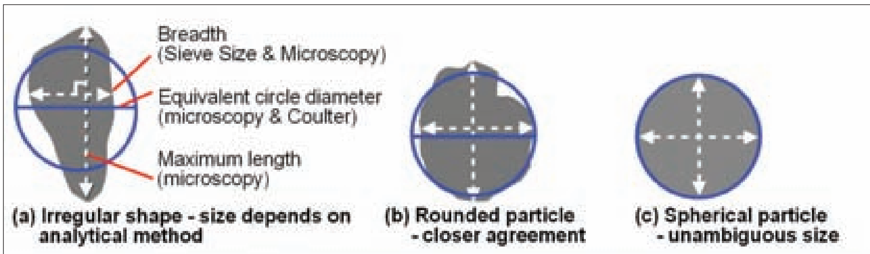


Figure 1. Irregular particles can give different results depending on the method of measurement

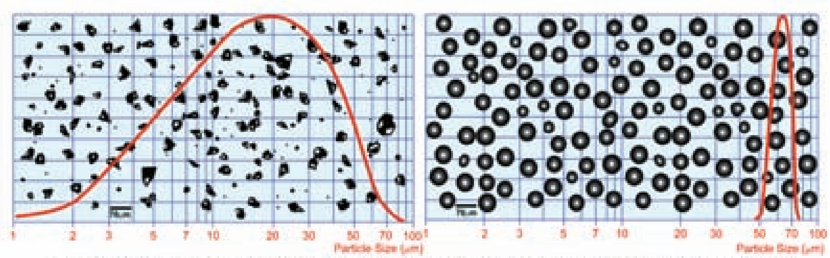


Figure 2. Narrow distribution microspheres give higher resolution results than broad distribution irregular particles

Table 1. Range of glass microsphere filter standards (μm)

2 - 6	5 - 9	9 - 11	10 - 14	12 - 18
16 – 25	20 - 34	26 - 36	31 - 46	36 - 55
45 - 62	53 - 73	63 - 86	75 - 103	80 - 103
106 - 147	127 - 175	151 - 209	180 - 248	214 - 295
252 - 346	304 - 417	360 - 498	383 - 591	484 - 700

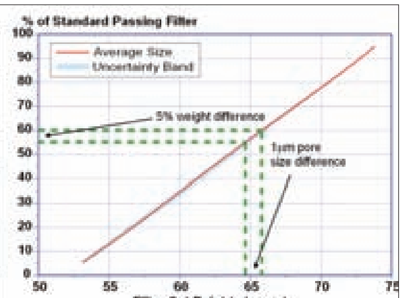


Figure 3. Narrow size distribution challenge particles produce highly accurate results

This method has the advantage that the particles can be reference to the International Metre, for example through the NIST (National Institute for Standards and Technology, USA). However, a disadvantage is that particle-sizing techniques are dependent on the method of analysis where particles are non-spherical.

This work reviews the latest techniques of challenge testing using spherical standards, where particle shape is not an issue. Filter cut points and pore size distributions can now be determined, even into the sub-micron region. Results will be presented for flat sheet filter media and also 3-dimensional small-scale filter elements.

THE CHALLENGE TEST PARTICLES

Challenge test particles come in a range of sizes and shapes, but Figure 1 illustrates the importance of using spherical particles to avoid ambiguity of particle sizing methods.

In order to further increase the accuracy of the challenge test, narrow distribution microspheres are to be preferred, Figure 2.

The only disadvantage of narrow size distribution challenge particles is that a wide range of standards must be prepared to cover all pore sizes, Table 1.

However, although time consuming to make, narrow size distribution filter standards produce very high-resolution results, Figure 3.

To ensure that the pore size is defined by the diameter of a sphere passing, non-spherical particles passing the filter under test should be removed. This can only be done electronically when microscopy and image analysis are used as the particle size analysis method, Figure 4.

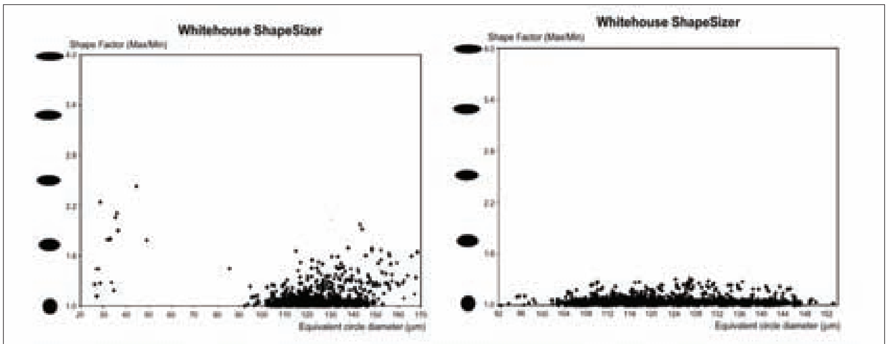


Figure 4. Non-spherical glass microspheres can be eliminated from the challenge test results when Image Analysis is used, which improves the accuracy of the method

As glass microspheres are difficult to produce below a few microns, polymer latex must be used if challenge testing is to be extended into the sub-micron region. However, polymer latex standards are only available as mono-disperse distributions and it is very difficult to produce the broader Gaussian distributions required for the challenge test described herein.

One solution is to make a "multi-modal" size distribution from a blend of mono-disperse standards, Figure 5.

