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FEBRUARY 2024



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Fire Authorities
Adopt Early Thermal
Runaway Detection
Technology



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Creating
Boiler Plant Control
Where None Exists

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DEDUCT THE FULL COST OF QUALIFIED PROPERTY IMPROVEMENT!

CARES ACT

The Coronavirus Aid, Relief, and Economic Security (CARES) Act closed a loophole that was included in the TCJA by making QIP 15-year property. This change made businesses of all sizes, regardless of the amounts spent on equipment, eligible to deduct the full cost of commercial fire sprinkler systems using bonus depreciation.

The time is now to upgrade your building's fire safety with a fire sprinkler system or a sprinkler retrofit. Under the new Section 179 guidelines, the one year deduction period phases out after 2022. Any new sprinkler system or retrofit completed between September 27, 2017 and December 31, 2022 will be able to be fully expensed in one year. After 2022, the allowed deduction percentage is as follows:

2021: 100%	2023: 80%	2025: 40%
2022: 100%	2024: 60%	2026: 20%

2027 and after: The depreciation schedule becomes permanently set at 15 years.

WHAT IS QIP?

The Tax Cuts and Jobs Act (TCJA), passed in December, 2017, gave small businesses the ability to deduct the full cost of Qualified Improvement Property (QIP) up to \$1.04 million in the year of installation using Section 179.

QIP is defined as improvements to the interior of an existing building that is not residential property. Commercial fire sprinkler systems, including upgrades of existing systems or retrofitting in existing structures, are considered QIP.

The Section 179 deduction is not phased out over time. However, there is a phase out of the amount allowed as a deduction based on a maximum spending amount of \$2.59 million on equipment in a year. Businesses that spend over that amount will see a dollar for dollar reduction of their eligible deduction. So a business that spends \$3.63 million or more on equipment in a given year would not be allowed any Section 179 Deduction.

WHAT HAS CHANGED?

Prior to the TCJA allowing Section 179 on qualified improvement property, including sprinkler systems, property of this type was only allowed a deduction on a straight line basis over a period of 39 years. In other words, a company spending \$390,000 on a commercial sprinkler system prior to the TCJA would only deduct \$10,000 per year for 39 years.

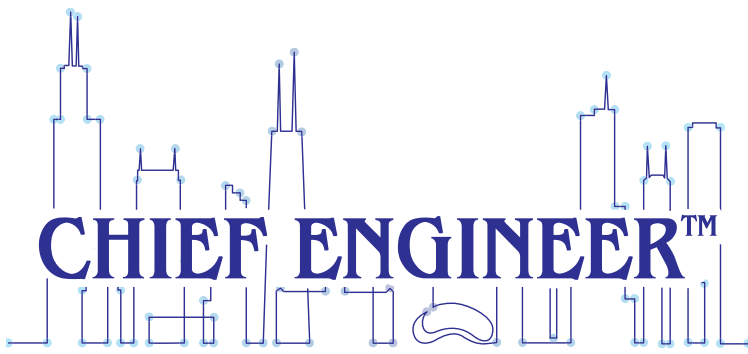
While many believe that the intention of Congress was to make Qualified Improvement Property 15-year property, which would have made this property eligible for bonus depreciation, the TCJA left the life of this property at 39 years. So, a taxpayer who did not elect to use the Section 179 Deduction or who has that deduction phased out would have been left to depreciate the remaining balance of the assets over a 39-year period.

Neither of these deductions is currently available for fire sprinkler systems installed in residential high rises. The National Fire Sprinkler Association (NFSA) continues to fight to obtain incentives for residential structures.

For more information on how these tax incentives might impact the business of your contractors, we would recommend that they contact their tax professionals, as situations differ based on the facts and circumstances for each business. As a general rule, we would not recommend that the Local provide tax advice to the contractors.



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Kate Gawlik talks to Chicago Public Schools Zone Chief Engineer Bob Bombard about his path through the educational system to becoming a chief engineer and Local 399 member — a Bombard family tradition.

20 Fire Authorities Adopt Early Thermal Runaway Detection Technology

With Li-ion battery energy storage systems applications expanding around the globe, fire authorities and life safety system experts are recommending detection technology that provides a warning far earlier than traditional monitoring and detection methods.

26 Creating Boiler Plant Control Where None Exists

New, connected HVAC system controls offer a great opportunity to reduce energy consumption and simplify maintenance in smaller buildings without installing a building automation system.

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Dear Members,

I would like to take this opportunity to say thank you to everyone who came out to celebrate our new Officers and Directors at the Inaugural Event at Thalia Hall last month. It was a great time, and I'm glad that so many of you came out to be a part of it all. We were glad to honor our Members of the Year, and to get into the spirit of the night with JUMP – America's Van Halen Experience giving a performance that was truly "unchained."

Making it all happen behind the scenes, we have to extend our thank-yous to both the Events Committee who helped bring this night together, as well as to our invaluable sponsors, including our Rockstar sponsor, Air Comfort, our Spotlight sponsors AMS Industries, Inc. and IUOE Local 399, our Backstage sponsors Parkway Elevator, UG2 and United Radio Communications, and our Groupie sponsors Cristaux International and Ryan Fire Protection, for making this night one for the books. Many thanks to all of you!

This month we host our annual Skatfest on Saturday, Feb. 17, from noon to 4:00pm at Morgan Park Sports Center at 11505 S. Western Ave. in Chicago. As always, families are invited, and there will be food, drinks, open skating and open gym for all. This is a great event for the kids, so I hope we'll see you there.

Event sponsorship opportunities are still available for the St. Patrick's Day Meeting, to be held Wednesday, March 20, at the Irish American Heritage Center, 4626 N. Knox Ave., Chicago. If your organization wants to take part in sponsoring one of the most popular CEAC meetings of the year, please reach out to our Events Committee at events@chiefengineer.org.

At this point in the season, I'm sure everyone is taking care of their coil cleaning, infrared inspections and such. Don't forget to reach out to our Associate Member businesses for any outside assistance you need – they deserve our support!

Let's stay warm and always keep in mind those men and women in uniform both here at home and abroad for keeping us and our way of life safe.

See you out on the ice at Skatfest!

Sincerely,



Doug Kruczek





ASHRAE's Latest Edition Performance Standard for Existing Buildings Shifts Focus to Decarbonization

ASHRAE has released the latest version of its energy efficiency standard for existing buildings, with an expanded focus to incorporate building decarbonization.

ANSI/ASHRAE/IES Standard 100-2024, Energy and Emissions Building Performance Standard for Existing Buildings is a code-ready building performance standard that provides processes and procedures for reducing energy consumption and carbon emissions through improved energy efficiency and performance of all types of existing buildings, including residential, commercial, institutional and industrial. The latest edition of the standard includes carbon emissions performance requirements for existing buildings, as well as emissions targets for dozens of building types.

"As the demand grows for reduced energy use and carbon emission in existing building, there has been heightened interest in Standard 100 within the past year for its potential to shape building regulations on an expanded level," said 2023-24 ASHRAE President Ginger Scoggins, P.E., Fellow ASHRAE. "The development of this revised standard underscores our commitment to advancing sustainability measures and responding to the evolving needs of the industry."

Key updates to the standard are as follows:

- New metrics provided for establishing greenhouse gas emissions targets, along with continued improvements to energy efficiency and performance in existing buildings.
- Building requirements to:
 - Establish an energy management plan incorporating efficient, low-carbon equipment into capital replacement.
 - Achieve energy and emissions performance goals
 - Implement an operations and maintenance program for continued building performance.
- Simple compliance mechanism for energy-efficient and low-emission buildings.
- Energy audit and decarbonization assessment and a separate compliance process for building types that do not have energy or emissions targets.
- Guidance for jurisdictions seeking to develop their own energy consumption and/or greenhouse gas emissions targets.



