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REPORT

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January 2024

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VOLUME 6 > NUMBER 1

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Welcome to 2024!



This issue you are reading, either in print or digitally, is a milestone for us. It's the first issue as we begin our 5th full year in existence. Most publications don't make it that far, especially when faced with outside circumstances as the pandemic. So we are very fortunate to not only have survived but thrived since our beginning 5 years ago.

Who do we thank for that? Our readership... OEM design engineers in the Appliance, HVAC and related markets. You proved to our advertiser base that you liked the content we produced and spent time reading it. So marketers who wanted to reach you followed.

Why is the design engineer a key target audience? Because he/she (usually he, sorry to say) is always looking for products and services that can help get the manufacturing done more effectively for the OEM. And once the design engineer has found what he is looking for, he can recommend and perhaps specify to purchasing the vendor(s) to contact.

Our first issue each year has bonus circulation at AHR, the major show for our industry (www.ahrexpo.com). We exhibit and if you attend and have time we'd love to see you there. The show is at McCormick Place in Chicago, where it rotates to every third year. We are at booth S10447. If you come buy grab an issue... you'll also find various materials from suppliers who asked us to include them in our "show issue polybag". We did this at the 2023 AHR and it was successful so we're doing it again in 2024.

I am often asked what do we need to be effective? That's an easy one... **we need content**. We are always looking for tech content, non-commercial, that we can publish. We don't pay for it and companies don't pay to have us publish it, but we do give authors, and their companies, credit in articles' bylines. So if you would like to be part of THE APPLIANCE & HVAC REPORT feel free to contact me. We want to see what you have that can educate our 24,000 readership.

In this issue we have content from CertifiGroup, the Copper Development Association, Littelfuse, Shurtape and others. And in a nice gesture of fellowship, our friends at SEMICONDUCTOR DIGEST allowed us to publish an excellent HVAC related piece.

Let's hope for a great 2024. It won't be easy... two wars happening, a presidential election coming up, lots to worry about. But somehow I know we will persevere.

Regards,
Brad Glazer
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APPLIANCE & HVAC REPORT

Reaching
Design Engineers
at the
OEM Level

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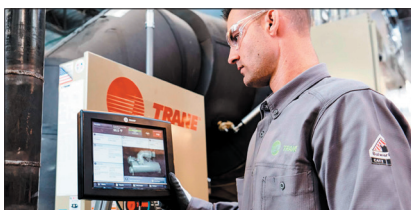
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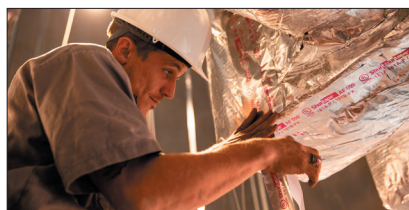
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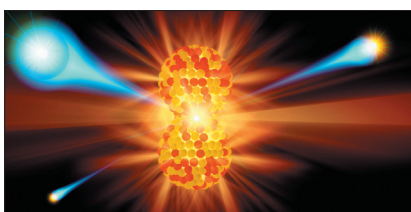
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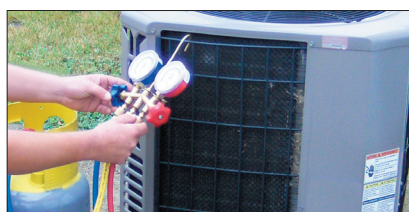
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Optimizing HVAC Energy Efficiency in Semiconductor Manufacturing Fabs

Substantial energy saving can be found in heating, ventilation and air-conditioning (HVAC) systems which can represent 40-50% of a total wafer fab's energy consumption



Sustainability has become an increasingly important aspect of the semiconductor manufacturing business, and most companies have recently issued sustainability reports with goals of reducing energy, water use and greenhouse gas (GHG) emissions in the coming years. Guidelines have been defined by SEMI's S23 standard, the ISO 50001 Energy Management System standard and The Greenhouse Gas Protocol (GHGP). The International Roadmap for Devices and Systems (IRDS) also has chapters focused on energy and water conservation needs and

challenges.

One of the main areas where substantial energy savings can be found is in heating, ventilation and air-conditioning (HVAC) systems, since HVAC represents 40-50% of a wafer fab's energy consumption [1]. "Although energy conservation opportunities are present across the spectrum of Intel's manufacturing operations, we have identified strategic investment opportunities in a number of areas," reads Intel's sustainability report [2]. "To reduce energy usage in operations, we are investing

in HVAC upgrades and heat recovery projects. For new factory construction projects, we are incorporating energy efficiency into design and equipment selections."

These efforts aren't only good for sustainability; they are also good for the bottom line. "Reducing energy use in our operations is core to Intel's overall climate strategy and our sustainability goals. Cumulatively we conserved approximately 970 million kWh of electricity from the 2020 baseline through the end of 2022, toward our 4 billion kWh 2030 goal. Cumulative cost savings from the 2020 baseline through 2022 total approximately \$70 million," the report notes.

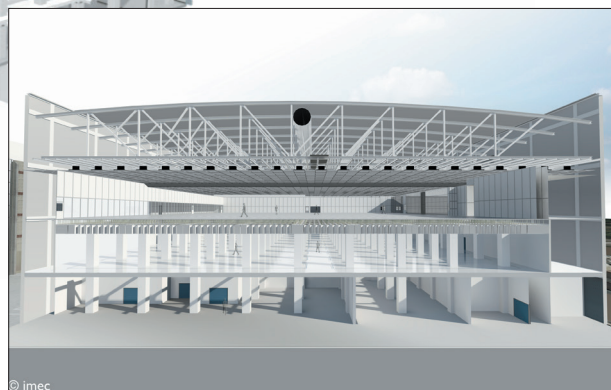
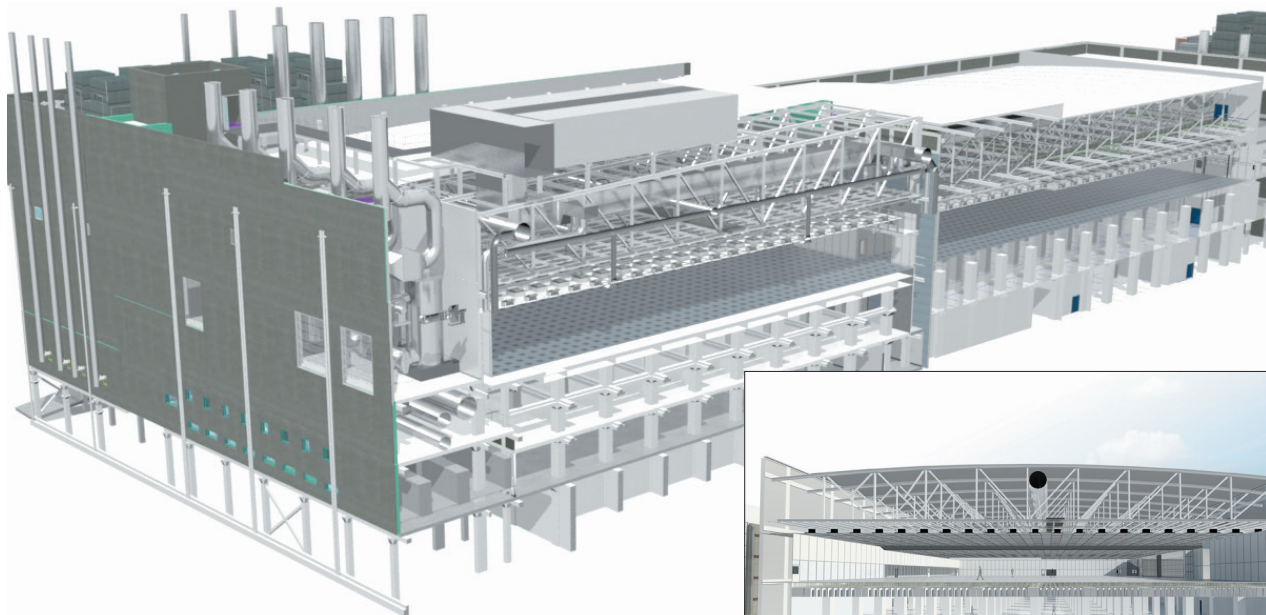
GHGP, HVAC, S23 and IRDS

The Greenhouse Gas Protocol (GHGP) establishes comprehensive global standards for measuring and reporting greenhouse gas emissions from private and public sector operations.

The GHGP categorizes emissions into three scopes:

- Scope 1 emissions are direct emissions from owned or controlled sources.
- Scope 2 emissions are indirect emissions from the generation of purchased power
- Scope 3 emissions are all indirect emissions (not included in scope 2) that occur both upstream and downstream in the value chain of the reporting company.

Semiconductor manufacturing equipment suppliers are working to understand the energy their tools consume and how it relates to Scope emissions. The same is true of HVAC suppliers.



Andy Alcorn, Senior Director, Global Accounts at Trane, a leading supplier of HVAC services and products, said “When someone approaches us and asks what we can do to help deliver on their sustainability goals, we’ll often walk them through our Scope 1 or Scope 2 emissions and look at what we can do to help with electrification. For example, things like taking away any burning of fossil fuels, indirect energy efficiency, and water consumption.” A wet scrubber, the HVAC system, ultrapure water production system, and the provision of process cooling water generate primarily scope 2 emissions from the electrical power they consume [3].

At Trane, part of how they help companies increase the overall energy efficiency of their space include chillers, chiller plant controls and heat pumps that optimize energy use. To reduce harmful emissions from fugitive refrigerants, Trane can help customers transition to refrigerants with a lower GWP.

The SEMI S23 guidelines describe a methodology for

semiconductor equipment manufacturers and the device manufacturers who use their products to evaluate the energy used by their equipment and their manufacturing processes. The standard also includes numerous recommendations for energy-saving changes, such as using the highest available electrical supply voltage, warmer process cooling water and higher temperature differentials in cooling towers, lower utility gas pressures, lower chemical purity, substituting compressed dry air for nitrogen, and smart exhaust systems that run only as needed. It also strongly encourages the development of a roadmap for energy savings.

Interestingly, it’s almost impossible to separate water and energy demands, in that they are strongly interdependent; Extracting, purifying, delivering, heating/cooling, treating and disposing of water (and wastewater) requires significant amounts of energy [4].

The IRDS notes that energy demand reduction is also essential to enable environmentally and affordable growth of semiconductor facilities. “The increasing number of layers driven by each new process technology increases the amount of energy needed as well as the amount of water and other utilities required by the manufacturing process. The energy intensity of the tools is relatively stable, but as more layers are added, this drives more tools and more cleanroom area, driving the energy demand upwards,” the report notes.

There are still considerable energy savings to be gained from improving efficiency of the central thermal management systems. In addition, it is still common to encounter considerable heat sinks on various parts of the semiconductor facilities which drive large cooling demand, whereas in other locations in the same facility a heater, furnace or boiler is used to generate heat for a unit operation or process step that occurs at elevated

temperatures. A more coordinated approach to water and energy management is critical to ensure that energy recovery opportunities are understood, and the feasibility of heat recovery can be evaluated [5].

"We'll have a low-temp loop and a medium-temp loop," explained Trane's Alcorn. "For normal cooling, instead of rejecting heat to the outside, we do heat recovery. We'll pull it back in to do preheating or eliminate boilers that would traditionally be used."