In order to include as many peaks as possible within the overall distribution, the latex standards should be as narrow as possible and the method of analysis should be very high resolution. The disc centrifuge is one of the few particle-sizing methods with sufficient resolution to fulfill this requirement.

CHALLENGE TEST APPARATUS

The filter media can be challenged by the glass beads either as a fluidized dry powder, the Sonic method, or using an ultrasonic method employing an aqueous suspension of the microspheres.

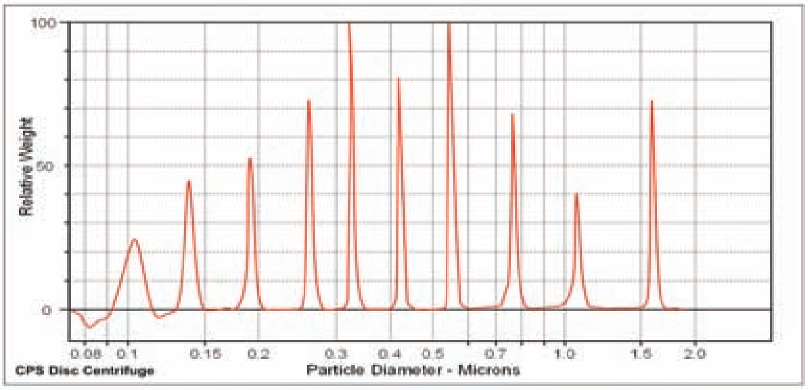


Figure 5. A sub-micron, latex challenge test standard

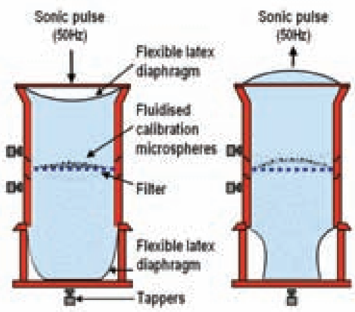


Figure 6. Fluidising action of the Sonic Filter Tester

Figures 7 and 8. The Sonic Filter Tester with 50mm and 90mm filter holders

Figure 9. 8mm diameter filter holder for the Sonic Filter Tester

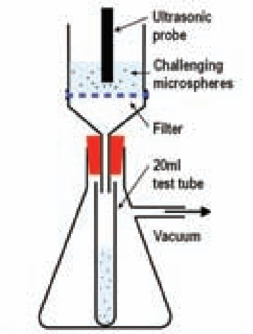


Figure 10. Ultrasonic challenge test apparatus

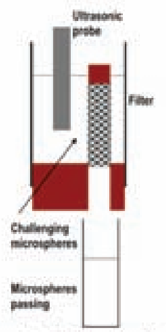


Figure 11. Adapter for filter tubes

Figure 12. A simple split filter apparatus for the wet challenge test

THE SONIC FILTER TESTER DRY TESTING

A new technology using sonic energy to fluidize the microspheres over the filter medium has been developed for the dry analysis of filters. The mechanism of the sonic action is shown in Figure 5.

The instrument measures discs from 90mm down to 8mm diameter using a range of special adapters, Figures 7, 8 and 9.

THE ULTRASONIC WET TEST

The lower limit of the Sonic challenge test is governed by the adhesion properties of the particles being used. As particles decrease in size attractive forces increase and it becomes more difficult to produce the individual particles required for the challenge test. Below about 16 microns therefore, a liquid carrier must be used.

The ultrasonic wet test can take filter testing down into the nanometer size range using for example, gold sols.

The other advantage of a suspension method of testing is that, unlike the Sonic method, the filter medium does not need to be in the form of flat discs. Figures 10 to 12 show the apparatus for testing various filter elements.

MEASURING FILTER CUT POINTS

A gravimetric method

In the Sonic dry test, the calibrating microspheres are certified using electroformed sieves, where the NIST traceability of the sieves is transferred to the filter standards. A calibration graph of weight passing versus cut point is then constructed, which can be used to derive the cut point of an unknown filter. As seen from Figure 3, the narrow distribution of the beads makes the method very sensitive.

In addition, the combination of the spherical nature of the beads with the speed of the Sonic process means that the end point is reached in as little as 1 minute.

MEASURING THE BEADS PASSING

In the analysis of the glass microspheres passing the filters, the concentration should be number rather than volume based as the data must reflect the number of apertures of particular size in the filter.

Furthermore, only spherical particles should be counted so that the pore size can be expressed in terms of a single dimension, the inscribed spherical diameter, Figure 4.

The results of a typical analysis are shown in Figure 13, where the cumulative distributions of the filter standard before and after passing the filter are compared.

Adopting the above criteria in the Image Analysis has shown remarkable agreement between the microscopic and gravimetric analyses, Figure 15.

MEASURING SUB-MICRON FILTER CUT

In the disc centrifuge analysis of cut points, the removal of larger peaks from the multimodal distributions is used to determine the maximum pore size in a filter.

Figure 15 shows the elimination of the larger peaks after the multimodal standard is passed through a 0.45- micron syringe filter.