To purchase Standard 100-2024, visit ashrae.org/bookstore or contact ASHRAE Customer Contact Center at 1 (800) 527-4723 or fax (678) 539-2129.

ASHRAE Announces Nominees for 2024-25 Slate of Officers and Directors

Nominations for officers and directors were made by the ASHRAE Nominating Committee from a list recommended by individual members and from Chapters Regional Conferences. The 2024-25 nominees are as follows:

- **President-Elect:**
Bill McQuade, P.E., Fellow ASHRAE, LEED AP
- **Treasurer:**
Sarah Maston, PE, BCxP, LEED AP
- **Vice Presidents:**
Devin Abellon, P.E.
Ken Fulk, P.E., Life Member ASHRAE
- **Directors and Regional Chairs:**
Charles Bertuch, P.E. (Region I)
Genevieve Lussier (Region II)
Sherry Abbott-Adkins (Region III)
Rob Craddock (Region XI)
Bassel Anbari, P.E. (Region-at-Large)
- **Directors-at-Large:**
Carrie Brown, Ph.D.
Patrick Marks, P.E.
David Yashar, Ph.D.
- **Alternate Director-at-Large:**
Suzanne LeViseur, P.E., HBDP, Fellow ASHRAE

ASHRAE members will vote on the nominees via electronic ballot in May. M. Dennis Knight, P.E., BEMP, Fellow Life Member ASHRAE, will serve as ASHRAE President for the 2024-25 Society Year. 🗳️🗳️

For more information on the 2024-25 slate of officers and directors, visit ashrae.org/2024-2025slate.

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2024 TOBY Gold Circle Awards Gala

Wednesday, Feb. 7, 2024
Hyatt Regency Chicago
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The TOBY Gold Circle Awards event celebrates the best of the best in Chicago’s commercial real estate industry. This premier event is the first BOMA event of every year, attracting more than 600 industry decision-makers.

At this event, BOMA/Chicago presents:

- The Outstanding Building of the Year (TOBY) awards, which recognize quality and excellence in building management
- The Gold Circle Awards, which honor individual excellence in the industry

Come take part in this event that celebrates the best in our industry in Chicago.

For more information and to register for tickets and sponsorship opportunities, visit tinyurl.com/4uj6wwaj



Illinois PHCC EXPO North

Friday, March 22, 2024
Drury Lane Conference Center
Oakbrook Terrace, IL

The Illinois PHCC has scheduled Friday, March 22, 2024, as the date for its annual trade show. The EXPO will once again be held at the Drury Lane Conference Center in Oakbrook Terrace, Ill.

The March 22 date will be a day for educational opportunities and attending the EXPO. A continuing education program will be offered from 9:00am-1:00pm. This will be held in the theater, allowing up to 800 people to receive their CEU credit. Exhibitors and attendees are both invited to the after-EXPO party, where there will be prizes and free food.

Booths are selling quickly, so act now to reserve your space for the event of the year. Both pages of the hardcopy contract MUST be signed and returned to the Illinois PHCC either by email or mail in order for the space to be held. Visit tinyurl.com/47fyjzw2 for the two-page hard copy contract you can mail in a check with your contract or visit tinyurl.com/5n8mzzhm to pay online by credit card. Discounts for four or more booths will calculate automatically after you make your selection on the form.

The 2023 Expo was sold out — act now to avoid disappointment by reserving your booths for 2024. For more information and to register, visit www.ilphcc.com/expo

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American Coatings Show & Conference

April 30-May 2, 2024

Indiana Convention Center
Indianapolis, IN

The American Coatings Show (ACS) is the leading North American coatings industry event, setting trends for future developments in the industry. Attending the show facilitates immediate business opportunities, access to a complete portfolio of high-grade competitive products, and myriad networking and connection opportunities.


The dynamic offerings to which attendees can look forward include:

- The American Coatings Conference, which is held concurrently with the exposition, will provide an in-depth comprehensive overview of advancements in coatings formulations, as well as key technological developments. Speak directly to top decision-makers in international coatings development or present your own expertise.
- Live, onstage Product Presentations, which allow you to be among the first to learn about new innovations in the coatings industry
- The Industry Buyers Lounge, which provides a designated area for show participants to set up important meetings.
- The trade show and conference newspaper, the American Coatings Show Daily, published all three days of the show, features daily highlights, interviews with industry experts, exhibitor booth locations, and more.
- In 2024, the ACS will once again feature a Powder Coatings Pavilion.

The ACS also will feature a keynote presentation from Dr. Robert Roop, Senior Vice President and Chief Technology Officer at Axalta Coating Systems. His lecture, Coatings Innovation in the Future: Sustainability and Performance, will explore the shift in coatings innovation focus. He will show how, in the past, innovation was driven primarily by the need for improved performance — durability, cure rates, consumption, etc. — while meeting regulatory compliance. And he will discuss the future of the industry, in which innovation will be heavily focused on improved sustainability, driven by societal demands.

Dr. Roop has served in his current role at Axalta since July 2019, and in various technology leadership roles across Axalta over

the preceding 10 years. Prior to those roles he spent 20 years in technology and operations positions at DuPont in various polymer and chemical businesses. Dr. Roop holds a B.S. in Chemical Engineering from West Virginia University and a Ph.D. in Chemical Engineering from Texas A&M University.

An added attraction for the benefit of the industry's future is the ACS Fun Run, sponsored by BYK, which will take place Wednesday, May 1, 2024, from 7:15-8:15am. You can register online or in-person for this event. Cost is \$30, proceeds of which go toward funding student participation in future American Coatings Conferences. 

For more information and to register, visit american-coatings-show.com

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Beverly Companies Named One of Chicago’s Best & Brightest Companies to Work For

The latest batch of winning companies for 2024 has been recognized by The Best and Brightest Companies to Work For®, celebrating their exceptional achievements. This esteemed accolade is reserved for companies demonstrating unparalleled innovation in business strategies and human resource practices. These distinguished winners represent top-tier companies, given the stringent 10-to-one ratio of this recognition program.

An independent research firm meticulously evaluated all entered companies, comparing them against other nationally recognized organizations. They were assessed across various criteria, such as Compensation, Benefits, and Employee Solutions; Creative Wellness and Wellbeing Initiatives;

Employee Enrichment, Engagement, and Retention; Employee Education and Development; Recruitment and Selection; Employee Achievement and Recognition; Communication and Shared Vision; Diversity, Equity, and Inclusion; Work-Life Balance; Community Initiatives and Corporate Responsibility; and Leadership, Strategy, and Company Performance.

The National Association for Business Resources (NABR), with over 25 years of experience in conducting the Best and Brightest competitions, has identified exemplary Human Resource practices, offering benchmarking for companies leading in employment standards.

Jennifer Kluge, President and CEO of NABR and The Best and Brightest Program, remarked, “The companies listed as the Best and Brightest Companies to Work For, as well as those consistently making the list, are undeniably remarkable. In today’s competitive landscape, marked by talent acquisition and retention challenges aggravated by the pandemic, these companies have showcased their superiority in navigating market conditions. Their innovative thinking and unwavering commitment to excellence shine through in this prestigious honor.”

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Best Practices: The Importance of Thermostat Calibration

Thermostat calibration is relatively simple to do, but with regular maintenance and optimization, can result in significant, long-term cumulative savings.

Among the various tools at the Chief Engineer's disposal for maintaining the efficiency and reduced costs for running your building's HVAC system is the relatively simple process of thermostat calibration. By adjusting your thermostat settings and connections to accurately reflect the temperature at which your HVAC system switches on, you can ensure that it does not run unnecessarily, avoiding inefficiency and unnecessarily higher energy bills.