Alcorn said it's important to take these considerations into account during the initial planning process. "One of the things we've been trying to do is get involved as early in the development and procurement process as possible, because decisions made at this stage don't only impact the initial construction: energy efficiency impacts the entire life of the building," he said. "When you're building in remote areas where you need a large parcel of land, it's important to get Trane's workforce assembled in that area to keep the building going, maintain critical uptime, and deliver the most efficient process we can."

Recent studies

The good news is that energy reduction efforts are paying off. An international benchmark study conducted by ISMI of fourteen 150 mm and 200 mm fabs around the world, the average energy consumption per unit of production in 2011 had decreased dramatically to one-third of what it was 1997. "This decrease in energy consumed per unit of production points to sharp improvements in energy efficiency of tools and other fab equipment," the report notes.

More recent studies show further energy saving are possible through HVAC improvements. Hu and Tsao examined five typical layouts of

HVAC systems -- including the air re-circulation unit (RCU), make-up air (MAU), fan coil unit, axial fan, and fan-filter unit (FFU) systems -- and their corresponding energy efficiency for a typical 200 mm wafer fab [1,6]. Their analytical results demonstrated that a MAU combined with a FFU system (considered the reference case and the most popular design for fabs) presents the best performance of energy use. In addition, they found that the energy consumption of the RCU system was significantly higher (i.e., 3.8 times the energy use) than that of the reference case, whereas that of the MAU with the axial fan was only slightly higher (i.e., 1.08 times the energy use) than that of the reference system.

They further proposed that the energy consumption of the RCU system could be reduced by 50% while mixing some portions of the return air with the make-up air. In general, the MAU system provides outside air, which is then mixed with re-circulated air from the clean room. Due to the large amount of air circulation in the fabs, the corresponding demand for cooling of the outside air is very high, leading to a significant consumption of energy. The make-up air cooling load generally accounts for more than 40% of the

total load, they note.

Therefore, the make-up air system might offer an energy-saving opportunity. For example, Tsao et al. [6] explored the energy use for different arrangements of the MAU system and reported that the dry coil cooling system with water return had the best energy efficiency among the cases studied. The results of another study demonstrated that a draw-through MAU system combined with two cooling water systems and a heat recovery arrangement, exhibited the lowest demand for electricity.

Suzuke, et al., note that the energy consumed in semiconductor fabs is classified into two categories, the manufacturing system and the air conditioning. The energy for the air conditioning is further classified into fresh air intake, recirculation (cleanroom) air conditioning and cooling system of the manufacturing system [7]. During fresh air intake in the summer, the moisture in the fresh air is condensed on a heat exchange-fin of the air-handling unit. This condensation decreases thermal exchange and increases intake-air resistance. Removal of it improves the performance; Their research showed a 24% improvement of coefficient of





heat exchange, a 5% of energy saving of the refrigerator, and a 3% energy saving of the overall HVAC system.

A recent study conducted by an Intel researcher described “a significant opportunity” to recover heat from chillers and air compressors [8]. This heat can then be used to eliminate boilers for most HVAC and deionized water heating. Interestingly, one of the report’s conclusions is that attention to details matters. “Maximizing energy saved can only be accomplished by operating the systems precisely to the new strategies. To this end, buy-in from and adequate training for the operating technicians cannot be ignored nor can their importance be underestimated. Constant monitoring and fine-tuning until the systems finally achieve the potential savings often takes longer than anticipated.”

Fab level changes could help

Further optimization could be possible by rethinking fab requirements. “The need to reduce resource consumption is an area that requires greater attention. This will necessitate the integration of new technologies in the design

and construction of facilities as well as different operational strategies,” the report notes [5].

For example, reduction of the cleanliness within the manufacturing space to ISO Class 7 could reduce the recirculation air volume requirements. Widening temperature, humidity, and pressurization requirements would have a ripple effect on the exhaust and make-up air systems; This would lead to a reduction in power consumption. Process equipment idle and sleep modes can also reduce energy consumption during non-processing times. Heat recovery systems can reuse heat otherwise dissipated to the atmosphere.

Green technologies must also be considered for integration into the design and construction of future facilities. For example, by incorporating concepts such as those outlined by the US Green Building Council’s LEED program into the design of the facility, energy and water conservation strategies would need to be more widely adopted.

With the new technologies and the introduction of mega fabs the energy and water footprints become significant when considering the local

available infrastructure. Seasonal draughts and geography specific water availability in some advanced microelectronics fab locations further exacerbate the concern. Construction costs can be substantially reduced by lowering exhaust /make-up air requirements, raising non-critical process equipment’s cooling water inlet temperatures to a level where no central chiller plant is required for this equipment and using higher voltage power for production equipment as much as feasible [5]. ■

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Thank you to Pete Singer, Editor-In-Chief, of SEMICONDUCTOR DIGEST for giving us permission to publish this article.

How HVAC Tapes Impact Long-Term System Performance

BY DENNIS INEMAN, PRODUCT MANAGER, HVAC & INDUSTRIAL TAPES, SHURTAPE TECHNOLOGIES, LLC



Details matter, especially when it comes to developing essential building systems like HVAC equipment. But we all know that equipment won't operate at its full potential if the system is improperly installed. While OEM design engineers have little control over an HVAC contractor's installation approach, one detail they can control is recommending the appropriate HVAC tape to be used during installation.

HVAC tape is a critical component to ensure that the HVAC system is fully sealed and airtight. Selecting a low-quality tape or the wrong tape for a specific application can lead to a risk of failure at joints. This failure can allow air to escape and contaminants like moisture, dirt, dust, insects and bacteria to enter — all of which cause the system to work harder and potentially lead to a shorter operational lifespan.

Building owners and occupants experiencing the impacts of this failure aren't going to blame a tape failure for their rising energy costs, poor indoor air quality or complete system failure. They're far more likely to connect this poor performance to their HVAC system selection.

While local building codes will provide some broad guidance on the type of HVAC tape to use for installation, design engineers can offer more nuanced guidance that will ensure optimal performance over the life of the HVAC system.

HVAC Tape Recommendations Begin with the Code

A contractor's first priority for selecting an appropriate tape for sealing an HVAC system should always be the applicable local building code. Accordingly, the national building code can direct

manufacturers in their installation recommendations. While state and local adoption will dictate the relevant code for installation, design engineers can make recommendations based on best practices identified in the latest code edition.

In general, the building code makes tape recommendations based on UL standards. For example, the 2021 International Mechanical Code requires the use of tapes listed in accordance with UL 181A for sealing fibrous glass ductwork, or UL 181B for sealing metallic and flexible air ducts, flexible air connectors and the connections between ducts and the flanges of air distribution system equipment.

Using a tape without a UL mark doesn't just lead to the potential for system failures — it can also cause installations to be found non-compliant, leading to project

delays and cost overruns. Finding this UL listing is as simple as examining the tape's packaging, although this mark can also usually be found on the tape's film or core label.

4 Critical HVAC Tape Characteristics to Consider

A UL mark is an important factor for dictating the appropriate tape to use, but from there, tape selection can get trickier. Below are four additional factors to consider when recommending an HVAC tape to installation contractors:

1. Appropriate application.

For rigid fibrous glass ducts, tapes must meet UL standard 181A-P. To be classified as UL 181A-P-compliant, HVAC tapes must be made of aluminum alloy foil or aluminum and include a release liner, the backing that protects the tape's adhesive until it's ready

for use. These tapes must have a minimum width of at least 2.5 inches.

When sealing metallic and flexible air ducts, tapes must comply with UL standard 181B-FX. To be certified, tape must be made of foil, film or cloth and have a maximum width of 1.88 inches.

2. Application and service temperatures.

The application environment will affect an HVAC tape's durability and long-term performance. If a tape is applied in an extremely hot environment, its adhesive can become runnier, preventing the tape from making a strong bond with the surface material. When applied in cold temperatures, the adhesive can become brittle or solidify to the point that it loses its ability to adhere to a surface entirely.

service temperature, or the temperatures a tape must withstand throughout its service life, can also impact a tape's long-term durability. Frequent thermal cycling – going from hot to cold and back to hot, for example – can stress an adhesive system that isn't designed to withstand these temperature fluctuations.

Specifying a tape that is designed to perform across vast temperatures limits the risk of failure in certain environmental extremes. Some tapes are designed for use in temperatures as low as -20 F to more than 250 F, which maximizes their year-round performance in virtually any environment.

3. Conformability. An HVAC tape needs to deliver a tight seal even when wound around

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rough or uneven surfaces or along tight corners — all common occurrences in HVAC systems. Selecting an HVAC tape with high flexibility and conformability helps prevent the possibility of air leakage through narrow gaps.

Tack and adhesion.

An HVAC tape clearly needs to stick to the surface to which it's applied, but there are two separate criteria to consider here. Tapes with high tack are able to stick immediately to the surface to which they're being applied. This initial "grab" can be useful when applying tape to rough or uneven surfaces. A tape's adhesion describes its ability to form a permanent long-term bond to the applicable surface material. High adhesion is an essential characteristic of a high-quality HVAC tape.

Application Tips to Optimize HVAC Performance

Of course, it's not enough for contractors to simply select an appropriate HVAC tape. Application is also important for ensuring the tape maintains adhesion and a tight seal over the long haul.

Appropriate application begins with consideration of the application environment. As noted above, environment matters, but this goes beyond temperature control. The presence of any contaminants, such as dust and debris or moisture from humidity, can weaken a tape's ability to adhere to the material surface. To form a strong seal, it's important that contractors use a dry rag to clean and dry all surfaces prior to applying tape.

Next, the contractor will have

to cut or tear the length of tape needed. When a longer piece of tape is needed, it may be more appropriate to apply the tape directly from the roll. In this case, it's best to unroll the tape a few inches at a time. In either instance, working with a few inches at a time can help prevent wrinkling and dust from settling on the tape.

During application, the tape should remain centered over the seam to be sealed. The contractor can pull off the liner as the tape is applied by folding down the corner of the tape on the end being used first, then peeling the liner back a bit at a time. The tape should not be overstretched as it is applied, as this can result in elongation that leads to a higher risk of air leaks.

Once the tape has been applied, contractors must see to it that the pressure-sensitive material creates a lasting bond. A squeegee, firmly applied to the tape, helps maximize surface contact for secure adhesion and an airtight bond.

Your Recommendation Matters to HVAC End-Users

Appropriate installation is of paramount importance in ensuring building owners are able to see and feel the performance capabilities to which an HVAC system is designed. By recommending criteria to guide the selection of HVAC tape used during installation, design engineers can ensure the use of high-quality materials that match the quality of their equipment. This attention to detail can also simplify the installation process for contractors and deliver lasting HVAC performance for building owners. ■



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his BA from Harvard University and his MBA from the University of North Carolina at Chapel Hill.