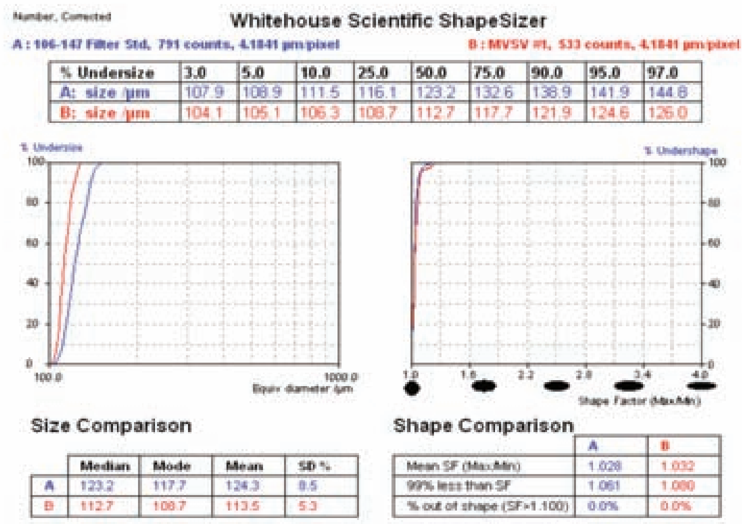


Figure 13. Image analysis of glass microspheres before and after passing a filter, where non-spherical microspheres have been eliminated from the analysis

RESULTS

Measuring filter cut points on a wire mesh

Direct optical measurement by Microscopy

For simple plain weave meshes and even some laminated meshes, it is possible to measure the apertures directly. When measuring square-hole meshes, at least 500 apertures should be counted and the X and Y dimensions recorded at the mid point of each aperture. This enables the shape of each aperture to be quantified. The minimum value is used to express the aperture sizes in terms of their inscribed circle diameters and facilitates better comparisons with the challenge test method.

In the ShapeSizer Image Analysis program, the mesh is illuminated from below and the image converted to a negative so the “white” apertures can be counted as “black” particles, Figure 16.

Apertures partially overlaid by the supporting mesh are ignored as are those containing any contaminant. Irregularly shaped apertures incorrectly generated by a “bleed” into the wire mesh in the process of creating the negative are also eliminated. The measured size was 68 microns.

Analysis of microspheres passing

Figure 17 shows a comparison of the challenging microspheres before and after passing the 75-micron mesh. The cut point is defined as the 97th percentile of the cumulative distribution of challenging beads passing the filter. The result of 69 microns was remarkably close to that obtained by direct measurement above.

CUT POINT FROM GRAVIMETRIC METHOD

In the final analysis, the 75-micron mesh was measured by the Sonic challenge test method, where the cut point was determined simply by weighing the percentage passing the filter and interpolating the calibration graph on the certificate. The cut point was once again, within experimental error, identical to the above methods at 68 microns.

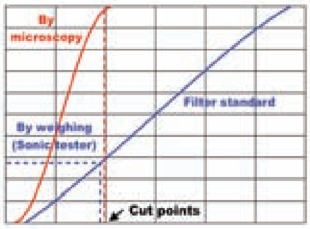


Figure 14. Filter cut points in the Sonic test are the same, whether determined gravimetrically or microscopically

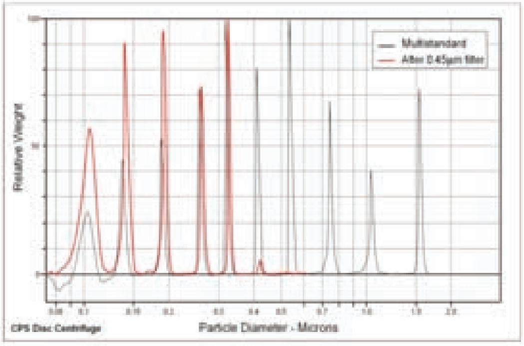


Figure 15. Measuring the cut point by disc centrifuge analysis of a multimodal filter standard before and after filtration through a syringe filter

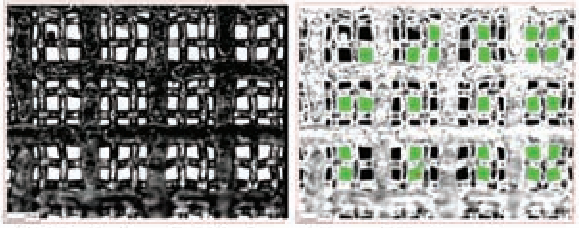


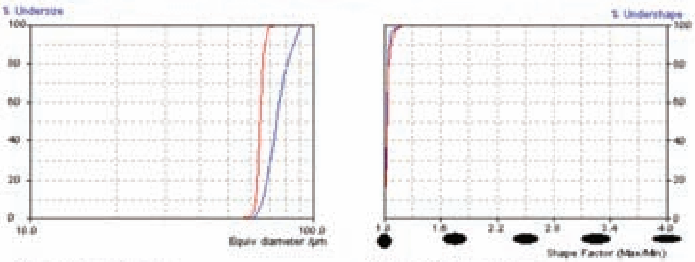
Figure 16. ShapeSizer Image Analysis of a woven filter mesh showing aperture measurement

Number, Corrected

Whitehouse Scientific ShapeSizer

A : 63-86um Filter std, 1178 counts, 2.1127 µm/pixel   B : 75um mesh #1, 838 counts, 2.1127 µm/pixel

% Undersize	3.0	5.0	10.0	25.0	50.0	75.0	90.0	95.0	97.0
A: size /µm	63.83	64.63	66.19	69.71	74.13	79.67	85.22	87.33	88.40
B: size /µm	61.43	62.12	62.57	63.66	64.81	65.94	67.44	68.47	68.84



Size Comparison

	Median	Mode	Mean	SD %
A	74.13	73.93	74.85	9.2
B	64.81	63.74	64.84	3.2

Shape Comparison

	A	B
Mean SF (Max/Min)	1.023	1.030
99% less than SF	1.050	1.074
% out of shape (SF>1.100)	0.0%	0.0%

Figure 17. Analysis of glass microspheres passing a laminated 75-micron

MEASURING THE CUT POINT 8 MM DISC

Because of the pleating and the small physical size of the sample, it was not possible to obtain enough counts to give a statistically robust measure of the aperture size by microscopy, Figure 18. However, an approximate estimate was 120 microns.