There are a number of aspects to proper thermostat calibration and maintenance. One of the first issues to investigate should be the monitoring of sensor performance. A bad or inoperative sensor is likely to cause inaccurate temperature readings, throwing off the operating cycle of the whole HVAC system. Regular testing of the sensors and checking for loose connections, frayed wires or other damaged elements that might disrupt communication between the thermostat and the HVAC system will ensure smooth and seamless integration between the two systems and prevent costly inefficiencies. (According to source Energy5, studies indicate that a properly calibrated thermostat can result in energy savings of up to 10 percent, which, over time, can result in much more significant savings overall.) It's also a good idea to regularly clean your thermostat and sensors, to ensure that they're free of dust or any material that might impede their performance, and inspect for any damage that might likewise interfere with its proper operation.

Once you have ensured the operability of your thermostat and its

connection to your HVAC system, you'll want to get an accurate reading of the room temperature in which your thermostat is located. Put a reliable thermometer near the thermostat, out of range of any heat sources or drafts, and wait about 15 minutes for a proper room reading. Check the thermometer's reading against that of your thermostat to see if there are any discrepancies. If there's a significant deviation between the two, it's time to recalibrate your thermostat. Most programmable thermostats offer a function to adjust the temperature differential or cycle rate at which your thermostat switches on or off your HVAC system. Consult the manual for your thermostat to locate these settings and adjust accordingly.

After calibration is made, it's a good idea to test your thermostat to ensure its accuracy and that it will function as needed at the proscribed temperature reading. Once the test is performed and the calibration results verified, documentation should be made of the calibration procedures and results for future reference and for any necessary compliance purposes, and the temperature settings should be optimized based on building occupancy patterns and appropriate to weather conditions.

Ensuring your thermostats' proper calibration can help demonstrate compliance during audits, inspections or certifications, and also instill confidence in your property owners, partners and regulatory bodies. What's more, you'll establish a comfortable working environment for your building's tenants, enhance efficiency and

lower the likelihood of costly system downtime due to disrepair. By making thermostat maintenance and proper calibration part of your regular routine, you'll lengthen the life of your systems, improve indoor comfort and help manage energy expenses. 

Employing Smart Thermostats for Optimal Calibration

Conventional thermostats, can, of course, be calibrated to optimize performance as outlined above. But with the introduction of smart thermostats, optimization has been taken to the next level, employing advanced sensors and computerized algorithms to further enhance calibration precision. Here are a few additional advantages of integrating smart thermostats into your systems:

Learning Capability – By learning your temperature preferences and setting patterns over time, smart thermostats can adjust automatically, and create personalized schedules based on your system's output and your building's needs, resulting in fine-tuned comfort and savings.

Remote Access – Through a manufacturer's app, you can control your building's thermostat from your cellphone, tablet or other smart device, providing control in the moment without the need to be onsite.

Energy Usage Reports – One of the best benefits to smart thermostats is their ability to generate detailed energy consumption reports, articulating your building's usage patterns, and allowing you to make accurate, informed decisions about energy-saving adjustments.

Source: Energy5



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All in the Family

By Kate Gawlik

Bombard and his wife, Maggie, have three children: Molly, Danny and Elizabeth.

The National Student Research Clearinghouse reported in spring 2023 that 4 million fewer students enrolled in U.S. colleges compared with 10 years ago. There are many factors contributing to this trend, such as the pandemic and high tuition prices. People also are increasingly questioning the value of a bachelor's degree and its necessity compared with other education options.

Two-year associate's degrees, trade schools and certification programs have always been viable options, and more people are starting to realize it.

This was the case for chief engineer Bob Bombard. He transferred to Washburne Trade and Continuance School after completing two years at Morgan Park High School. It was his girlfriend and future wife, Maggie, who turned Bombard's career path toward the Chief Engineers Association of Chicagoland (CEAC). Maggie's uncles, Jim and Jack Doyle, introduced Bombard to the engineering trade. Both have been members of local 399 for more than 60 years. Maggie's grandfather, Michael Doyle, also was a 399 member.

Jim worked at Cook County Hospital, Jack worked at Cook County Oak Forest Hospital, and Mike worked at the University of Illinois at Chicago.

"In 1999, Maggie's uncles said, 'If you're going to marry Maggie, you need a better job.' They got me started in classes

at the Hall that year," Bombard remembers. It turned out to be a great decision, on many levels.

A Focus on Upgrades

Bombard's first engineering job was at the Congress Plaza Hotel in 2000. He worked his way up from engineer, refrigeration engineer, assistant chief engineer to chief engineer over a 22-year span.

During that time, Bombard oversaw daily operations, capital projects, room maintenance, renovation of guest rooms, new equipment installations, upgrading pumps and chiller systems, and repairing boiler burners.

"I always loved to teach the trainees new things — ice machine repairs, boiler and chiller cleaning, changing gaskets, refrigeration repairs — and troubleshooting various issues throughout the hotel," Bombard says. "I also enjoyed working with the pipefitters when they were in to repair various items; they were a wealth of knowledge."

Bombard joined local 399 in 2008 with most of his training taking place at the Hall. "When I started, we had nine classes, and now local 399 offers over 88 classes," he adds. "And it keeps growing."

Taking advantage of the seminars and monthly meetings has allowed Bombard to be an active member while meeting other contractors, vendors and engineers.

In 2022, Bombard became Zone Chief Engineer at Chicago Public Schools (CPS) for MZI Group. MZI Group maintains a total of 160 schools for CPS, including 36 schools in Bombard's assigned zone, which includes six high schools and 30 elementary schools.

The focus for MZI Group is to make the schools' systems more cost- and energy-efficient. The upgrades also improve the learning and teaching environments for the students and staff. Common focuses are lighting upgrades, chiller updates, and adding VFD drives and BAS systems.

His team was responsible for completing the new ES chiller rebuild at Sullivan High School and VFD replacements at Hyde Park Academy High School. At Dunbar Vocational Career Academy, the building had a larger update, from painting through mechanical upgrades.

For Bombard, keeping the process running smoothly at all the CPS schools is not always easy. But he adds, "I don't necessarily see every obstacle as a challenge. These are more like learning experiences and discovering how to overcome the issues."

CPS has pushed to make its schools more energy efficient. Part of its goal is to reduce its electricity use by 30 percent from 2019 to 2025. It also is striving to lower natural gas by 20 percent within the same timeframe. Smart energy behaviors

have to be encouraged by the schools' occupants to achieve these goals, but the buildings also have to be retrofitted with more sustainable energy management solutions.

In the past two years, MZI Group has made freon replacements, installed LED lighting and solar panels, switched heating systems to electric, and added electric vehicle charging stations. Immediate plans for 2024 include steam trap testing and replacement and upgrading to hot water boilers from steam boilers.

The Greatest Reward

The tasks can stack up for Bombard at work. At home, he can be found outside enjoying time with his family or playing and watching sports. With Maggie, Bombard has three children: Molly, a nanny and aesthetician student; Danny, who is working toward degrees in business and sports medicine at the University of Louisville; and Elizabeth, a high school student, who plans to pursue a career as an FBI profiler.

The family combines their time together and love of sports while watching Danny play rugby for the University of Louisville in Kentucky. Danny was a member of the state championship rugby team for Brother Rice High School, and now he is a player for the Mid-American Conference (MAC) Rugby winning team.



Bombard focuses on energy-efficient upgrades at CPS schools, like freon replacements, LED lighting and solar panel installs, heating system upgrades and adding electric vehicle charging stations.



Rugby is a family affair for the Bombards.

Bombard says, "Danny chose Louisville because of his love for rugby and their head coach, Emil Walton. The program is only seven years old, and we have been in two national championships and won the MAC conference five years in a row. Bowling Green ran the MAC for 40 years, and we have dethroned them of that title.