Why Small Diameter Copper Tube is Suitable for Transitioning to Low-GWP Refrigerants

BY MARCUS ELMER, DIRECTOR, TUBE AND FITTINGS, COPPER DEVELOPMENT ASSOCIATION

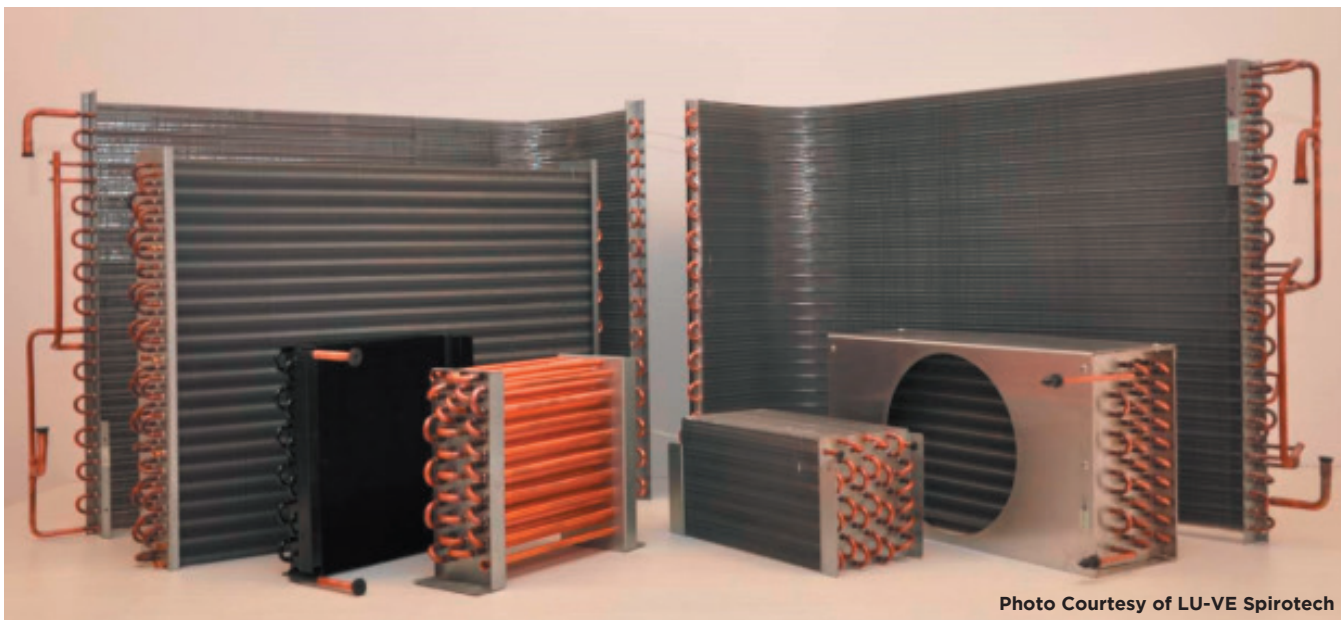


Photo Courtesy of LU-VE Spirotech

In today's increasingly environmentally conscious world, reducing the use of high global warming potential (GWP) refrigerants has become a crucial goal for industries worldwide. The HVAC/R industry, in particular, has recognized the urgent need to transition towards low(er) GWP alternatives from traditional hydrofluorocarbon (HFC) refrigerants.

HFC refrigerants, commonly used in air conditioning and refrigeration systems, are potent greenhouse gases known for their harmful impact on climate. These refrigerants have significantly high GWP, contributing to the depletion of the ozone layer and exacerbating global warming. According to the Environmental Protection Agency (EPA), HFCs can have a warming effect thousands of times greater than carbon dioxide. These staggering statistics highlight

the urgent need to reduce HFCs and find more sustainable alternatives.

Regulatory bodies, such as the EPA, have taken decisive action to implement phasedown regulations for HFCs. These regulations create a framework that encourages HVAC/R equipment manufacturers to transition to low-GWP alternatives.

Transitioning to "modern," alternative refrigerants (HFO, HC, natural)

Transitioning to "modern" alternative refrigerants is emerging as a viable solution for reducing the environmental impact of HVAC/R equipment. The three main types of "modern" alternative refrigerants gaining prominence are Hydrofluoroolefins (HFOs), Hydrocarbons (HCs), and natural refrigerants. These alternatives offer lower GWP and zero

ozone-depletion potential (ODP), making them an excellent choice for manufacturers looking to reduce their environmental footprint.

To meet today's industry needs, alternative refrigerants must have:

- low toxicity, depending on the application. For example, Ammonia is natural but toxic.
- zero, or as close to zero, ODP as possible;
- lower flammability, depending on the application. For example, many naturals, like Propane, are flammable.
- low GWP, once again depending on the application; and finally,
- the thermophysical properties have to have a useful working range.

HFOs, such as R1234yf and R1234ze, have emerged as promising alternatives to traditional refrigerants with

significantly lower GWPs than their predecessors. However, challenges, such as compatibility with existing equipment and increased cost, remain a consideration for HVAC/R equipment manufacturers.

There is increasing evidence that some HFOs like R1234yf are toxic, causing liver cancer and polluting water and land. The EU is working to ban these “forever chemicals” asap. Only R32 stayed on the list of acceptable refrigerants.

Natural refrigerants

Natural Hydrocarbons, such as propane (R290) and isobutane (R600a), provide another viable option for transitioning to alternative refrigerants. These natural hydrocarbon-based refrigerants have low GWP and are widely used in small refrigeration systems. Safety concerns related to flammability can be addressed through proper handling and design considerations.

Other natural refrigerants, including carbon dioxide (R744) and ammonia (R717), offer a sustainable solution. R744 is non-flammable and non-toxic. In addition, it has a GWP of 1, compared to traditional refrigerants, such as R134a or R410a, which have GWPs of 1,430 and 2,088, respectively.

While they provide an extremely low GWP, carbon dioxide and ammonia have their own challenges for implementation, depending on the targeted end use. Carbon dioxide has high operating pressures, for example, and ammonia's toxicity is not suitable for all applications.

Design Process

As industries continue to adopt

alternative refrigerants with lower GWP, HVAC/R equipment manufacturers are holding their breath, as they grapple with the various challenges in designing new heat exchangers for HVAC/R systems or redesigning existing ones.

But what factors drive these transitions, and what challenges do they present?

To answer these questions, we must discuss the design process and explore the considerations when transitioning to alternative refrigerants.

Three overarching factors drive heat exchanger design:

- Environment and safety; i.e., direct refrigerant emissions, carbon footprint (e.g., CO₂, end-of-life equipment), and safe material selection (resources).
- Cost of material and tooling, including the impact of size/weight
- Energy efficiency; i.e., the energy consumed in buildings, COP, billing cost, primary energy use, CO₂ emissions, and partial load.

Design Challenges

Physical properties and heat capacity: One of the most significant considerations when switching to a new refrigerant is the difference in physical properties, particularly heat capacity.

Higher-pressure refrigerants generally exhibit higher heat capacities. This results in wider vapor domes and larger enthalpy differences across the evaporation or condensation phase.

The upshot —

- A refrigerant with a wider vapor dome and more heat capacity allows the

manufacturer to achieve the same cooling or heating capacity while also reducing the refrigerant mass flow rate.

- Conversely, transitioning to a refrigerant with lower heat capacity requires increasing the refrigerant mass flow rate to achieve the desired capacity.

Flammability and Toxicity:

Another challenge when dealing with alternative refrigerants is finding suitable alternatives with low flammability and low toxicity. To address these challenges, the most common solution is to reduce the amount of refrigerant used, especially when it comes to using a flammable refrigerant alternative.

This can be achieved by designing heat exchangers with smaller diameter copper tubes, which reduces the internal volume of the heat exchanger (i.e. reduces the refrigerant charge amount). However, to prevent changes to system performance, proper heat exchanger design needs to take place.

Design Solutions:

When navigating these design challenges, there are several knobs manufacturers can turn to achieve optimal performance. Increasing the number of small tubes and tube circuits is often necessary when using smaller tubes or when a higher mass flow rate of refrigerant is required. However, these steps may introduce additional labor, material costs, and concerns about refrigerant distribution.

Increasing heat transfer performance can be achieved by adding more fins to the heat exchanger. This may not always be feasible due to limitations in fan capacity, available space,

concerns around fouling, or because of condensate/frost issues. In such cases, longer or additional tubes can be an option, when system footprint or tooling changes are allowable.

Small-Diameter Tubes: One effective tool for addressing design challenges in transitioning to alternative refrigerants is the use of small-diameter tubes and enhanced fins. Switching from larger diameter tubes to smaller ones allows for greater convective performance and improved heat transfer in a compact space.

This solution not only saves material but also minimizes the need for major changes to the product layout or enclosure design. However, it brings the challenges of circuiting and tooling to the forefront, as expertise and capital investment may be required to implement small-diameter tubes.

What Makes Small Diameter Copper Tubes Well-suited for Low GWP Refrigerants?

Copper's unique properties make it highly compatible with a wide range of refrigerants, including low GWP options.

Energy efficiency can be achieved at a lower material cost with smaller diameter tubes, and overall system size can be reduced.

In addition, smaller-diameter tubes can operate at higher pressures, making them more desirable as operating pressures increase. Working pressure is directly proportional to tube wall thickness and inversely proportional to tube diameter. In other words, for tubes with the same thickness, smaller diameter tubes can withstand higher pressures than larger diameter tubes.

Less material: Tube-diameter reduction results in more effective heat transfer and, consequently smaller, lighter coils. Less tube and fin material could provide equivalent heat transfer, or the same quantity of material could provide much more heat transfer.

Less refrigerant: A dramatic reduction in refrigerant volume is a further benefit of small diameter copper tubes. The smaller internal volume of the coils means that less refrigerant is necessary to charge the coil. The need for less refrigerant results in other design advantages, including a further reduction in overall system weight.

Durability: Coils made of copper tubes and aluminum fins or Round Tube Plate Fin (RTPF) are durable and dependable. They set the industry standard for corrosion resistance and long, reliable

service life. Advanced coatings and surface treatments continue to improve durability in the harshest environments. The industry has found it difficult to improve upon the exceptional durability of copper tubes.

Familiarity: Tube suppliers, OEMs, mechanical systems engineers, and HVAC contractors all enjoy a high familiarity with CTAF technology. Up and down the value chain, the materials and processes are well understood. The fabrication, assembly, installation, service, repair, and recyclability are not substantially changed in the migration from conventional copper tubes to small-diameter copper tubes. ■

Marcus Elmer, Director of Tube and Fittings with the Copper Development Association, is a seasoned professional with over 15 years of experience in the plumbing and mechanical industries. He leverages his expertise to identify and influence market trends for copper tube and fittings products, driving strategic programs that encompass technical research, codes and standards, advocacy, and education. With a unique perspective gained from his time as a project manager with commercial plumbing, mechanical, and refrigeration contractors, Elmer has a deep understanding of the industry. He holds a Master of Business Administration from Union University in Tennessee and a Bachelor of Science in Construction from the University of Wisconsin - Stout.

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ASGE is a society that promotes technical education in the subject of gas-fired fuel, components, and appliances. Our key objectives are advancing the theory and practices of gas engineering; promoting the safe, efficient, and ecologically compatible utilization of gas, and the standardization of terminology, techniques, and laboratory testing methods. We encourage research and innovation in the gas industry, and provide forums and media through which experiences and information may be shared and discussed for the common good.

ASGE was formed on November 30, 1954, by eight engineers who agreed there was a need for a gas engineers' association. The Society was first formed with localized chapters that were located across the United States. The chapters held regional meetings and technical training classes. The national model was adopted in December 2005 and brought all the regional chapters together under one membership and operating society.

Our membership program offers the opportunity to share in ASGE's educational programs and constructive activities. Our annual Technical Conference is our flagship event where we explore and advance gas industry interests with fellow professionals. The two-day event is held in Las Vegas the first week of June each year. Technical presentations are given from gas industry professionals and consultants on the subjects of gas burner/appliance innovation, safety, and regulations.