The filter disc was therefore tested by the Sonic gravimetric method, analyzing the beads passing and the ultrasonic wet method.

All three methods gave very similar results: 120, 125 and 125 microns, respectively.

It is interesting to note the "near mesh" beads that are trapped in the mesh, which when released and measured, would reflect the pore size distribution of the mesh.

MEASURING NON-WOVEN CUT POINTS

5 mm dia., 32 mm long filter element

Sonic challenge testing such small profile filter elements is difficult so the test is best performed as a wet method. This filter was produced by winding a stainless steel tape on a former so the aperture size is not as well controlled as in the weaving, Figure 19.

The results from two ultrasonic tests were 90 and 105 microns, respectively. Although these results are within the experimental error associated with the method, the deviation may be more to do with the non-uniformity of the filter itself rather than the challenge test.

MEASURING SUBMICRON FILTERS

As discussed earlier (Figure 16), by examining which peaks are removed from a multimodal standard after passing a filter, the cut point can be determined.

Figure 20 shows the results for a 0.2-micron syringe filter. It can be seen that a small peak is evident at 0.32 microns indicating that the cut point is higher than expected from the nominal rating.

MEASURING PORE SIZE DISTRIBUTIONS

Pore sizes greater than approximately 100 microns

It was shown above that when the calibrating glass beads trapped in a mesh during an analysis are released, their size would reflect the pore size distribution of the filter, Figure 18. It is therefore possible to measure pore size distribution not just in simple plain weaves, but complex 3-dimensional filters that cannot be easily measured by any other method.

Figure 21 shows the result of collecting the near mesh beads from a twilled mesh and reveals two distinct peaks at 275 and 315 microns. Porometry is the only other method capable of measuring pore size distributions, but the high porosity of this very open mesh would make the technique very difficult to get reliable results.

DISTRIBUTIONS - SUB-MICRON REGION

At the other end of the pore size spectrum, a multimodal standard can be used to measure pore size distribu-

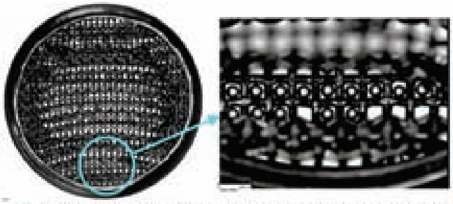


Figure 18. A pleated 8mm diameter disc showing some near mesh microspheres trapped in the mesh

Figure 19. A 5 x 32mm tape wound filter tube

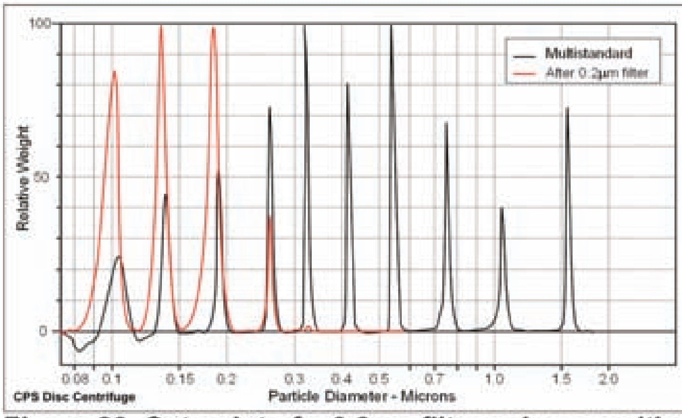


Figure 20. Cut point of a 0.2um filter using a multimodal standard

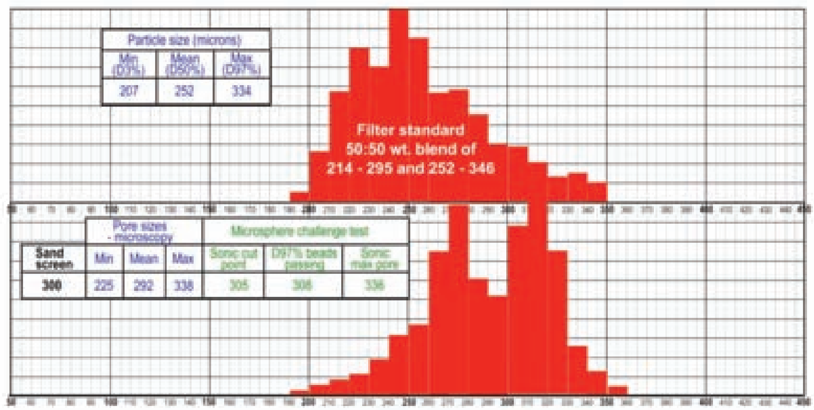


Figure 21. Pore size distribution in a twilled mesh using the near mesh method

tions in sub-micron filters. The method involves looking for the relative depletion of the peaks after passing the filter. It assumes that the smallest size will pass the filter without a concentration dilution because the particles can pass through unimpeded. All other peaks are therefore normalized to the 0.01-micron peak and the decrease in concentration reflects the number of pores that can trap the microspheres. A cumulative pore size distribution can therefore be constructed, Figures 22 and 23.