"We always attend every game together no matter where it is or how long the car drives are," Bombard continues. "Laughs during all of this keep our family pretty tight. When Danny started, there were 20 players on the team. Now we have 48 players and an extended rugby family all over the United States."

Perhaps Bombard is a sports fan because his philosophy for perseverance and achievement in sports is similar to his view on becoming a chief engineer.

"You can start from the bottom, work your way up through school and continue with your education that is specific to your career goals," Bombard says.

And it never hurts to do so with family at your side. 🍷🍷

Kate Gawlik writes about construction, design and business trends from Lockport, IL



Danny Bombard plays rugby for the MAC championship team at the University of Louisville in Kentucky after being part of Brother Rice High School's winning team.

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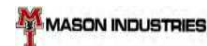
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Breathing Easier: Air Filtration Innovation Eliminates Smoke, Improves Indoor Air Quality

By Greg Rankin

A surge in the frequency, severity, and duration of wildfires around the globe has become increasingly problematic. One of the most concerning issues surrounding these fires is the widespread smoke that they produce. A prime example is the series of Canadian wildfires of 2023 that impacted large portions of North America with Air Quality Index (AQI) values frequently below safe levels. In fact, at times more than a third of the American population was under an air quality alert. Smoke also penetrated homes, schools and businesses, with numerous people reporting bouts of coughing, wheezing, headaches and even difficulty breathing. While that wildfire raged on for months, Europe and Australia were also dealing with deadly infernos and smoke-filled skies.

Prolonged exposure to smoke can cause a range of health problems making the escalation of wildfires more troubling. Even when ventilation systems are present, smoke particles can be difficult to remove from indoor air, and it is those microscopic particles that present the biggest health threat. However, an innovative technology coming out of a university research laboratory is showing the potential to play a key role in this battle.

The new filtration technology, called SPAR (Smoke and Pathogen Air Removal) — formerly known as FIL-TEX — removes smoke by actively attracting and capturing the smoke particles from the indoor air.

It was originally developed by a team led by Dr. Warren Jasper, a professor in the Textile Engineering, Chemistry, and Science Department at the Wilson College of Textiles at North Carolina State University (NC State University). Ironically, the device he invented was not intentionally designed to eliminate indoor smoke.

“It really came about by accident,” says Jasper. “I was looking at how particles get absorbed onto fibers, particularly when using charged polymers. When you charge the particles, you get improved filtration efficiencies at lower pressure drops.”

A Happy Accident

This led Jasper to theorize about the possibility of a more active approach to filtration. The innovation he came up with took electrodes made up of stainless-steel yarns and embedded them into non-conducting yarns — like cotton, polyester, Kevlar, or even recycled plastic. This creates a non-thermal plasma field on the surface of the textile media.

“We really had no idea how well it would work,” adds Jasper. “Turns out it increased the filtration efficiency somewhere between a factor of 10,000 to 100,000, which was amazing.”

Jasper’s team then began testing to see what other types of particles the new active filtration device could capture. A colleague happened to have a smoke box where they were undergoing testing for a nonrelated research project.

“It was not a planned experiment, I just asked if we could put the filter in the box to see what would happen,” explains Jasper. “There were no moving parts, no active convection going on. It was purely an electrostatic attraction with the plasma filter charging the particles from the smoke.”

A video of the experiment available at youtu.be/FG8FQey-OL8 clearly demonstrates how the smoke gets absorbed onto the fabric, and within minutes the box is free of smoke.

Non-thermal Plasma Filtration

Plasma is often referred to as the fourth state of matter, but instead of the hot plasma seen in lightning or stars, non-thermal plasma generates little to no heat. Instead, it produces reactions on a microscopic scale. Acting like a magnet, the SPAR Filter attracts smoke particles — oil, tar, carbon, soot and ash — and removes those unwanted contaminants from the air without emitting any harmful byproducts. Because the filter actively attracts smoke by creating natural convection, it does not require a fan. However, an added fan will increase efficiency.

The SPAR filter is very thin, just 2mm thick, and lightweight. It is designed so that air can pass through the media without significant power requirements. The filter technology is licensed from NC State University through Stitch Partners where it is accessible to manufacturers who want to incorporate it into a new or existing product line. The company has advanced the patented technology to a point where it can now be easily mass produced.

Applications range from air cleaning devices, like a filter within an HVAC system, to a free-standing air cleaner. For military transports, such as submarines, ships, aircraft, tanks, and personnel carriers that cannot easily and quickly ventilate smoke, the SPAR Filter adds another level of safety for troops.


Top Form Filtration

While wildfire smoke has become a focal point, there are a number of other related indoor air quality issues that the new filtration technology is tackling. These include smoke from kitchens, fireplaces, cigarette smoke, as well as exhaust from manufacturing and processing facilities.

Beyond smoke, the SPAR Filter has also proven to be effective against airborne pathogens. In a recent efficiency test, CREM Co Labs — an independent laboratory in Canada specializing in testing for the infection prevention and control (IPAC) industry — recently published its assessment of SPAR Filters.

The report authored by Dr. Bahram Zargar — an expert in virology and microbiology — demonstrated that the filter can effectively remove 99.92 percent of airborne viruses, and 99.99 percent of airborne bacteria, while deactivating 98 percent of viruses found on the filter’s surface. The testing was done utilizing a large, 26 cubic meter aerobiology chamber.

In a separate test that ran concurrently with the Canadian wildfire, CREM Co ran a longevity test on the filter in its large loading dock area.

“The filter was intact after running continuously (24 hours) for two months,” concluded the report. “During the period of longevity tests the quality of Toronto’s air was one of the worst in the world because of the fire in Quebec.” 



Fire Authorities Adopt Early Thermal Runaway Detection Technology

By Del Williams

BESS battery back-up systems are an ideal backup power source for data centers.

At data centers across the United States, demand for battery energy storage systems (BESS) is rapidly increasing. Comprising an interconnected series of batteries, BESS are self-contained, rechargeable battery units that store energy, which they can then disperse in case of power loss. This makes BESS battery back-up systems an ideal backup power source for data centers.

Despite the significant benefits, BESS are subject to thermal runaway conditions because, at their core, they utilize rechargeable batteries. However, the risks associated with the use of BESS can be exacerbated with the implementation of lithium-ion (Li-ion) batteries. In Li-ion BESS scenarios, thermal runaway can occur due to thermal abuse or overcharging, which can cause excess heat to create a reaction that increases the internal temperature of the battery. The increase in heat can cause the electrolyte solution inside of a Li-ion battery to begin to turn into a vapor.

If left unchecked by built-in system protections or the Battery Management System, this process can continue to increase temperatures and pressure inside of the hermetically sealed battery cell, eventually causing the battery cell separator to melt down and degrade.

This stage of Li-ion battery failure is referred to as “off-gassing” or “initial cell venting.” Failure to address the continued increase in heat at this stage will result in the internal temperature of

the battery continuing to rise until a point of thermal runaway, which can propagate into fires in adjacent cells and other combustibles in the area.

Although smoke and gas detectors are required by code in BESS, smoke detectors are searching for particles of combustion, which are not present until thermal runaway occurs. Most gas detectors are designed to manage threats in lead-acid battery BESS and so detect either a generic hydrocarbon gas or quantity of gas at one physical location.

“Today, the new technology for preventing thermal runaway is ahead of the [NFPA] code. ... So, the consensus is moving toward installing Li-ion-specific early warning detection systems over more generalized gas detection technologies”

– Kenneth Pope, President and Owner of Pope Technologies LLC

Due to these factors, traditional smoke and gas detectors used in a Li-ion BESS may only indicate a thermal runaway event once it is already occurring inside the container, rather than providing sufficient warning to prevent a fire.