Gas Cooking Presentation given during the 2023 National Tech Conference
In Las Vegas, NV

ASGE continued...

Multiple times a year, the Certified Gas Engineer Exam is administered to individuals who meet the requirements to participate in the program. The Certified Gas Engineer Exam (CGE) is what distinguishes the Society from other associations. By offering a certification program, the Society sets the benchmark for engineers in the gas industry. The exam tests on gaseous fuel basics, properties, supply, handling, safety, operating characteristics, standards, tendencies, and criteria. Since the Exam's inception, ASGE has accredited over 300 CGEs within our membership and the gas industry.

Currently the Society is revising and adding content to the ASGE Handbook. The Handbook is a gathering of gaseous fuel information that is vital for the gas engineer. The new edition of the Handbook will be available for purchase starting in June 2024.

In addition to the Technical Conference and the Certified Gas Engineer program, ASGE is very involved in regulatory committees and regulations. Many members sit on safety standard committees and also other association committees who lobby for the viable and correct future of gas. ASGE has signed onto letters that comment on regulations that have been created by federal departments like the DOE and EPA.

For more information on the Society, we have several forms of contact.

Website: asge-national.org

email: asgecg@aol.com

Address: **P.O. Box 311069 Independence, OH 44131**

Please consider joining us at our Technical Conference on June 2-4, 2024. We also have quarterly newsletters available by subscription. We look forward to hearing from you!



How to Design Safe and Reliable Robotic Appliances

Work smarter, not harder, to protect your next design

BY PAULIUS JUSKEVICIUS



Consumers are taking advantage of the benefits that automation and the Internet of Things (IoT) bring to their lives. Robotic appliances can make life easier by reducing the work of cleaning and maintenance. As a result, there is a growing demand for these devices as they can integrate into smart home systems. In addition, developments in artificial intelligence (AI), machine learning, and sensor technologies are enabling more sophisticated domestic robots. These robots can navigate complex environments, recognize objects, and respond to voice commands. **Figure 1** illustrates some examples of robotic appliances.

Developers have the challenge of designing complex electronic circuitry that creates robotic appliances. They also have the challenge of protecting their product from electrical hazards and ensuring efficient control and reliable sensing. This article will focus on the most ubiquitous of these products, the robotic vacuum cleaner. This article introduces designers to the latest solutions that support safety, efficiency, and reliability.

Protection, efficient power control, and reliable sensing for a robotic vacuum cleaner

Figure 2 highlights the different functions of an example robotic vacuum cleaner. Each function lists components that provide circuit

protection, energy-efficient control, and reliable sensing.

Figure 3 provides a detailed block diagram of the example robotic vacuum cleaner. The adjacent table offers recommended components for specific circuit blocks requiring protection, efficient power control, and reliable sensing. Some of these unique components can ease the designer's development task.

Protection and efficient control for the Docking Station

We will start with the external system, the Docking Station. The Docking Station supplies the power to charge the robotic vacuum cleaner's battery. **Figure 4** expands upon **Figure 3** and presents a block diagram of the Docking Station. The Docking Station connects to the AC mains and is subject to high current if an overcurrent occurs in the Docking

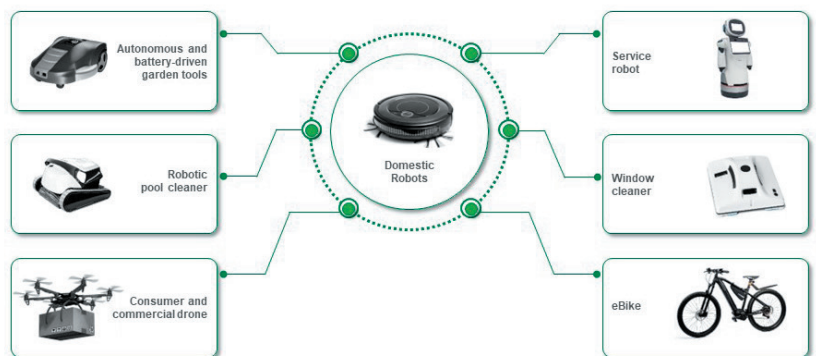


Figure 1. Home Robotic Appliances share common safety and control requirements

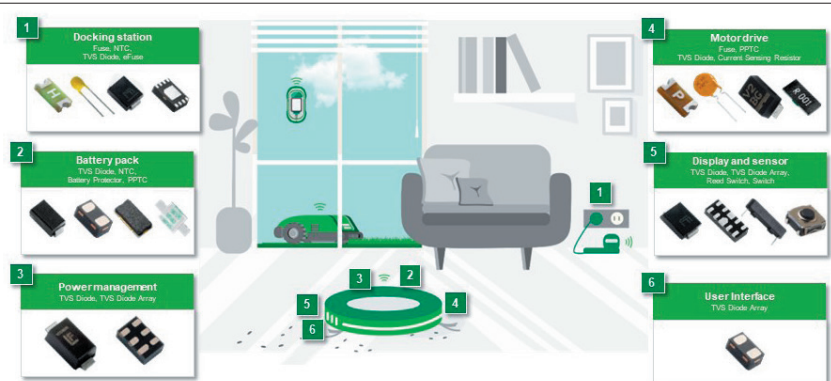


Figure 2. Robotic Vacuum Cleaner – Protection, control, and sensing components

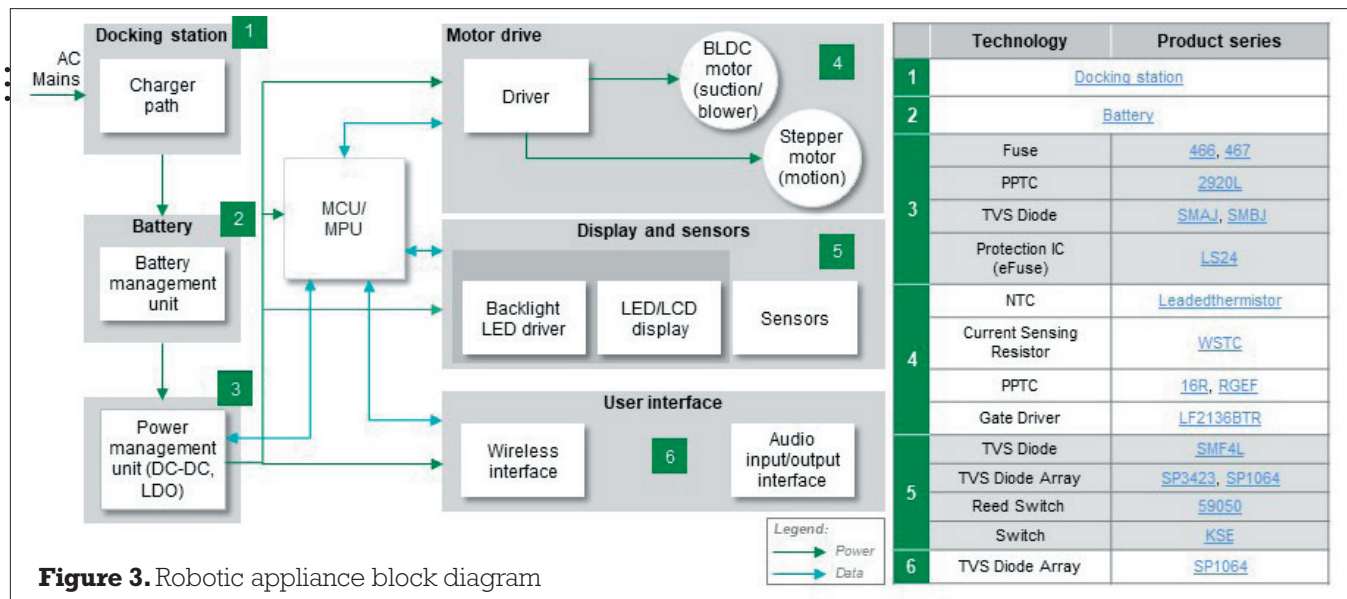


Figure 3. Robotic appliance block diagram

Station. It is also susceptible to transients induced on the AC mains due to lightning strikes and transients resulting from the effects of inductive loads switching on and off. The circuitry needs protection from high-capacity current and transient surges to ensure a robust and reliable Docking Station.

AC Input Primary Protection block

The AC Input Primary Protection circuit requires a fuse for overcurrent protection from an internal circuit failure. Look for a time lag fuse with:

- An ampere rating that prevents an excess of current from entering the circuit but avoids nuisance tripping

- A low internal resistance to minimize power loss and heat rise
- Vibration resistance
- Voltage rating exceeding 110% of the AC mains voltage
- Compliant with IEC 60127-4 or an equivalent UL standard.

To protect the circuitry from a transient, a metal oxide varistor (MOV) can safely absorb a 2 ms pulse of energy as high as 530 J or a 20 μ s current pulse as high as 10 kA. For further protection, MOVs are available with internal thermal elements that will open to protect the MOV from overheating due to the overvoltage condition. As with the fuse, which is in contact with the AC mains, save compliance certification time by selecting an

MOV compliant with UL 1449 or an equivalent standard.

Rectification, PFC, High Frequency Converter, and Output DC Protection circuits

The Rectification, PFC, High Frequency Converter converts the AC input voltage to a DC voltage. Then, it converts it into a pulsed signal for the transformer to couple to the secondary rectifier and filter circuit. The power factor correction circuit reduces the phase magnitude of the circuit block to minimize both the apparent power and the harmonics drawn by the Docking Station circuit. The Output DC Protection block prevents transients or ESD from propagating