CONCLUSIONS

Although challenge testing using test dusts has been used for many years to determine filter cut points, its accuracy and reliability has been compromised by a combination of broad particle size distributions and differing shapes of the dust particles.

By making a new range of narrower size distribution standards based on glass microspheres, certified by NIST traceable electroformed sieves, it has been possible to significantly improve the reliability of the method.

In combination with the new standards, a dry sonic device for fluidizing the microspheres over the filter has been developed, which is able to perform a test in as little as 1 minute with an uncertainty down to 1 micron. Furthermore, no particle-sizing instrument

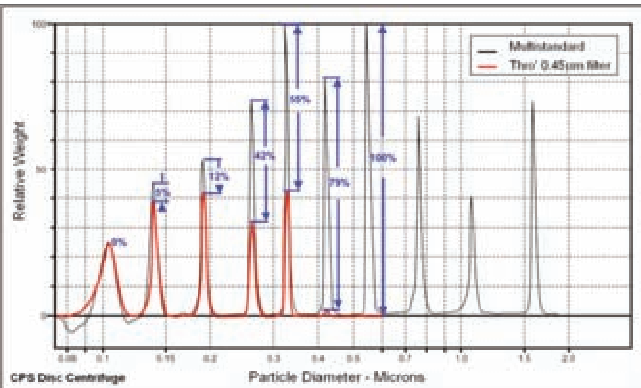


Figure 22. Microspheres passing a 0.45-micron filter normalized to the minimum peak (0.01 microns) pore sizes

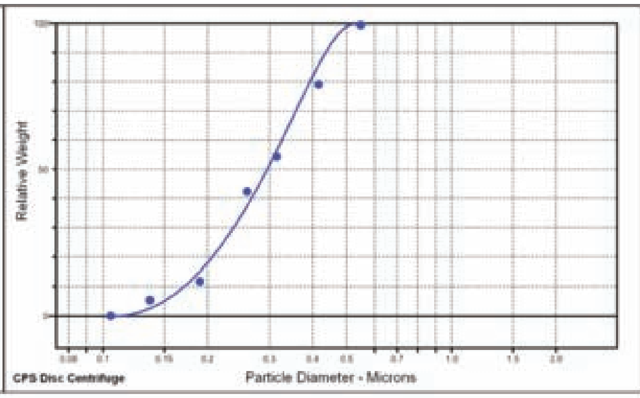


Figure 23. Peak suppression after passing a 0.45-micron filter expressed as a cumulative distribution of pore sizes

is required to measure the beads passing and the cut point can be measured simply from the percentage of the microspheres passing.

This work compared the results from the gravimetric test with those obtained by measuring the beads passing. For the most accurate results, microscopy and image analysis is recommended as the particle size analyzer as any non-spherical particles can be eliminated from the analysis. It was then found that there was remarkable agreement between the two methods

As an alternative to the dry sonic method, an ultrasonic suspension method was also evaluated. This method is particularly useful where the microspheres are too small to be successfully fluidized in the sonic device or where the filter profile does not readily lend itself to sonic testing, for example, small-scale filter tubes. It was found that, when any non-spherical particles were removed from the particle size analysis, there was again excellent agreement between the two methods.

By collecting the "near mesh" particles trapped in the pores it has also been possible to measure pore size distributions in complex 3-dimensional woven filters that would be very difficult to measure by any other technique.

Finally, a new "multimodal" polymer latex standard has been developed, which has been very successful in measuring both filter cut points and pore size distributions in filters down to 0.2 microns.

For more information contact:
Dr. Graham Rideal
Whitehouse Scientific Ltd.
Tel: +44-1244-332626
Fax: +44-1244-335098
Email: rideal@whitehousescientific.com
Website: www.whitehousescientific.com

AFS Gears Up for Oil & Gas and Chemical Processing Conference

By Ken Norberg, Editor

Oil and gas, chemical processing, filtration and separation, are the focus for AFS' 2014 Spring Conference to be held in Texas..

The American Filtration & Separations Society is gearing up for the 2014 Spring Conference in Houston, Texas, where focus will be on the Oil & Gas and Chemical Processing Filtration & Separations Conference. The event is scheduled for March 25-26 and will be held at the Houston Marriott Westchase.

The ever-increasing demand for energy and hydrocarbon-based products, process separation plays a critical role in enabling operations to run at higher capacities with low operational cost and reduced environmental impact. The conference will address a variety of separation methods available to the industry, from filters and coalescers to membranes and cyclones, and many more.

AFS encourages anyone involved in the oil, gas or chemical processing industry to attend; specialists and process engineers looking to understand specific separation methodologies, research and development scientists who want to present their innovations, and young engineers looking for a primer in this exceptionally important area.