Now, a growing number of fire authorities and life safety system experts are addressing this issue by recommending detection technology that provides a warning far earlier than traditional monitoring and detection methods. This helps to stop thermal runaway before it begins, increasing data center safety and reliability.

The approach is not only being adopted throughout the country but also is increasingly being adopted by fire authorities as a de facto standard for Li-ion BESS applications.

“Today, the new technology for preventing thermal runaway is ahead of the [NFPA] code and most Authorities Having Jurisdiction (AHJs) are open to technology that satisfies the code’s intent. So, the consensus is moving toward installing Li-ion-specific early warning detection systems over more generalized gas detection technologies,” says Kenneth Pope, President and Owner of Pope Technologies LLC, a fire alarm and smoke control life safety systems designer and installer. Pope has worked in the industry for more than 25 years.

Seeking Earlier Li-ion Detection, Greater Safety

With Li-ion BESS applications expanding around the globe, the need for better protection from thermal runaway

is increasing and becoming a crucial topic among fire departments and other AHJs. The danger is emphasized by incidents such as a runaway Li-ion battery explosion that injured nine first responders at the McMicken Energy Storage facility in Surprise, Ariz., in April 2019.

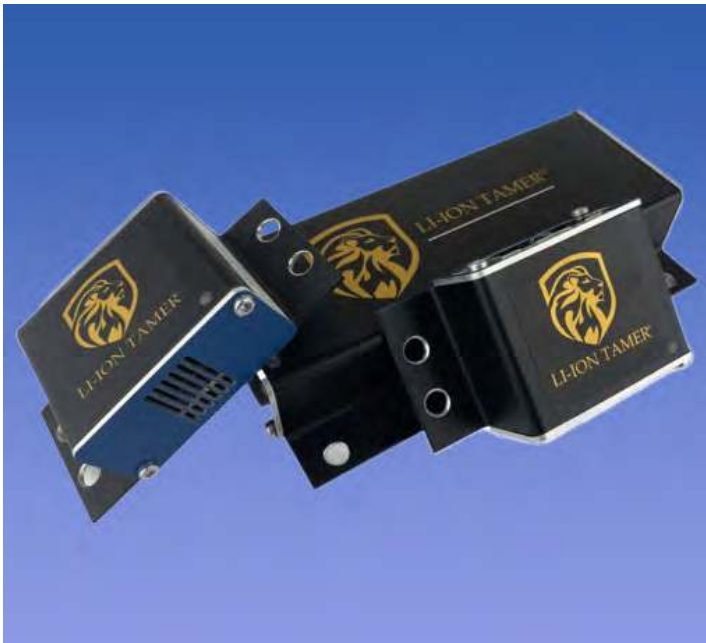
So, when an area data center decided to install a large quantity of Li-ion BESS, the local AHJ required that gas detection solutions be retrofitted into the eight existing BESS containers as well as additional BESS containers planned for the site.

To satisfy the requirements for the project, the AHJ contacted Randy Snow, Managing Principal at Progressive Edge Technologies, a fire and life safety system consulting firm. Snow considered code-approved gas detection systems used in BESS, but wishing to provide a more robust solution, he began searching for alternatives. He consulted with Kenneth Pope at Pope Technologies, who recommended Li-ion Tamer, a detector that specifically targets the off-gas electrolyte vapor that is characteristic of a Li-ion battery cell vent release.

Li-ion Tamer by Honeywell consists of two primary components: a controller and a network of off-gas sensors installed above the battery racks. The sensors utilize sophisticated detection algorithms to monitor Li-ion BESS and provide an alert to the



BESS are subject to thermal runaway conditions because, at their core, they utilize rechargeable batteries.



The Li-ion Tamer gas detection system enables quick alarm initiation and immediate mitigation measures.

initial venting of electrolyte solvent vapors. This early warning helps prevent fires by allowing increased time to shut down the charge to the affected rack(s) in the estimated 8-15

minutes between off-gassing of the electrolyte vapors and the beginning of thermal runaway.

The Li-ion Tamer controller is designed to diagnose when and where the off-gassing of electrolyte vapors is occurring, with an electrolyte solvent release of just a single battery cell. This enables quick alarm initiation and immediate mitigation measures such as opening louvres, engaging exhaust fans, and alerting occupants and first responders of the off-gassing event via the NOTIFIER Fire Alarm Control Panel.

"The AHJ liked the idea of providing an early warning detection system along with a means of suppression before thermal runaway," says Snow.

Still, the AHJ had to approve safety measures involving a gas detection requirement. "We had a fire protection engineer review our documents and confirm that our use of Li-ion Tamer would satisfy the AHJ's gas detection requirement for their jurisdiction," Snow says. "We got their blessing and approval."

Snow states they now utilize Li-ion Tamer in the data center BESS, along with other fire detection and suppression technologies. This includes a VESDA aspirating smoke detector for early warning smoke detection because the heat from a combustion fire in the BESS can trigger a Li-ion thermal runaway event as well.



The VESDA VLF aspirating smoke detection system was chosen for early warning smoke detection because the heat from a combustion fire in the BESS can trigger a Li-ion thermal runaway event as well.

The VESDA VLF aspirating smoke detection system was chosen for this task. The VESDA system continuously draws in small samples of air through holes in piping or tubing and evaluates it for smoke particles at a central location. This provides very early smoke detection capability, even before smoke becomes visible. The system provides several programmable alarm thresholds that help enable a swift escalating response, which can help to stop a fire and minimize potential damage before fire suppression release.

“We had a fire protection engineer review our documents and confirm that our use of Li-ion Tamer would satisfy the AHJ’s gas detection requirement for their jurisdiction. ... We got their blessing and approval.”

– Randy Snow, Managing Principal at Progressive Edge Technologies

“When combined with VESDA and fire suppression system elements, Li-ion Tamer provides the tools and the interface we

need to protect BESS essentially anywhere they are installed. Li-ion Tamer is a flexible, effective option that can take the place of traditional gas detection,” says Snow, adding that many BESS units will be retrofitted with this technology over the course of the next year.

According to Pope, the importance of Li-ion-specific early warning detection systems will only increase, given the rapid growth of Li-ion BESS beyond data centers. Today, BESS systems are being installed by utilities, renewable energy producers, and those in the industrial, retail, defense, healthcare, and transportation sectors.

“We expect thousands of these pods to be manufactured in the next couple of years,” says Pope. “It is all about effectively increasing the level of protection and decreasing the level of risk. It just makes sense for end users to protect their BESS investment.”

For more information, contact Dawn Wotapka, Director of External Communications at dawn.wotapka@honeywell.com.

Del Williams is a technical writer based in Torrance, CA



CHIEF ENGINEER MEMBER INFO AND REMINDERS

Here are a few things to keep in mind about your membership and Chief Engineer events.

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Things got a bit loud at the 2024 CEAC Inaugural Event at Thalia Hall, as we celebrated and congratulated both our new slate of Officers and Directors for the 2024-2026 term, and bestowed honors on deserving individuals and organizations. We proudly named Patrick Schaefers our Member of the Year, Neil Masterson our Lifetime Member of the Year, and Bear Construction as our Associate Member of the Year. We're grateful to have all of you as part of the CEAC.

We're also thankful to everyone at Thalia Hall and to JUMP – America's Van Halen Experience for lending that electric element of rock 'n' roll to this unforgettable evening, and to Doug Kruczek and the Events Committee for putting all of the hard work into planning this event to make it so memorable. And of course, we're especially grateful to our event sponsors, without whom no event would have been possible. To our Rockstar sponsor, Air Comfort, our Spotlight sponsors AMS Industries, Inc. and IUOE Local 399, our Backstage sponsors Parkway Elevator, UG2 and United Radio Communications, and our Groupie sponsors Cristaux International and Ryan Fire Protection – we are ever grateful for your support and participation!