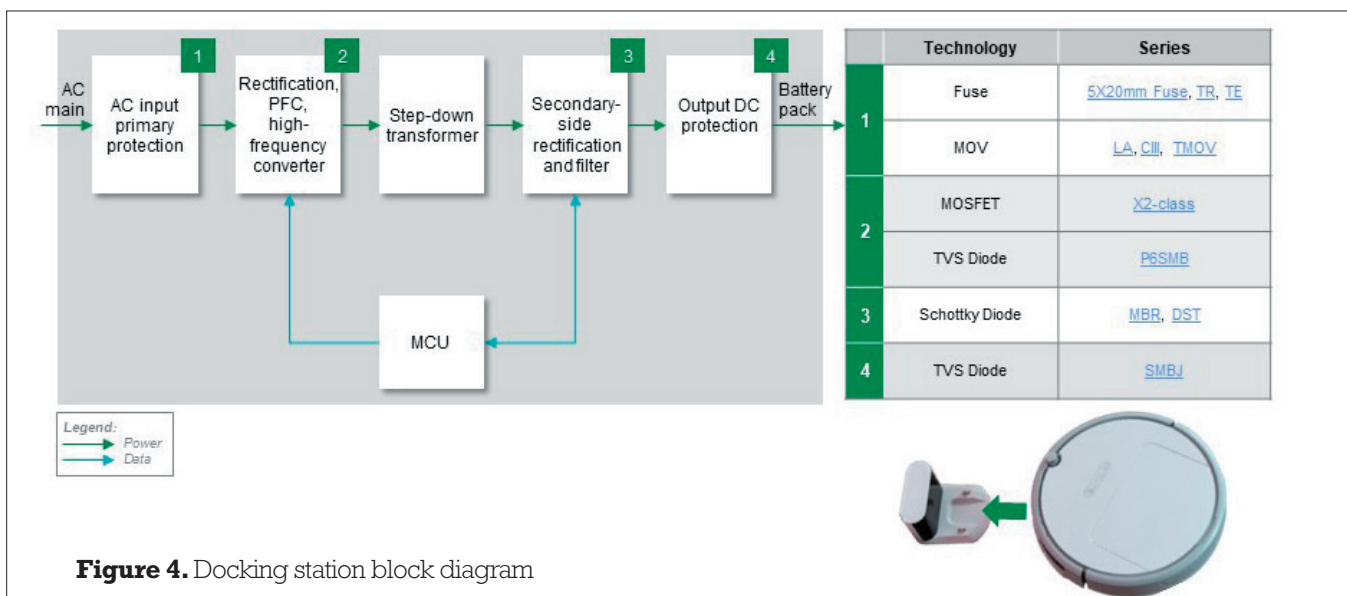
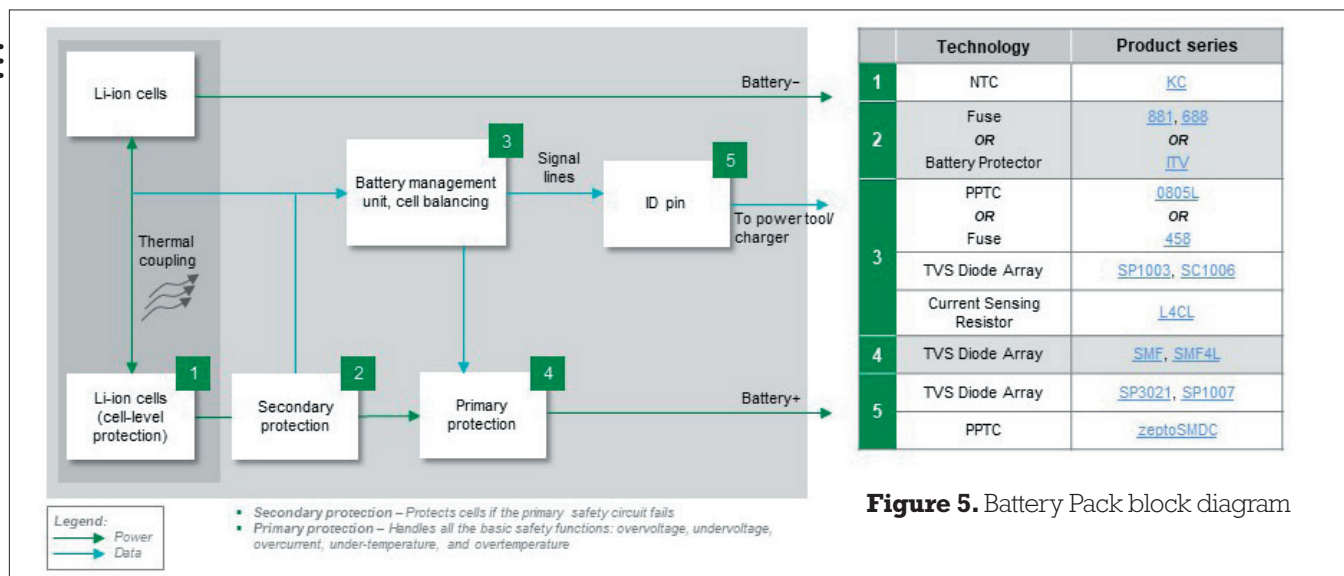


Figure 4. Docking station block diagram



into the battery pack.

For both these circuits, transient voltage suppressor (TVS) diodes can safely absorb fast transients and ESD strikes to protect downstream circuitry and the load, the battery pack. The recommended TVS diodes:

- Can absorb 600 W of peak pulse power from a 10/1000 μ s waveform
- Withstand an ESD strike up to 30 kV
- Have models with either uni-directional or bi-directional (two diodes in a cathode-cathode connection) polarity protection
- Have very fast response times
- Low clamping voltages
- IEC 61000-4-2 and 61000-4-4 compliance.

Consider using a power MOSFET and a Schottky diode to maximize efficiency in the Rectification and Secondary-Side Rectification circuits. Milliohm-level RDS(ON) values reduce on-state power loss and nanocoulomb gate charge, voltage-per-nanosecond dV/dt rates, and nanosecond switching times reduce switching power losses. The high switching rates of these MOSFETs allow higher frequency switch-mode AC-DC converter circuits to maximize efficiency. Similarly, Schottky barrier power diodes offer low forward voltages, significantly under 1 V,

and can operate at high switching frequencies to contribute to improved converter efficiency.

Protecting the Battery Pack

The battery pack supplies the power to operate the robotic vacuum. The individual batteries are Lithium-ion (Li-ion) cells, which have high power density but can be susceptible to substantial damage due to mechanical or electrical abuse.

The Battery Pack circuitry, including the battery cells, monitoring circuits, and the Battery Management Unit, require monitoring and protection components. Figure 5 details the circuit blocks of the Battery Pack.

Li-Ion Cells

Monitoring the temperature of the Li-ion cells is the most critical parameter for ensuring the safety of the Battery Pack during charging and discharging cycles. Thermistors offer accurate temperature readings, fast thermal response, and a small form factor for a solid connection to the battery.

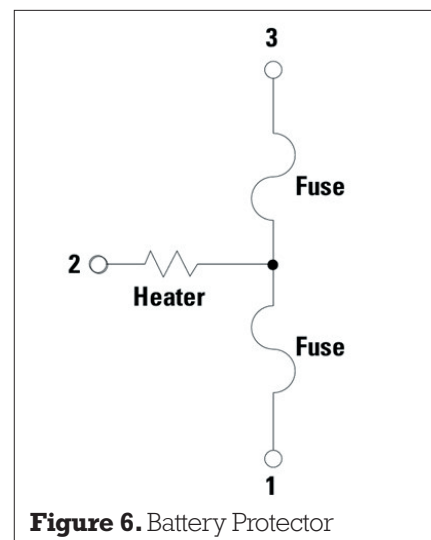
Secondary Protection circuit

The Secondary Protection circuit provides backup protection to the Primary Protection circuit. A high-current rating, surface mount fuse can interrupt a current overload on the battery. Alternatively, Littelfuse

offers a unique component, a battery protector, which provides overcurrent and overcharge protection. The battery protector is a three-terminal fuse component. **See Figure 6.** The fuses protect the battery from an overcurrent, and an IC in the Secondary Protection circuit activates the heater, which blows the fuse if an overvoltage occurs during charging.

Battery Management Unit and Cell Balancing circuit

The Battery Management Unit and Cell Balancing circuit monitor the battery's health and ensure all cells carry an equal amount of load current. Protect this vital circuit block with a fast-acting, small surface mount fuse or a surface mount, resettable polymer positive



temperature coefficient (PPTC) fuse. Also, use a TVS diode to protect the circuit from ESD strikes. Select a TVS diode that can absorb strikes of at least 8 kV.

Using a current sensing resistor allows the Battery Management Unit to monitor the battery charge and discharge current accurately. Surface-mount 4-wire connection resistor elements are available with milliohm resistances and maximum resistance tolerances of 1.0%. The 4-wire contacts enable a Kelvin connection of current sourcing on two terminals and voltage measurement on the other two terminals to provide an accurate battery current measurement.

Primary Protection circuit

The Primary Protection circuit protects and controls the battery pack from overvoltage, undervoltage, overcurrent, under-temperature, and overtemperature. Keeping this circuit operational is essential for ensuring the battery is kept safe. Since it interfaces with a charger or the load, the Primary Protection circuit needs protection from ESD. A TVS diode with 30 kV of absorption capacity is the recommended component to protect the circuit. Versions can have either uni-directional or cathode-cathode bi-directional configurations.

ID Pin circuit

The ID Pin circuit ensures that only the correct model charger can apply power to the battery pack. This circuit has I2C interface lines. A TVS diode can prevent the data lines from getting corrupted by ESD transients. Look for TVS diodes capable of absorbing at least 8 kV of ESD strikes, are bi-directional, and have low capacitance to minimize distortion to the data transmissions. Prevent

damage to the TVS diodes from overcurrent with a resettable PPTC fuse in a small, space-saving, surface mount, 0201-sized package.

Protecting the Power Management Unit

The Power Management Unit, in the Figure 3 block diagram, provides all necessary voltages for the robotic vacuum circuitry. One option for protecting the Power Management Unit includes discrete components for overcurrent protection from a short in the motor or in another part of the circuitry and voltage transient protection. Either a fast-responding one-time fuse or a fast-responding resettable PPTC fuse can provide overcurrent protection due to a short in the motor or in another circuit. A TVS diode offers the necessary overvoltage surge protection for the downstream circuitry. The TVS diode in the table in Figure 3 recommends 400 W pulse absorption capability and 30 kV absorption of an ESD strike.

The alternative to the discrete components is a unique Littelfuse component, the eFuse. The eFuse combines programmable overcurrent protection, overvoltage protection, inrush current limiting,

and reverse current blocking in a single IC. **Figure 7** shows a schematic of one type of eFuse. In addition, eFuse ICs offer:

- Overtemperature protection, which effectively disconnects the load from the supply when the detected temperature exceeds a specific limit.
- Under voltage lockout, which prevents powering the load until the supply voltage is high enough to power the load safely.
- Models with operating voltages down to 2.5 VDC and up to 24 VDC
- Models with current ratings up to 6 A
- Low power loss between supply and load with power control MOSFETs having RDS(ON) values $\leq 50 \text{ m}\Omega$.

An eFuse provides a complete array of protection modes in a single package. One component can save printed circuit board (PCB) space and save circuit development time.

Protecting the Motor Drive circuit

The Motor Drive circuit powers the motor that draws the dust and dirt into the vacuum and the stepper motor that transports the vacuum.

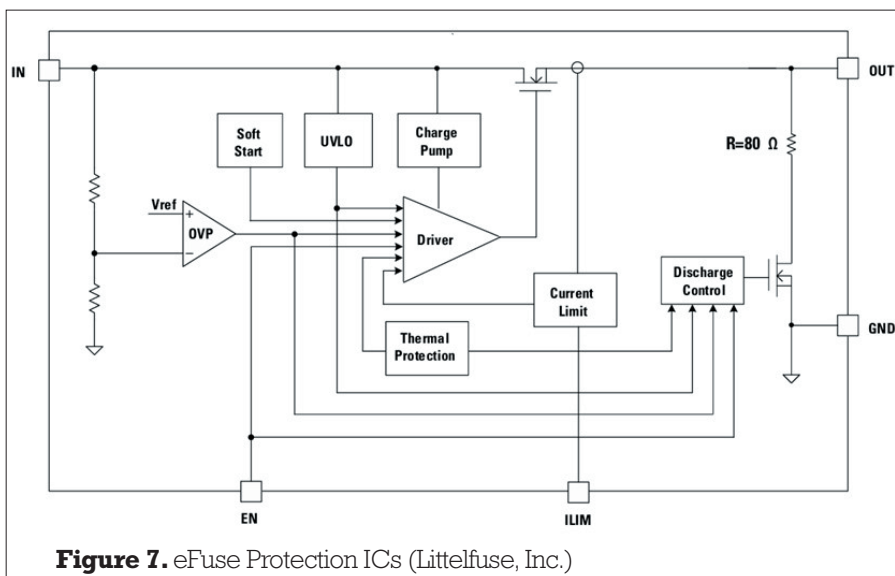


Figure 7. eFuse Protection ICs (Littelfuse, Inc.)