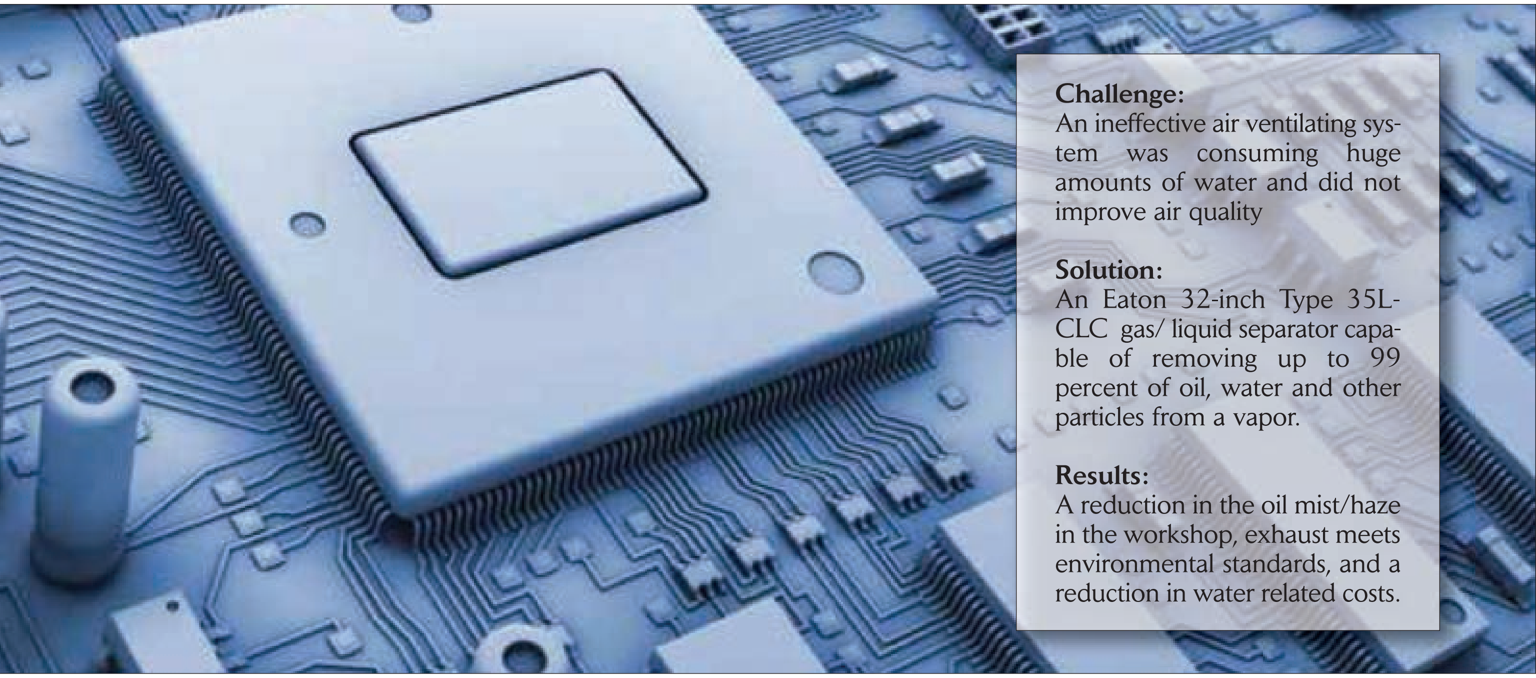
The conference will include not only talks on technologies, but also on key subject areas such as produced water treatment and natural gas processing, and will focus on both mechanical and chemical means to promote process separations.

The conference will be preceded by specialized training short courses and accompanied by leading industry experts as keynote speakers and presenters. This conference is primarily technical; however a select number of suppliers will also be available to show new products and services.

The venue is conveniently located in the energy corridor of Houston, a city that is the heart of the hydrocarbon-processing world. This conference will help engineers to understand best-in-class practices for their filtration and separation questions, and help them build their professional network to include some of the foremost authorities in the world on these processes. FN

For more information visit:
www.spring.afssociety.org

Eaton Gas/Liquid Separator Solves Ineffective Air Ventilating System



Challenge:
An ineffective air ventilating system was consuming huge amounts of water and did not improve air quality

Solution:
An Eaton 32-inch Type 35L-CLC gas/ liquid separator capable of removing up to 99 percent of oil, water and other particles from a vapor.

Results:
A reduction in the oil mist/haze in the workshop, exhaust meets environmental standards, and a reduction in water related costs.

A computer component manufacturer's ineffective air ventilation system was solved by Eaton's gas/liquid separator.

One of the world's largest manufacturers of touch panel screens, notebook covers and related electronics equipment reached out to Eaton to help it reduce environmental issues related to its sophisticated manufacturing process. The Taiwan-based manufacturer believes that it has the most computer numerical control (CNC) machines in the world, and its international lineup of customers, which reads like a Who's Who in the computer and communications industries, helps support that claim. Computer numerical control was introduced to the machining industry in the early 1970s. It has since revolutionized the way various metals are milled, lathed, drilled, cut and polished. The most basic function of any CNC machine is automatic, precise and consistent motion control.

Rather than applying completely mechanical devices to cause motion as is required on most conventional machine tools, CNC machines produce motion control via computer programming. All forms of CNC equipment have two or more directions of motion, called axes. These axes can be precisely and automatically positioned.

The CNC machining often uses lubricants to help diminish the high levels of heat typically generated in the process. Another downside is the vaporization of coolant, which often produces an airborne mist or haze. Though not believed to be a serious health hazard, the haze can make breathing uncomfortable and irritate eyes. In addition, the mist cannot be released into the atmosphere according to local environmental protection laws. Doing so would result in substantial fines. Corporate sustainability mandates would also be compromised.

CHALLENGE

Eaton's customer was relying on an old and ineffective air ventilating system that consisted of a scrubber and plasma treatment equipment. Becoming increasingly more ineffective over the years, the two-step arrangement was also consuming huge amounts of water. That same water was being contaminated with oil residues and had to be transported to sewage treatment facilities. Meanwhile, the plant air quality did not improve.