The CEAC has event sponsorship opportunities available now for upcoming events, including our ever-popular St. Patrick's Day meeting on March 20. For information on sponsorship opportunities, please reach out at events@chiefengineer.org.







Creating Boiler Plant Control Where None Exists

By Eric Balt and Mercedeh Fallahkhair

Firing a multi-boiler system.

According to Forbes, the occupancy rate among U.S. multi-family housing units rose to 96.9 percent in mid-2021, and the trend has continued post-pandemic.

With real-estate prices increasing sharply and rent costs reaching all-time highs, there's more incentive than ever to renovate, update and repurpose commercial and light commercial facilities, whether properties include multi-tenant housing, mixed office space, retail locations, etc.

Compared to new construction, however, this leaves property owners, managers and mechanical contractors at a disadvantage: Older but serviceable mechanical equipment can be difficult to integrate with a smart and connected control platform.

This may be especially true in northern climates, where hydronic systems have been the default source of space heat due to boiler efficiency, comfort, longevity and the ability to provide ample domestic hot water.

Older boiler plants generally lack connectivity in the 50,000-square-foot and under market, where installing a building automation system (BAS) may not be worth the expense.

James Dice, PE, CEM, CMVP, founder of Nexus Labs, recently wrote a white paper titled "The Untapped 87%: Simplifying Controls Technology for Small Buildings." In it, the author explains that a 20,500 square foot building was retrofitted with a BAS by the United States Department of Energy's Pacific Northwest Laboratory (PNNL) in 2010. Within the first two years, this led to a 22 percent energy savings, 25 percent return on investment, and a "dramatic decline" in occupant comfort complaints.

The white paper goes on to explain that buildings smaller than 50,000 square feet represent 94 percent of commercial buildings in the U.S., 44 percent of electricity use, and 44 percent of total energy use. Yet, only 13 percent of these buildings are equipped with a BAS.

The reason? BAS systems are either too complex or not cost effective enough for the average building owner. BAS frequently cost \$50k to \$100k, which exceeds the fiscal budgets of many building owners. In addition, they require an expensive annual service plan.

Because of this, there is massive opportunity to reduce energy consumption and simplify maintenance with the use of new, connected HVAC system controls without installing a BAS.



Kenny Walker, with Summers & Zims, installs the tekmar Smart Boiler Control 294.

Aging Boiler Plants

Many commercial boiler plants feature multiple boilers for staged input or redundancy. Over the years, as various boilers were replaced, it's not uncommon to have multiple different boiler models serving the same system.

For example, a system that was originally served by three conventional boilers of the same model might have been retrofitted with a single condensing boiler to replace two of the originals, while the third existing boiler remained in place for supplemental heat on design days.

In new construction applications or in systems in which every boiler in the system is replaced, the boiler manufacturer's onboard cascading controls are often used for lead-lag cycling of the units, though establishing remote access can still be a frustration.

Fleet management is a major problem for facility managers. The heating system equipment is usually different in every building. This is due to the buildings being built and updated at different times, and buildings being acquired and sold by the management company.

So facility managers, property owners and mechanical contractors involved with light commercial systems too small to warrant the installation of a BAS are left asking how to control and remotely monitor their systems. If multiple properties are involved, the challenge is multiplied.

Evolving Needs

"We've been building multi-stage boiler controls for over 30 years," said Jay Vath, life cycle engineer at tekmar Control Systems. "There are a number of other control manufacturers with similar products, and for everyone in this market sector, the initial goal was to provide outdoor temperature reset for boilers that didn't offer it."

The demand for features in a boiler control package evolved along with the boilers themselves, along with the need for greater efficiency and control. Boiler manufacturers began offering outdoor reset and onboard staging across multiple,

identical units. So the focus shifted to remote access, existing boiler plants, and the installation of hybrid condensing and non-condensing boiler plants.

Control manufacturers introduced modules that offered some degree of remote monitoring capability for boiler plants, but one large issue remained: Many existing boiler plants included disparate models, often with decades separating them. There was no way to aggregate different brands and models onto a single, Web-enabled control platform short of installing a BAS.

Long-Sought Solution

The primary drawbacks to installing a BAS solely for boiler plant control in a facility that otherwise doesn't need it are the initial and maintenance cost, but equally important is the level of responsiveness on the part of the controls contractor. A BAS system creates an additional hurdle between the system and the service contractor. If an alert is generated by the boiler plant, the controls contractor — who may or may not be responsive in a reasonable amount of time — notifies the service contractor.

Eliminating the controls contractor and creating a direct conduit from the boiler plant to the service contractor reduces expense and expedites the service response.

"This is a key consideration for any connected boiler control," said Vath. "It puts power in the hands of the service contractor, while providing remote monitoring capability for systems that may feature a number of different boiler makes and models."

Tekmar's Smart Boiler Control 294 is an Internet-connected control that can be accessed via any Web-enabled device for remote boiler plant monitoring and control. A boiler wizard provides integration with thousands of boiler models, and various levels of control and permission can be set for specific individuals, such as the service contractor, a facility manager and the building owner.



Two technicians set up the new smart boiler control.

Compound Savings

"Installing a smart and connected boiler plant control system provides real potential to save money on energy and maintenance," said Vath. "Compared to a fixed operating setpoint system, outdoor reset alone can save upwards of 30 percent in fuel expenses."

But there are many other savings advantages, some not as easy to quantify. Automatic boiler and pump shutoff reduces energy use when the system isn't needed. Short-cycling is reduced or eliminated. Rotating boilers balances runtime hours, providing maintenance and longevity advantages. Staging boilers correctly helps accurately match the heating input to the load. Conventional and condensing boilers in the same plant can be grouped together and staged independently, keeping the least-efficient appliance offline until needed. Some savings though, take place outside the mechanical room.

"With the notifications and insight that Web-enabled boiler controls provide, the service technician knows what's needed in the event of an alert, which they receive via email, text or push notification," said Vath. "For example, a pressure input could indicate that the expansion tank's diaphragm is flooded, so the technician would know in advance to put a replacement in the truck. With remote monitoring, dispatching occurs quickly. Alternatively, if the control generates an alert on an issue that can wait until the next scheduled service interval, an unnecessary trip is eliminated. This kind of information reduces unnecessary expense and allows service professionals to be proactive. The Watts OnSite app provides notifications when boilers and pumps are due for servicing based on runtime hours. This allows for the creation of scheduled maintenance plans."

Using a flexible boiler plant control also offers cost-saving options in the event of a retrofit. If the ability to connect an old boiler to a new control system is the only factor prohibiting a facility from leaving existing capacity online while retrofitting a portion of the mechanical system, that's no longer a concern. New boilers can be paired with old boilers for backup heat, ultimately reducing the amount of new firing capacity needed.

Forward-Backward Compatibility

"For systems that already include tekmar boiler controls, updating the system with the 294 is simple," said Vath. "All the equipment applications we've had in the past are covered by the 294."

Similarly, the 294 can be quickly updated as new apps or other improvements are introduced. Updates and new features are sent to existing units as they're developed. This is a big advantage for code compliance.

"In the future, if certain codes are accepted that require specific monitoring parameters, the 294 is designed to be updated to provide reporting as required."

This flexibility allows the owner to remain current, not just to become current now. It's a matter of being proactive, not reactive.



Brandon Content, at Plumbing Systems Inc., establishes a connection between several boilers and the tekmar control system that serves the large vacation home.

For example, 30 municipalities across the U.S. currently are phasing in higher standards for commercial real estate emission reductions and energy consumption. A long-known problem is that systems become less efficient over time due to poor maintenance. Remote monitoring is a key method to keep the boiler system operating at the designed efficiency.