Protecting the motors requires monitoring for overtemperature and overcurrent. Failure to monitor either can severely damage the motors and the robotic vacuum cleaner circuits. NTC thermistors are excellent temperature sensors for monitoring overtemperature. They are high-reliability components with fast thermal response, exceptional accuracy, and small packages for placement in the most appropriate locations.

Monitor motor current with current sensing resistors in series with the motors. The recommended current sensing resistors consume minimal PCB space, have low resistances under 50 mΩ, and have low-temperature coefficients of resistance no higher than 100 ppm/°C.

When the thermistor detects a high temperature on the motor, include a resettable PPTC fuse to interrupt the motor current. Resettable PPTC fuses can have fast trip times and low resistance values under 60 mΩ.

Protecting the Display and Sensors circuit and the User Interface circuit

The LCD touchscreen display is subject to ESD from charge buildup on users. TVS diodes can safely absorb the strikes to protect the display and display driver ICs. TVS diode options are available with either low leakage current or low device capacitance. Low capacitance TVS diodes minimize distortion on digital signal lines. Low leakage current TVS diodes minimize signal loss on analog sensor lines. Models can include protection for a single data or sensor line or multiple data/sensor lines.

The User Interface is also subject to ESD from the external environment. ESD can propagate through the antenna of the Wireless Interface and through the circuitry of the Audio Input/Output Interface. Multi-line TVS diodes can efficiently protect the multiple signal lines of the two interfaces.

Protecting the User

When the lid of the robotic vacuum cleaner is open, the user could expose themselves to active mechanical parts or electrical shock from the internal circuitry. A hermetically sealed reed switch can act as an interlock to shut

down the moving parts and de-energize the vacuum when the lid is open. By using a magnetic actuator to control the reed switch, the designer can help minimize power consumption.

Reliable and efficient controls for the Motor Drive and Display and Sensors circuits

Designers can maximize the efficiency of the Motor Drive circuit with gate drivers to control the MOSFETs that power the motor. Three-phase, floating half-bridge drivers are available from Littelfuse in a single IC to control three-phase brushless DC motors. The IC combines high voltage and high speed. The propagation delay between each phase is matched to within 50 ns. The gate driver IC can safely withstand negative voltage transients. It also has internal protections including under voltage lockout, overcurrent protection, and shoot-through protection logic, which prevents the fault state of high outputs with low inputs. Furthermore, the IC has design features that enable operation in high-noise environments.

Standard	Sub-section requirement	Components supporting standard	How Littelfuse benefits OEMs
UL 1017, IEC 62784, GB4706.7	4.17: Any protective component must be evaluated to its basic component standard	All safety critical components (Fuse, MOV, PPTC, NTC)	Approved by third party safety certification agencies: UL, IEC, and CSA
	4.15.3: Clearance requirement in accordance with UL 840	MOV	Use of MOV allows for reduction in spacing requirements
	5.8: Limit temperature to acceptable levels	NTC	Prevent appliances from reaching temperatures that constitute risk of fire or material damage
	Section D8.3: Limited circuits	PPTC	Maximum available current in secondary circuit inherently current limited
UL 2595, IEC 62133-2	7: Rechargeable battery-powered appliances	PPTC, NTC	Meet the general requirements of battery-operated appliances UL 2595
UL 1310, UL 1012 IEC/EN 61000	Section D2: Class 2 circuits	PPTC, Fuses	Docking station: charging station shall meet requirements of UL 1310
UL 1434; UL 248	4.9.3: Motor overload protection	SMD PPTC, SMD Fuse	PPTC approved to UL-1434 spec, UL60730-1 for motor overload protection; Fuses approved to UL- 248
	5.26: Abnormal overload test	Fuses approved to UL 248	Product will withstand overload conditions at 110%, 135%, 200%
UL 1017	Section D8.3: Limited circuits	PPTC	Maximum available current in secondary circuit inherently current limited

Table 1. Home robotic appliances safety standards

Select a reliable, long-life, on-off switch for use in the Display and Sensor circuits. Low-profile tactile switches are available with a 300,000-cycle life and IP67-rated protection from moisture and dust.

Applicable safety and compliance standards for robotic appliances

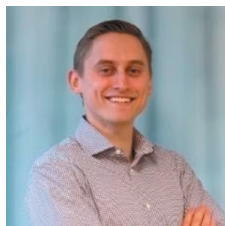
Table 1 lists the standards that robotic appliances must meet so they can be marketable products. The table indicates the components that support standard compliance. It also describes how Littelfuse supports product development.

The solution for a safe, reliable, and robust robotic appliance

By making wise choices, electronics designers can protect their circuits from electrical hazards and minimize energy consumption. They need to consider certification requirements and potential application hazards when considering component selections. Fortunately, they can get assistance and save development time by utilizing the manufacturers' expertise. Working with a manufacturer's application engineers, such as application engineers at Littelfuse, can help with:

- Selection of cost-effective efficient, and compact components for protection, control, and sensing
- Advice on applicable safety and compliance standards for enabling sales in worldwide markets
- Performing pre-compliance testing to save time and costs with certification standards testing.

Collaborating with Littelfuse can help designers create safe, low-power consumption, reliable, and robust robotic appliances. ■



About the author
Paulius Juskevicius is a Strategic Marketing Manager for the Electronics Business Unit at Littelfuse. Paulius joined Littelfuse in 2016 as field application engineer for the EMEA region. His current responsibilities include the management of marketing activities for new

product launches and performing marketing studies and feasibility analysis for new product ideas. Paulius earned his master's in electrical engineering from Kaunas University of technology.

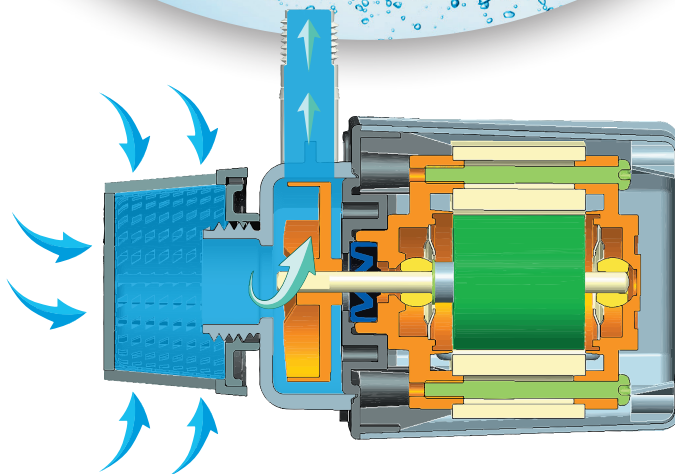
References: Additional resources, courtesy of Littelfuse, Inc.

- Circuit Protection Product Selection Guide
- Sensing Products Selection Guide
- Power Semiconductor Selection Guide
- Integrated Circuits Selection Guide

Learn more about protecting appliance designs with proper circuit protection, courtesy of Littelfuse, Inc.

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What's Happening

After Maine Surpasses 100,000 Heat Pump Goal Two Years Ahead of Schedule, Governor Mills Sets New, Ambitious Target

White House National Climate Advisor Ali Zaidi joins Governor Mills to announce milestone at heat pump workforce lab at Kennebec Valley Community College

Governor Janet Mills announced that Maine has – two years ahead of time – surpassed its goal of installing 100,000 new heat pumps by 2025, a milestone that represents significant progress in reducing Maine's reliance on heating oil, lowering heating costs, and curbing harmful carbon emissions.

To continue Maine's momentum, Governor Mills also unveiled a new target: installing another 175,000 additional heat pumps in Maine by 2027, thereby bringing the number of heat pumps installed in Maine homes, businesses, and public buildings during her time in office to 275,000. If this target is achieved, Maine would have more than 320,000 heat pumps in total installed across the state.

Maine's heat pump progress stems from legislation signed by Governor Mills in 2019, which established the state's heat pump target of 100,000, enhanced heat pump rebate incentives through Efficiency Maine, and established a low-income heat pump program at MaineHousing. Through these programs, approximately 104,000 heat pumps have been installed in Maine.

Governor Mills announced the milestone at Kennebec Valley Community College (KVCC) in Fairfield, where she unveiled the initial goal in 2019. Following that announcement, the Maine Community College System expanded its heat pump workforce programs, and has trained 558 heat pump technicians to date, including more than 250 at KVCC, which opened an all-new heat pump workforce training lab in early 2021.

The governor was joined for the announcement by White House National Climate Advisor Ali Zaidi, who extended his congratulations to Governor Mills and the State of Maine for its climate leadership by embracing heat pumps to reduce reliance on fossil fuels, increase overall energy efficiency, and decrease greenhouse gas emissions.

Maine's success in installing heat pumps has earned wide recognition for how the high-efficiency



(Left to right): White House National Climate Advisor Ali Zaidi, Maine Community College System President David Daigler, Governor's Energy Office Director Dan Burgess, and Governor Janet Mills receive a tour of the heat pump workforce lab at Kennebec Valley Community College.

heating and cooling technology works well in rural areas with cold climates and can generate new economic and workforce opportunities for Maine people.

Installation data from Efficiency Maine Trust show heat pumps have broad adoption in rural and northern Maine, which underscores the economic benefits of the program and success of the enhanced incentive program enacted by Governor Mills in 2019.

"You have to be impressed with what Maine's community of heat pump installers have accomplished in our state," said Michael Stoddard, Executive Director of Efficiency Maine. "Their adept marketing and skilled installations make them the perfect partners for the incentive programs that the Governor and Legislature have funded through Efficiency Maine's programs, and together we are changing how Mainers heat and cool their buildings."

Since taking office, Governor Mills has prioritized action against climate change in Maine through reducing carbon emissions, transitioning to renewable energy, and making Maine communities more resilient to climate effects.

In May, she was elected co-chair of the U.S. Climate Alliance, a bipartisan coalition of 25 governors committed to fighting climate change, which together represent more than half of the U.S. population and 60 percent of the national economy.

In 2019, with bipartisan support of the Legislature, Governor Mills enacted laws setting ambitious targets for transitioning to renewable energy and reducing greenhouse gas emissions. These include reducing greenhouse gas emissions in Maine by 45 percent by 2030 and 80 percent by 2050, and transitioning Maine's electricity use to 80 percent renewable energy by 2030.

Earlier this, with Maine experiencing high energy prices caused by volatile global markets, Governor Mills committed to accelerate Maine's transition to using 100 percent clean energy to 2040, a move that would ensure the expansion of climate-friendly technologies in Maine – such as heat pumps – are powered by clean electricity.

In 2019, Governor Mills also pledged Maine will become carbon-neutral by 2045, a commitment which she signed into law in 2022.

The governor in 2021 also announced a new State program, the Community Resilience Partnership, that was recommended by the climate plan to help Maine communities reduce emissions, transition to clean energy, and increase resilience to climate effects.

Since opening to enrollment in early 2022, 148 Maine cities, towns and Tribal governments

have chosen to participate in the Partnership as individual entities or regional coalitions, and more than \$3.7 million in grants have been awarded to 74 community projects across the state.