Costly, dirty and encumbering quality, the system that kept tools and metals cool and lubricated needed to be replaced.

Eaton was recently summoned to clean up the mess.

SOLUTION

An Eaton gas/liquid separator was installed to replace the outdated system to clear the air inside the manufacturing facility of that unpleasant mist. A 32-inch Type 35L-CLC was selected for the application, which is capable of removing up to 99 percent of oil, water and other particles more than four microns in size.

The self-contained two-stage design of the system functions by, first, increasing the size of liquid droplets through a wire mesh de-misting pad in the vessel's container. Next, the droplets are centrifugally thrown to the outside wall and flow to the bottom of the vessel for draining. The Eaton gas/liquid separator also prevents the droplets from being re-entrained after separation.

Additional features of the Eaton gas/liquid separator include:

- High efficiency of oil mist removal
- No internal moving parts
- Reduced maintenance
- No media to be disposed

Eaton boasts one of the world's largest inventories of filtration products. Designed for efficiency in a variety of demanding markets, applications, and environments, Eaton's lineup of filters includes pipeline basket strainers, mechanically cleaned filters and strainers, tubular backwashing filters, filter bags and bag filter housings, filter cartridges and cartridge filter housings, gas liquid separators, depth filtration, as well as hydraulic and lubrication oil filtration solutions to help optimize filtration performance, quality and plant productivity.

Eaton Type 35L-CLC Gas /Liquid Separator with Side Inlet for Vertical up Flow. The unique two-stage design removes 99% of liquid and solid particles larger than 4 microns in size. The Eaton Coalescer/Separator's efficiency far exceeds that of any other type of centrifugal, cyclone, turbine, or vane separator.

Eaton Type 31L-CLC Gas/Liquid Separator for Vertical Applications – In the first of a two stage separation process, smaller liquid droplets enter a de-misting pad in the vessel. The purpose is to increase the size of the droplets so they can be removed. In the second stage, the larger droplets are centrifugally thrown to the outside of the vessel for draining.

RESULTS

After installation, oil mist/haze has been reduced to a minimum in the workshop, exhaust is meeting the necessary environmental standards, and the grease from the cooling liquids can be reclaimed and reused – an added benefit that was not possible with the old system.

Because no water is used with the Eaton separator, filtration costs have been reduced substantially, as have associated transport and disposal costs of contaminated water.

Employees at the site are also benefitting with cleaner, healthier working conditions, and Mother Nature is pleased by the absence of harmful emissions and water contaminates.

That's precisely what the company wanted.

ABOUT EATON

Eaton is a diversified power management company providing energy-efficient solutions that help customers effectively manage electrical, hydraulic and mechanical power. A global technology leader, Eaton acquired Cooper Industries plc in November 2012. The 2012 revenue of the combined companies was $21.8 billion on a pro forma basis. Eaton has approximately 102,000 employees and sells products to customers in more than 175 countries. FN

For more information contact:
Eaton
44 Apple Street
Tinton Falls, NJ 07724
Website: www.eaton.com/filtration

U.S. Demand for Water Treatment Equipment to Reach $13 Billion in 2017

Demand for water treatment equipment in the U.S. is forecast to grow 5.9 percent per year to $13.0 billion in 2017. Gains will be supported by increasing concerns about the health risks and environmental impacts of biological contaminants, chemicals, and disinfection byproducts in supply water and wastewater, and by more stringent manufacturing requirements in process water. These and other trends are presented in *Water Treatment Equipment*, a new study from The Freedonia Group, Inc., a Cleveland-based industry market research firm.

WATER TREATMENT EQUIPMENT DEMAND (million dollars)					
% Annual Growth					
Item	2007	2012	2017	2007-2012	2012-2017
Water Treatment Equipment Demand	7760	9760	13010	4.7	5.9
Municipal	3630	4610	5950	4.9	5.2
Manufacturing	1818	2350	3150	5.3	6.0
Commercial & Residential	1076	1110	1520	0.6	6.5
Resource Extraction	618	973	1470	9.5	8.6
Power Generation	525	588	690	2.3	3.3
Other Markets	93	129	230	6.8	12.3

The resource extraction market is expected to show the most rapid gains among the major markets, as the treatment requirements for produced water in oil and natural gas extraction continue to rise, and as water recycling and reuse increase to satisfy the needs of expanded hydraulic fracturing activities. An expected rebound in mining output, particularly for minerals, will also contribute to an increased need for water treatment equipment. Rising demand will particularly benefit conventional filtration systems, which are the most commonly used type of equipment in the resource extraction market. The anticipated implementation of new U.S. EPA regulations for hydraulic fracturing is also expected to promote growth in the resource extraction market in the long term.

The commercial and residential markets for water treatment equipment are expected to continue to recover from the declines seen during the 2007-2009 economic recession, with demand boosted by greater consumer interest in drinking water quality, increased consumer confidence, and expanded commercial and residential construction activities. Point-of-entry membrane filtration, disinfection, and deionization equipment is expected to benefit the most from rising demand.