Customized Control

Web-enabled boiler controls offer a "BAS Lite" solution. With that comes substantial customization.

"The fact that dissimilar boiler technology is being controlled by a single system, tailored to the needs of an individual customer and property means that the control platform has to be extremely versatile," said Vath. "For that reason, the 294 can be configured for many combinations."

For example, a fixed "lead" boiler can be established, in the event that a draft is needed for one of the boilers in the system. A fixed "last" can also be established in the event that a conventional boiler is used only under design conditions, allowing condensing units to fire first.

Control can be established for firing rates or water temperatures, and the system can switch between the two depending on the call for heat. A DHW call may create a water temperature setpoint while a call for space heat may dictate boiler firing rate, and so on.

Security and Ownership

Much of the remote access in buildings from the past 20 or 30 years was closed-loop, like key card room access, fire alarms, auto-dialers, etc. To provide full-featured remote access to a variety of team members, an Internet connection is needed for a cloud-based platform.

"Fundamentally, where we've changed gears from what was done in the past is connectivity," said Vath. "Once the 294 is connected via Wi-Fi or Ethernet, we use the Watts Onsite app or browser interface to remotely access the device with the ability to adjust every setting in the control. This has a great deal of value for property management groups that have a fleet of buildings, seeking control consistency across properties and boiler plants."

Security is built into the control and into the Microsoft Azure platform that it operates on. Access is end-to-end encrypted, just like a banking app. Login information is specific to each individual on the team, and does not need to be shared among members. The physical control also includes a passcode to prevent unauthorized access.

The program and information resident on the physical controller is a digital twin of the control on the remote device. The virtual device can be modified in real time, immediately updating the physical device. This reduces trips to the property and allows every member of the team to access the system. Team members who have access to the digital twin can be added and removed, and different levels of access can be established for each.

The new control offers as many advantages to the owner as it does to the service professional. Ownership can be transferred in the event of property sale. Transfer of responsibility is quick and simple, if the service contract changes hands.

The property owner can also monitor and review the responsiveness of the contractor. An acknowledgement is logged when the service professional reviews the alarm. This allows the owner to see if they're receiving the service they're paying for.

Ultimate Flexibility

Creating remote access for existing light commercial boiler plants requires a great deal of flexibility. Varying loads, mismatched boiler models and different building codes to

conform to all require a control package to be extremely flexible. Looking ahead, the potential addition of air-to-water heat pumps is something that a modern boiler plant control system has to be able to facilitate.

"The only constant is change," said Vath. "Building owners change, technology changes, service contracts change, codes change. A modern boiler control package must adapt to these transitions." ■■

Eric Balt is technical sales manager for tekmar Control Systems and Mercedeh Fallahkhair is senior product manager for tekmar Control Systems.



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Bradford White Announces Launch of New Brute® XTR Commercial Boilers and Volume Water Heaters


Bradford White Water Heaters, an industry-leading manufacturer of water heaters, boilers and storage tanks, announces the release of its new Brute XTR commercial boilers and volume water heaters.

Brute XTR boilers and volume water heaters are available in six sizes, ranging from 399 MBH to 1500 MBH, and deliver AHRI-certified thermal efficiency of 96-plus percent.

“With the Brute XTR, we’re offering an advanced solution that meets the high standards of heating professionals in the field and empowers them to deliver the high-performing, long-lasting products their customers need,” said Louise Prader, senior director of product management for Bradford White. “The Brute XTR was developed to ensure our professional customers have a robust, easily installed solution that fits a wide range of applications.”

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- Convenient touchscreen control platform 

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MSA Safety Showcases Power of Data in HVAC-R Technology

CHICAGO /PR Newswire/ — The power of data analytics is quickly becoming a game-changer in the HVAC-R industry, largely because advances in detection technology are helping companies gather and deploy data in entirely new ways. At this year's AHR Expo in Chicago, MSA Safety, Inc., displayed new connected solutions that make it easier to access and use data to help increase safety compliance, protect people and infrastructures, and reduce emissions.

"With this year's expo focusing on the rapid pace of change in the industry, this is an optimal time for us to highlight MSA's market-leading detection and connected technologies," said Gustavo Lopez, MSA Safety Vice President of Product Strategy and Pricing.

"As we look broadly at the HVAC-R industry, customers want technologies that go beyond detecting refrigerant leaks," Lopez said. "They want connected solutions that detect leaks, but also help reduce emissions and strengthen safety compliance. They want consistent and reliable data they can use to help them achieve their overall safety goals."

Expo attendees were able to see the depth and strength of the MSA Safety detection portfolio and learn how the company's solutions are helping safety managers take their safety programs from reactive to proactive. One particular featured solution is the Parasense Connected Platform, which is a cloud-based system designed for low-level leak detection, refrigerant tracking, and managing compliance.

"It's clear the future of detection technologies for HVAC-R applications lies in connected solutions and the ability to provide data that's actionable and can have a positive impact on process safety," Lopez said. "With remote connectivity, our solutions can provide data-driven insights while also activating alerts if a leak is detected. Ultimately, our goal is to help companies reduce refrigerant emissions and reportable emissions events."

Other systems MSA showcased at AHR 2024 include:

- MSA Chillgard® 5000 Monitor and Bacharach® Multi-Zone Gas Monitor: Both provide 24/7 remote leak monitoring and data analytics, and are aspirated detection systems, meaning air is pulled from strategically placed sample points and into the unit where sensors measure the concentration of refrigerant in the air and trigger alerts if a leak is detected. The Chillgard 5000 offers solutions for the HVAC market, while the Multi-Zone unit offers solutions for refrigeration applications.
- MSA FieldServer™ Gateways: These gateways enable users to connect with their detection devices and deliver real-time insights to help improve products, processes and production.
- MSA Grid: This cloud-based software, featuring the FieldVEU App, provides users instant access to data and sends notifications on device functionality.



Review MSA's AHR Expo happenings by visiting msasafety.com/ahr-expo or by following MSA's social media platforms.



Providing 24/7 remote leak monitoring and data analytics, the MSA Chillgard® 5000 Monitor is an aspirated detection system offering solutions for the HVAC market.

The MSA FieldServer™ Gateways enable users to connect with their detection devices and deliver real-time insights to help improve products, processes and production.

Providing 24/7 remote leak monitoring and data analytics, the Bacharach® Multi-Zone Gas Monitor is an aspirated detection system offering solutions for refrigeration applications.



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ACROSS

- 1 That hurts!
- 5 Explosive
- 8 Cowboy leg wear
- 13 Laundry detergent brand
- 16 **Acronym for ration of useful energy out to in**
- 17 Garden tool
- 18 Hollered
- 20 Hubbub
- 21 Scroungers
- 23 Less colorful
- 24 Not (refix)
- 25 Ewe's mate
- 26 Takes care of
- 28 Nettle
- 30 Food
- 32 Yea
- 33 Reporter's question
- 34 Bars
- 35 Small island
- 38 BB association
- 41 Pacific island
- 44 Tax agency
- 45 Security
- 46 Stony
- 47 Negative
- 48 **Capture excess heat for H2O heating**
- 50 Short
- 51 N.T. prophet
- 52 Omelette ingredient
- 53 Ms. Winfrey
- 55 Limited (abbr.)
- 56 Peewee
- 58 Boredom
- 60 Clodhopper
- 64 Necessary
- 68 Climbing vine
- 71 Fried bread
- 72 A wager (2 wds.)
- 75 Type of star
- 76 Peachy
- 78 **Acronym commonly**