Governor Mills has also committed to more than doubling Maine's clean energy jobs to 30,000 by 2030, and made several historic investments in climate priorities, thanks to Maine's strong economic recovery and the Maine Jobs & Recovery Plan. These investments include:

- \$50 million for energy efficiency programs, such as residential weatherization and heat pumps and other efficiency upgrades for schools, towns, non-profits, and hospitality businesses.
- \$27.5 million for municipal grants to protect infrastructure from flooding, rising sea levels, and extreme storms.
- \$8 million for the Clean Energy Partnership, an initiative to grow the Maine's clean energy workforce and innovation economy.

For an updated guide on climate incentives now available for Maine residents and businesses, please visit mainewontwait.org.



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 **JABS Media, LLC**

A.O. Smith Acquires Water Tec of Tucson, a Water Treatment Solutions Provider, to Expand West Coast Presence

A.O. Smith announced it acquired Water Tec of Tucson, an Arizona-based water treatment company, in an all-cash transaction. Terms of the transaction were not disclosed.

Water Tec joins other A. O. Smith acquisitions, Atlantic Filter (2022), Master Water Corporation (2021), Water-Right Group (2019), Hague Quality Water (2017), and Aquasana (2016) in the company's growing North America Water Treatment business.

"The acquisition of Water Tec further expands our west coast presence and supports our growth strategy. A. O. Smith delivers innovative, differentiated solutions that heat and treat water and Water Tec aligns perfectly with our values and commitment to quality," said Kevin J. Wheeler, president and chief executive officer.

The second-generation, family-owned company was founded in 1967 and is based in Tucson, Arizona with an assembly location in Las Vegas, Nevada. Water Tec is a manufacturer and dealer of water treatment equipment for residential, commercial, institutional and industrial use. Water Tec's products are sold through their retail dealership located in Tucson, Arizona.

"Water Tec is a perfect fit to join the A. O. Smith family. The company's long-standing history of providing effective water treatment solutions has made them a leader in the water industry," said D. Samuel Karge, president, A. O. Smith North American Water Treatment. "The company has a reputation for quality and is committed to serving customers with honesty and integrity, which is the foundation of A. O. Smith."

"I am very pleased the business founded by my parents, along with our family legacy, will continue to thrive as a result of this acquisition," said Leigh DeGrave, owner/president, Water Tec. "As a global water solutions company, A. O. Smith brings great expertise and resources to our organization, allowing for growth in markets we would not have otherwise been able to penetrate."

Jennifer and Leigh DeGrave, along with their son Hunter, will stay with the business. They will continue operating out of their Tucson and Las Vegas locations.



Littelfuse Launches Its Class J Fuse Disconnect Switch

Product combines switch and fuses to simplify operation and protection while saving space

Littelfuse, Inc., a diversified, industrial technology manufacturing company empowering a sustainable, connected, and safer world, has launched its Class J Fuse Disconnect Switch. The compact device combines a switch and multiple fuses into a single product offering a simpler way to manually open and close a circuit while safeguarding against overcurrent and short circuits. When the switch detects an overload or short circuit, the fuse blows automatically to open or break the circuit both upstream and downstream and shuts off the equipment. The 600 V switch is available in 30, 60, 100, and 200 A and protects many applications in various industries including HVAC/R, mining, solar, energy storage, and industrial.

"When installing or maintaining equipment, the Class J Fuse Disconnect Switch makes it both safer and easier to connect or disconnect the power in an isolated area," stated Augusto Sanchez Littelfuse Industrial Business Product Manager. "In addition, with a higher interrupting rating, the switch delivers more robust protection, increases personnel safety and offers a longer switch life."

Other Class J Fuse Disconnect Switch features include:

- Small footprint to save space and provide design flexibility.
- A no-tools-required frontal direct handle for easy and quick installation.
- Safe-to-touch transparent fuse covers that cannot be opened in the "ON" position for extra protection and offers visibility to fuses—without opening module—for added convenience.

- Horizontal, vertical or 45-degree switch mounting options for installation adaptability.
- Optional handles with front or side operation to accommodate system design.
- An optional lockout-tagout padlock that can be added when the device is in the "OFF" position to ensure equipment is properly shut off during maintenance or repair to prevent the release of hazardous energy safeguarding personnel and equipment.
- A "TEST" position on handle to permit control circuit auxiliary testing without switching the main contacts on for added safety.

Burloak announces rebrand to MAINWAY New brand, image, and website launched at FABTECH 2023 in Chicago

MAINWAY

Burloak Tool announced a new brand and identity at FABTECH

Burloak Tool & Die Ltd. is now known as MAINWAY Metalworks Inc. The FABTECH booth features the new branding, and coincides with the launch of phase one of a new website at www.mainway.com.

Burloak Tool was acquired by Summit Ridge Capital in February 2021. In December 2022, Burloak acquired Armactool, and early in 2023 Burloak acquired CadTek. All three brands are now harmonized under the MAINWAY marque.

"We're excited to bring this new brand to life, with decades of pre-existing technical underpinnings", noted Sean Brown, President & CEO of MAINWAY. "Burloak, Armactool, and CadTek are all strong brands in their own right, in different parts of North America. Built on this platform, MAINWAY instantly becomes a trusted national brand to turn to for North American built tooling and stamping for the appliance, automotive, heavy duty, military, and other demanding industries".

The name is a legal name change only. There has been no restructuring or change in ownership. MAINWAY remains backed by Summit Ridge Capital, and ownership of the Burloak Tool, CadTek, and Armactool brands remains with MAINWAY. All old email addresses still work, and will slowly transition to @mainway.com.

MAINWAY Metalworks is a trusted supplier to the appliance, automotive, heavy duty, and other industries. Customers can engage with Burloak at any stage of the value chain they require – Design, prototyping, toolmaking, machining & cutting, short or long run production stamping, value-added afterwork, and die repair and tuning.

Spectrolite® Introduces New Products: GLO Seal™ Kits



Spectronics announced the launch of two new kits for the GLO Seal™ product family. These new UV dye and AC sealant kits will provide customers with additional choices when it comes to selecting complete leak detection solutions.

The Advantage of Using GLO Seal

GLO-SEAL™ is fully compatible with all refrigerant types including new A2Ls, and is engineered with a non-polymer, oil-soluble formula that's safe for system components and recovery equipment. It meets ASHRAE 97 standards for chemical stability without any damage to the system.

With one quick installation, GLO Seal™ pinpoints the exact location of all leak and micro-leak areas and AC&R leaks from the inside will be sealed. GLO Seal™ is perfect for preventing further issues and ensuring all leaks will be found, making it a strong 2-in-1, find and fix solution for AC&R systems and preventative maintenance solutions.

About The Kits

The GLO Seal™ Stick Complete Fluorescent Leak Detection Kit (SPE-MVLGSDS) and The GLO Seal™ EZ-Ject™ Complete Fluorescent Leak Detection Kit (SPE-MVLEZDS) are composed of everything needed to find and fix a leak. They come with (4) GLO Seal cartridges, injector and hose assembly, UV LED leak detection lamp, Glo-Away Plus dye cleaner, and R-410a adapter. Each cartridge treats up to 3.5 tons (12.3kW)

of cooling, for a kit total of 14 tons (49.2kW) of cooling.

SABAF Acquires 51% of Mansfield Engineered Components

The Sabaf Group, a leading designer and manufacturer of components for household appliances, is taking another important step towards international growth and diversification of its product range.

Sabaf S.p.A., through its subsidiary Sabaf America Inc. I, today signed an agreement to purchase 51% of Mansfield Engineered Components LLC ("MEC"), a US company based in Mansfield (Ohio) and the leading North American manufacturer of hinges for household appliances (mainly ovens, washing machines and refrigerators), designed and manufactured to meet the high quality levels and demanding standards required by the US market. The transaction closing took place at the same time as the acquisition agreement was signed.

MEC was founded in 1987 by Bruce, Steven and Claudia Cummins, who still own 49% of the company. Bruce and Steven Cummins will manage the acquired company as CEO and Vice Chairman, respectively. MEC employs 200 people.

In the period between January and May 2023, MEC recorded revenues of USD 14.3 million, proforma2 EBITDA of USD 1.43 million and pre-tax profit of USD 0.80 million. In 2022, MEC generated revenues of USD 35.7 million, achieved a pro-forma2 EBITDA of USD 2.5 million and a pre-tax profit of USD 1 million.

The agreements reached envisage an evaluation of MEC of USD 21 million (Enterprise Value). The lump-sum payment of USD 10.5 million for the acquisition of 51% of the share capital was made at the same time as the

transaction was completed. The purchase price was determined based on provisional figures showing a positive net financial position of USD 0.6 million and working capital of USD 14 million, and will be subject to adjustment based on MEC's net financial position and working capital figures to date.

The agreements with the sellers also provide for a call option in favor of Sabaf for the remaining 49% of MEC's share capital (exercisable in 2028) and a put option in favor of the minority shareholders (exercisable from 2025 to 2028). The valuation of the residual stake will be based on an Enterprise Value equal to 8 times MEC's average EBITDA of the two financial years preceding the date of exercise of the relevant option, adjusted for the net financial position at that date. With the acquisition of

a majority shareholding in MEC, the Sabaf Group, already present on the market for hinges for household appliances through its subsidiaries C.M.I. s.r.l. and Faringosi Hinges s.r.l., becomes the leading manufacturer of hinges for household appliances in the Western world.

The Sabaf Group is thus expanding its industrial footprint and optimizing its production location and supply chain in all the main reference markets, allowing further logistics efficiencies. The direct presence in the United States, together with Sabaf Mexico, which has recently started the production of burners, will allow us to consolidate relations with major American players with which the Sabaf Group has excellent business relations and which are MEC's historical customers. With the acquisition of MEC, the impact of



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sales in the North American market will account for 26% of the Sabaf Group's turnover, up from 16% in 2022.

MEC integrates with the other Group companies, expanding the offer of innovative products of the four divisions: gas, hinges, electronics and induction. The transaction is part of the expansion and diversification process outlined in the Business Plan, which aims at positioning Sabaf as an operator able to offer a wide range of high-tech components which, thanks also to the potential offered by electronics, are more and more synergistic. Through the implementation of this strategy, between 2018 and 2022, the Sabaf Group increased turnover by 68% (from €150.6 million in 2018 to €253 million in 2022) and reduced the impact of gas cooking components from 90% in 2018 to 63% in 2022.

Reserved Capital Increase to Support The Acquisition

In connection with the acquisition, today, Sabaf's Board of Directors exercised the proxy granted by the Shareholders' Meeting on 4 May 2020, resolving on a reserved capital increase against payment, for a maximum nominal amount of €1,153,345.00, corresponding to 10.00% of the Company's share capital existing to date, with the exclusion of the right of option pursuant to Article 2441, fourth paragraph, second sentence of the Italian Civil Code, through the issue of a maximum of 1,153,345 new ordinary shares of SABAF with a par value of €1.00, bearing dividend (the "Capital Increase").

Following the decision to exercise the proxy, the Board of Directors received an expression of will and commitment to fully subscribe the Capital Increase from Montinvest s.r.l., a company controlled by Fulvio Montipò (Founder and Chairman of Interpump Group S.p.A.), who is the ideal partner for the Company thanks to his unquestionable entrepreneurial experience.

The newly issued shares were therefore offered for subscription as part of a reserved placement, without publication of a public offering and/or listing prospectus for the newly issued shares (benefiting from the exemptions envisaged in Article 1, para. 4, letter b) and para. 5, letter a) of Regulation (EU) 2017/1129).