The municipal market for water treatment equipment is expected to continue to experience healthy growth through 2017. Expanded manufacturing output in response to the improving U.S. economy, as well as increasingly stringent manufacturing requirements, will support growth in demand for every major type of water treatment equipment. While quite small in 2012, ballast water treatment is expected to be the fastest growing market segment overall, as U.S. ships will soon be required to have ballast water management systems, including membrane systems and ultraviolet disinfection equipment, installed onboard to prevent the spread of invasive marine and aquatic species between ecosystems. FN

For more information contact:
Corinne Gangloff
The Freedonia Group
Tel: 1-440-684-9600
Fax 1-440-646-0484
Email: pr@freedoniagroup.com
Website: www.freedoniagroup.com

CLARCOR Acquires Bekaert Advanced Filtration Business

CLARCOR Inc. announced in December 2013 that it has acquired the Bekaert Advanced Filtration business from NV Bekaert SA for a purchase price of approximately €6 million ($8 million), before various contractual adjustments. The Advanced Filtration business is engaged in the same line of business as CLARCOR's subsidiary, Purolator EFP – the manufacture and supply of engineered metal filters and systems used primarily in the polymer fiber and plastics industries.

With estimated 2013 sales of approximately €15 million ($20 million), the business, which has been renamed Purolator Advanced Filtration, has approximately 170 employees and manufacturing facilities located in Belgium and Indonesia, as well as sales personnel in North and South America. The transaction also includes a supply contract under which the combined business can continue to purchase specialized Bekipor® metal fiber filtration media from Bekaert for incorporation into certain of the company's products. The acquisition is not anticipated to be materially accretive or dilutive to CLARCOR's 2014 earnings.

Christopher L. Conway, CLARCOR's chairman, president and CEO commented, "Bekaert is known in the industry for its top level engineering capabilities and superior product quality, and it is not uncommon for customers with demanding applications to insist upon Bekaert Advanced Filtration systems and filters. The acquisition of the Advanced Filtration business will expand the technical capabilities of Purolator EFP, improve the product offerings that the company brings to market and help us continue to grow in Europe and in Asia."

Commenting on the acquisition, Oliver Forberich, the general manager of Bekaert Fiber Technologies, agreed with Mr. Conway, stating, "This transaction makes perfect sense for both parties. As a leader in polymer and plastics filtration, Purolator EFP can grow its global footprint and leverage its product catalog and sales and marketing strengths, while at the same time Bekaert will focus on its core strength of providing advanced metal filtration media."

CLARCOR is based in Franklin, Tennessee, and is a diversified marketer and manufacturer of mobile, industrial and environmental filtration products and consumer and industrial packaging products sold in domestic and international markets. Common shares of CLARCOR are traded on the New York Stock Exchange under the symbol CLC.

Bekaert (www.bekaert.com) is a world market and technology leader in steel wire transformation and coatings. Bekaert is a global company with headquarters in Belgium, employing 27,000 people worldwide. Serving customers in 120 countries, Bekaert pursues sustainable profitable growth in all its activities and generated combined sales of € 4.4 billion in 2012. FN

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UNITED KINGDOM:
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UNITED STATES OF AMERICA:
Tel: + 1 704 552 3708
Joan Oakley, Email: joan@filtnews.com
Debra Klupacs, Email: debra@filtnews.com

ALL OTHER COUNTRIES:
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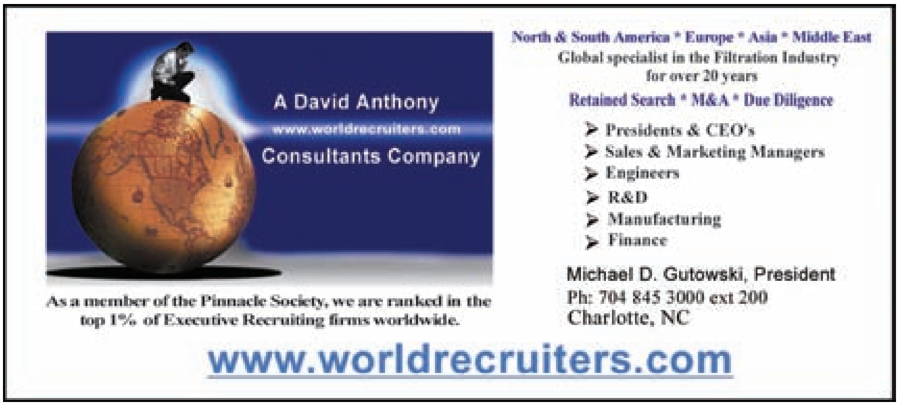

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Sabine Dussey
INTERNATIONAL JOURNALS
Duppelstr. 7
D-42781 Haan, Germany
Tel: 49 2129 348390
Fax: 49 2129 3483910
Email: Sabine.Dussey@dussey.de

Austria, Switzerland
Martina Kohler
IFF Media AG
Emmersbergstrasse 1
CH-8200 Schaffhausen, Switzerland
Tel: 41 52 633 08 88
Fax: 41 52 633 08 99
Email: m.kohler@iff-media.ch

Italy
Ferruccio Silvera
Silvera Pubblicitá
Viale Monza 24, I-20127 Milano, Italy
Tel: 39 02 284 6716
Fax: 39 02 289 3849
Email: ferruccio@silvera.it

United Kingdom
Judy Holland
Textile Media Services Ltd.
Homerton House, 74 Cawston Road
Reepham, Norfolk NR10 4LT, UK
Tel: 44 1603 308158
Fax: 44 8700 940868
Email: jholland@textilemedia.com

China
Zhang Xiaohua
Beijing, China
Mobile: 0086 13522898423
Email: intl_business@126.com

India
Yogesh Jog
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Tel: 91 79 26752628
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UNITED STATES OF AMERICA
Joan Oakley
Debra Klupacs
6000 Fairview Road, Suite 1200
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ALL OTHER COUNTRIES
Ken Norberg, Editor
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