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110						111					112				113			

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- used to describe systems**
- 79 Short-term memory
- 80 Skinny
- 81 It ___ Upon a Midnight Clear...
- 82 Deer relative
- 83 **Moves fluids**
- 85 Both
- 86 Single beat
- 87 Not cons
- 88 Expression of surprise
- 90 Throng
- 91 Execute
- 92 Thief
- 95 Desert pond
- 97 Key
- 98 Flightless bird
- 99 Bunny
- 101 Corn Flakes makers
- 106 Foot

- extension
- 107 What pepper makes you do
- 108 Wrath
- 109 Winnows
- 110 American sign language
- 111 Tonal
- 112 Dowel
- 113 **Pipe for waste gas**

DOWN

- 1 Lout
- 2 Flying saucer
- 3 Dog
- 4 Playing cards suit
- 5 Not us
- 6 Neither's partner
- 7 Quiz
- 8 Young swan
- 9 Groups together

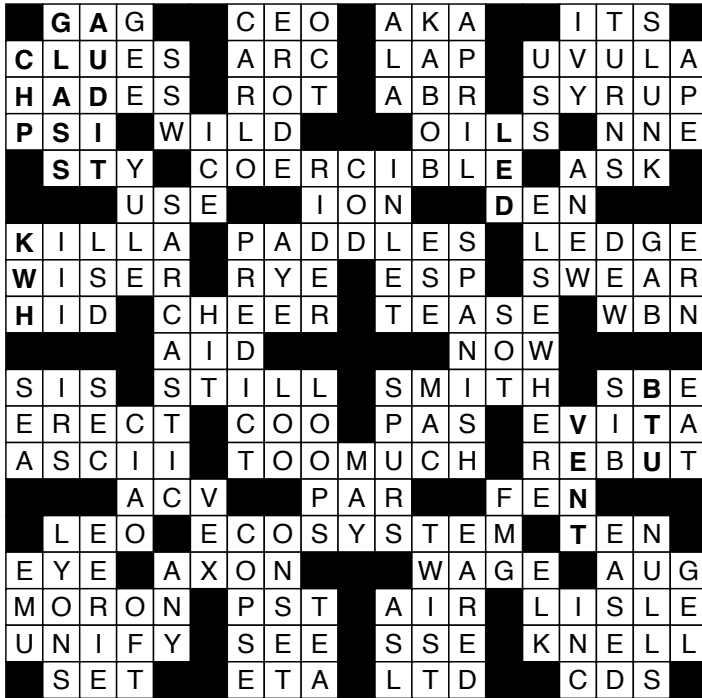
- 10 Alack's partner
- 11 Wooden sheet
- 12 Was looked at
- 13 Gossiping
- 14 Movie star
- 15 **Divided area**
- 19 Depicted
- 22 **Type of fuel commonly used in furnaces**
- 27 Blinker
- 29 Extremely high frequency (abbr.)
- 30 Land mass
- 31 **Evaporators primary fuction relating to heat**
- 34 **Small flame**

- 35 Computer makers
- 36 Jib
- 37 Fuzz
- 38 Prophet who built the arc
- 39 Make unclear
- 40 Improvise a speech
- 42 Run
- 43 ___ A Small World...
- 46 Hertz
- 49 Represent graphically
- 52 Time period
- 54 Shade
- 57 Mr..'s wife
- 59 Elite intellectuals' society
- 61 Order
- 62 Not digital
- 63 Scarf holders
- 65 Child's toy
- 66 Cruel

- 67 Dike
- 68 Evil spirit
- 69 Beef
- 70 Sweet potatoes
- 72 Viper
- 73 **Unit of measurement for heating power**
- 74 Name of Messiah
- 77 Ball holder
- 84 Doctoral degree
- 86 Hung up a notice
- 87 Bribe (2 wds.)
- 89 Ventilates
- 90 Indian corn
- 91 Movie 2001's talking computer
- 92 Second letter
- 93 Famous cookies
- 94 **Container for storing fuel**
- 95 Do what you're told
- 96 Jump
- 97 Horse fly
- 100 Honey maker
- 102 Before, poetically
- 103 Girl
- 104 African antelope
- 105 Compass point

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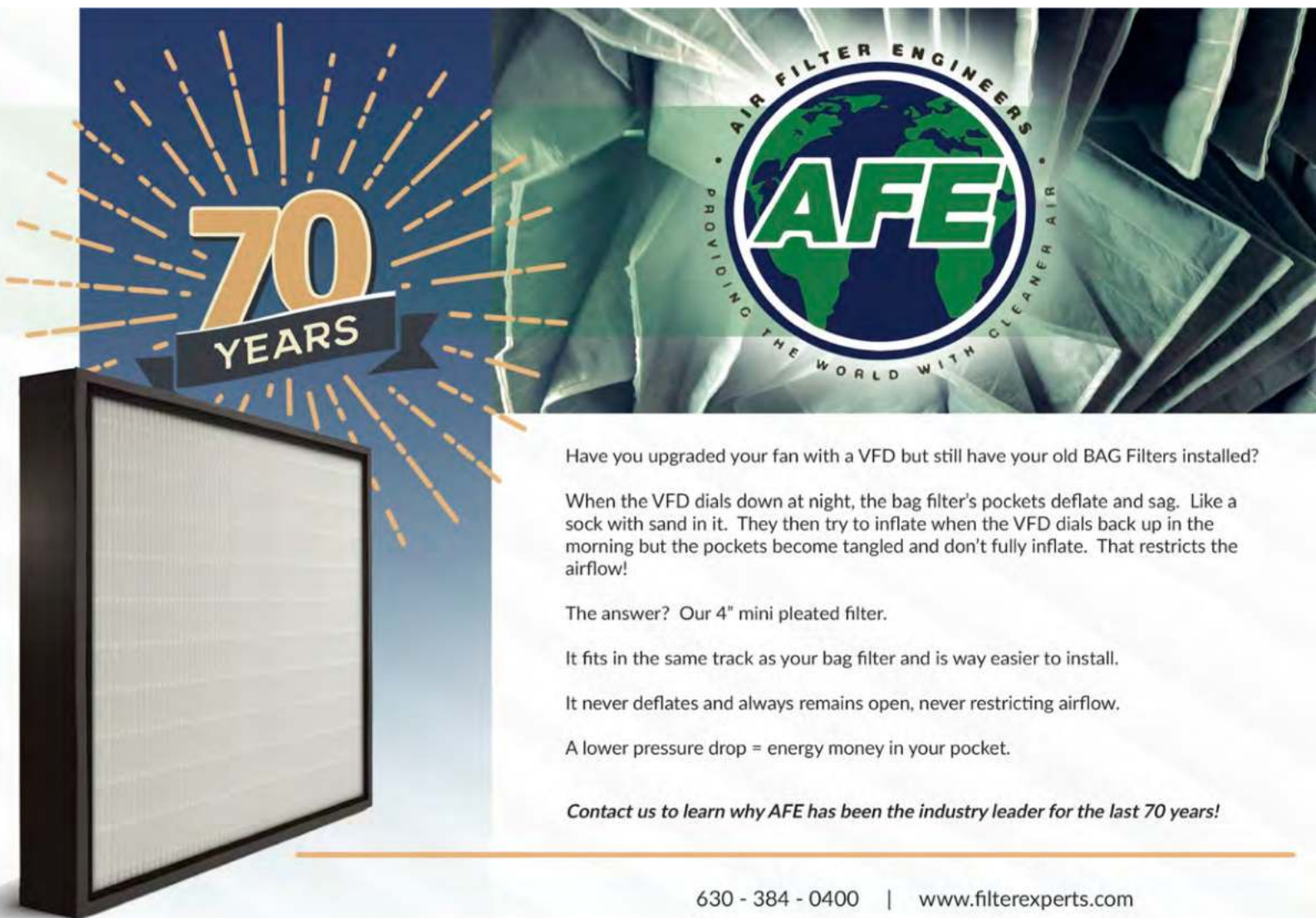
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