The issue price of the new shares, including the share premium, was determined by the Board of Directors, with the support of Equita SIM S.p.A.

as financial advisor, at €15.01 per share, equal to the average stock market price of Sabaf share recorded in June, increased by a premium of €0.52 per share (and therefore for a total value of €17,311,708.45), based on the criteria illustrated in the Report of Directors approved today by the Board.

The Independent Auditors EY S.p.A. issued their opinion on the market value of the shares issue price pursuant to Article 2441, paragraph four, second sentence, of the Italian Civil Code and Article 158 of Italian Legislative Decree no. 58/1998.

The capital increase is expected to be completed by 31 July 2023. Following the full subscription of the new shares, the post-Capital Increase share capital will amount to €12,686,795.00, represented by 12,686,795 shares, of which 6,703,123 are ordinary shares and 5,983,672 are ordinary shares with increased voting rights.

Pietro Iotti, Chief Executive Officer of Sabaf, declared: "Sabaf takes a major step towards growth in the USA, becoming the major player in the Western world and assuming global leadership in the design and manufacture of hinges, a distinctive component for quality household appliances. We found the Cummins siblings to be fully aligned with our corporate values and shared the opportunities and strong synergies, both technical and commercial, that will result from MEC joining our group.

I myself and the President Claudio Bulgarelli, on behalf of the entire Board, are honoured that Fulvio Montipò, a world master in business management, has personally supported this initiative, a tangible sign of his appreciation for our Group and our growth strategy."

"We are thrilled about this alliance and the opportunities for growth it presents", said Bruce Cummins, CEO of MEC. "We cannot imagine a better fit, with the many collaborative synergies this partnership provides. Together we will become the leader in the global appliance hinges market".

"We are very excited about our collaboration with Sabaf. While we operate from a place of humility, this move will make us part of the premier source for engineered hinge mechanisms in the global white goods markets. There is a level of trust between MEC and Sabaf that we believe is unique, and gives us confidence both in our market position and just as importantly to Bruce and Claudia and I, confidence in our ability to maintain our long-term presence in Mansfield's industrial base" said Steven Cummins, Vice-president of MEC.



Birla Carbon Acquires Nanocyl to Drive Growth In Battery Materials for Lithium Ion Batteries

- Expanding material portfolio for key markets
- Establish leadership position in material critical to LiB performance
- Leveraging innovation to drive growth beyond Carbon Black

Birla Carbon, one of the leading manufacturers and suppliers of high-quality carbon solutions, completed the acquisition of Nanocyl SA, a worldwide leader in multi-wall carbon nanotubes (MWCNT's) based in Sambreville, Belgium. The acquisition expands Birla Carbon's presence in the Energy Systems market, creating a leadership position in material critical to Lithium Ion battery performance along with other conductive applications.

Speaking about the acquisition, Dr. Santrupt Misra, Group Director, Birla Carbon; Director, Chemicals & Director, Group H.R., Aditya Birla Group, said, "Birla Carbon has been nurturing a number of innovation opportunities in its effort to realize its multi-prong sustainability agenda. The acquisition of Nanocyl is a clear step towards executing its strategy in that direction. We hope that this partnership will enable Birla Carbon to be a significant player in the emerging energy systems space. He further added, "Aditya Birla Group has been concentrating on investing in sustainability and circularity-driven initiatives led by innovation in order to be future-ready. The same is in line with our Purpose: to enrich lives by building dynamic and responsible Businesses that "inspire" trust."

Sharing his thoughts on the acquisition, John Loudermilk, President and Chief Executive Officer, Birla Carbon, said, "We are thrilled to welcome Nanocyl into the Birla Carbon family. Laurent and his experienced team have been pioneers in the field of carbon nanotubes that provide unique performance characteristics for a wide range of applications, most notably energy systems such as lithium-ion batteries." He further shared, "Birla Carbon's commitment to driving growth through innovation in sustainability aligns well with the potential for MWCNTs to enable the electrification of the transportation industry, deliver enormous environmental benefits, and

prevent climate change. We are committed to partnering with our growing family of customers to create unprecedented value with the expanded carbon portfolio of products and technologies."

Laurent Kosbach, Chief Executive Officer, Nanocyl, stated, "We are proud of our journey to develop and commercialize MWCNT's successfully over the past 20 years as an entrepreneurial start-up, with the support of our current partners and investors. However, with growing needs for our products, the time has come to join a Global industry leader in order to maximize the synergies and the potential of these materials across many end uses." Mr. Kosbach continues, "Birla Carbon's R&D expertise, portfolio of products, and market experience will enable Nanocyl and our products to reach their full growth potential"

Along with the Conductex™ family of conductive carbon black additives and active anode materials, the inclusion of Nanocyl's advanced MWCNTs provides Birla Carbon with a remarkable range of solutions for conductive applications.

Registration is Now Open for APEC 2024 — Being Held Feb. 25-29 in Long Beach



APEC returns to Long Beach, Calif., for the first time since 2016; full conference registration includes exceptional range of papers, seminars, exposition and events; attendees encouraged to register early, book hotel reservations

Registration is now open for the 38th Annual Applied Power Electronics Conference. The APEC 2024 conference and exposition, running February 25-29 at the Long Beach Convention Center, continues its long-standing tradition of addressing issues of immediate and long-term interest to the practicing power electronics engineer. Providing a truly exceptional professional experience, full registration at APEC is nevertheless offered at one of the lowest costs of any IEEE conference. Complete details for registering and hotel booking can be found on the APEC Registration page.

APEC 2024 Conference registration includes access to outstanding technical content, such



as peer-reviewed Technical Program paper presentations, Industry Sessions discussing the latest advances in commercial developments, as well as half-day Professional Education Seminars presented by industry experts on a range of topics geared to both introductory to expert-level participants.

In addition to the conference program, full registration includes admission to the sold-out APEC 2024 Exposition that brings together nearly 300 leading manufacturers. Special events – including the MicroMouse contest, the FIRST Robotics event and the always-popular Wednesday evening Social Event – round out a lively, interactive tradeshow environment.

APEC 2024 offers discounted rates at five hotels near the Long Beach Convention Center. Attendees are encouraged to secure their reservations early since hotels are expected to book up well in advance of the conference. (Please note that hotel reservations can be made only after completing conference registration, whereupon an automatic confirmation email is sent to the registered attendee with links to APEC's contracted hotels.) For more details, please visit APEC's Travel Information page.

"APEC is simply a must-attend event for practicing power electronics engineers," said Tim McDonald, Conference General Chair. "Its technical program, tutorials, plenary sessions, exposition and social events – this conference and exhibition is unrivaled in providing our global community with opportunities to advance their careers while having fun. We encourage attendees to register now for APEC 2024 in Long Beach – and to reserve an APEC-contracted hotel before they are full."

About the Applied Power Electronics Conference (APEC)

The Premier Event in Applied Power Electronics™, APEC focuses on the practical and applied aspects of the power electronics business. This is not just a designer's conference. APEC has something of interest for anyone involved in power electronics:

- Equipment OEMs that use power supplies and dc-dc converters in their equipment
- Designers of power supplies, dc-dc converters, motor drives, uninterruptible power supplies, inverters and any other power electronic circuits, equipment and systems
- Manufacturers and suppliers of components and assemblies used in power electronics

- Manufacturing, quality and test engineers involved with power electronics equipment
- Marketing, sales and anyone involved in the business of power electronics

Compliance engineers testing and qualifying power electronics equipment or equipment that uses power electronics



Teknor Apex Announces New CEO to Replace Jonathan Fain

Experienced industry professional Donald K. Wiseman has taken on the CEO role.

Teknor Apex has a long and rich history of serving customers in finding unique and complex product solutions within the plastics industry. For the past 51 years, Jonathan Fain has led the organization to develop long term partnerships with the company's suppliers and customers in order to build a strong resilient company. During his tenure, the company revenue has grown by more than 650%, expanded beyond North America to a global footprint, and completed eleven acquisitions.

Mr. Fain has decided to step aside as CEO of the company. He will remain a major stakeholder and continue serving as Chairman of the Board; a position he assumed from his father. "I have had the privilege and honor to lead a great company for over 50 years, and while I am not retiring, I do want to hand over the day-to-day responsibility to someone who can drive to keep the company strong, growing and build upon our culture," says Fain. "I am very confident in our future leadership and plans for supporting our growth, innovation and sustainability for years to come. Don brings a wealth of experience and is an ideal fit into our company and culture."

The new Teknor Apex CEO, Donald Wiseman, has a robust history within the plastics industry and a deep expertise in masterbatches and compounding. Most recently he held the position of CEO at Star Plastics. Previously, he was the President for Performance Products and Solutions with PolyOne, Managing Director and General Manager in Taiwan for Cabot Microelectronics,

and various leadership roles at Americhem. He will be relocating from Cleveland to work out of the Teknor Apex Headquarters in Pawtucket RI. "I am very excited to join the leadership team of Teknor Apex. What began almost 100 years ago as a small venture in Rhode Island is now among the world's leading custom compounders. I firmly believe that people and culture are a true competitive advantage for Teknor. I will demonstrate this by removing barriers, collaborating, and rewarding performance to ambitious goals and solve the most demanding business problems, all while emerging a more robust team," Mr. Wiseman said.

Therm-O-Disc changes name

sensience

ADVANCED SENSING TECHNOLOGIES

Therm-O-Disc, the manufacturer of highly engineered sensing, control and sealing components, has changed its name to Sensience.

The name change follows the company's acquisition from Emerson last year by an affiliate of One Rock Capital Partners.

With the name said to reflect the company's legacy of delivering reliable sensor science, Sensience CEO Julie Furber commented: "We are confident our new name will help us blaze a bold future forward without losing sight of the elements of service and quality that have helped us attain so many loyal customers."

Originally founded 75 years ago, the company creates mission-critical protection and valuable data for a wide range of systems, including appliances, heating, air conditioning and refrigeration units, industrial process equipment, motor vehicles, aircraft, and other platforms.

New product line features easy-to-remove, printable scored liner

Mactac® Graphics & Signage Solutions announces the launch of Printvinyl Scored™, the first of its kind for the wide-format graphics industry. The new product line includes two pressure-sensitive adhesive (PSA) products with a scored liner for screen and wide-format printers.

Mactac Printvinyl™ film is recognized for its proven quality and consistent printability. The new precision-scored liner, with a 1.25" spacing, guarantees a seamless and hassle-free removal process. Products are printable on both the film face and liner, expanding promotional messaging capabilities with an easy-to-remove scored liner that simplifies the application experience.

"Mactac is committed to enhancing our service and growing our capabilities to bring more value to printers, print buyers, and installers," said Nate Goodman, Technical Product Manager of Mactac Graphics & Signage Solutions. "We have invested in advanced converting technologies in our Minneapolis, MN plant, enabling these value-added applications like stickers, labels, and promotional materials."

Printvinyl Scored products have a durability of 5 years. These products are available in permanent and removable adhesives and can be wide-format digital or screen-printed

PVS528UR features an ultra-removable acrylic adhesive with a 3.2 mil matte white polymeric vinyl film and 78# bleached kraft liner back scored liner at 1.25" apart.

PVS528P has a permanent acrylic adhesive with a 3.2 mil matte white polymeric vinyl film and 78# bleached kraft liner back scored liner at 1.25" apart.

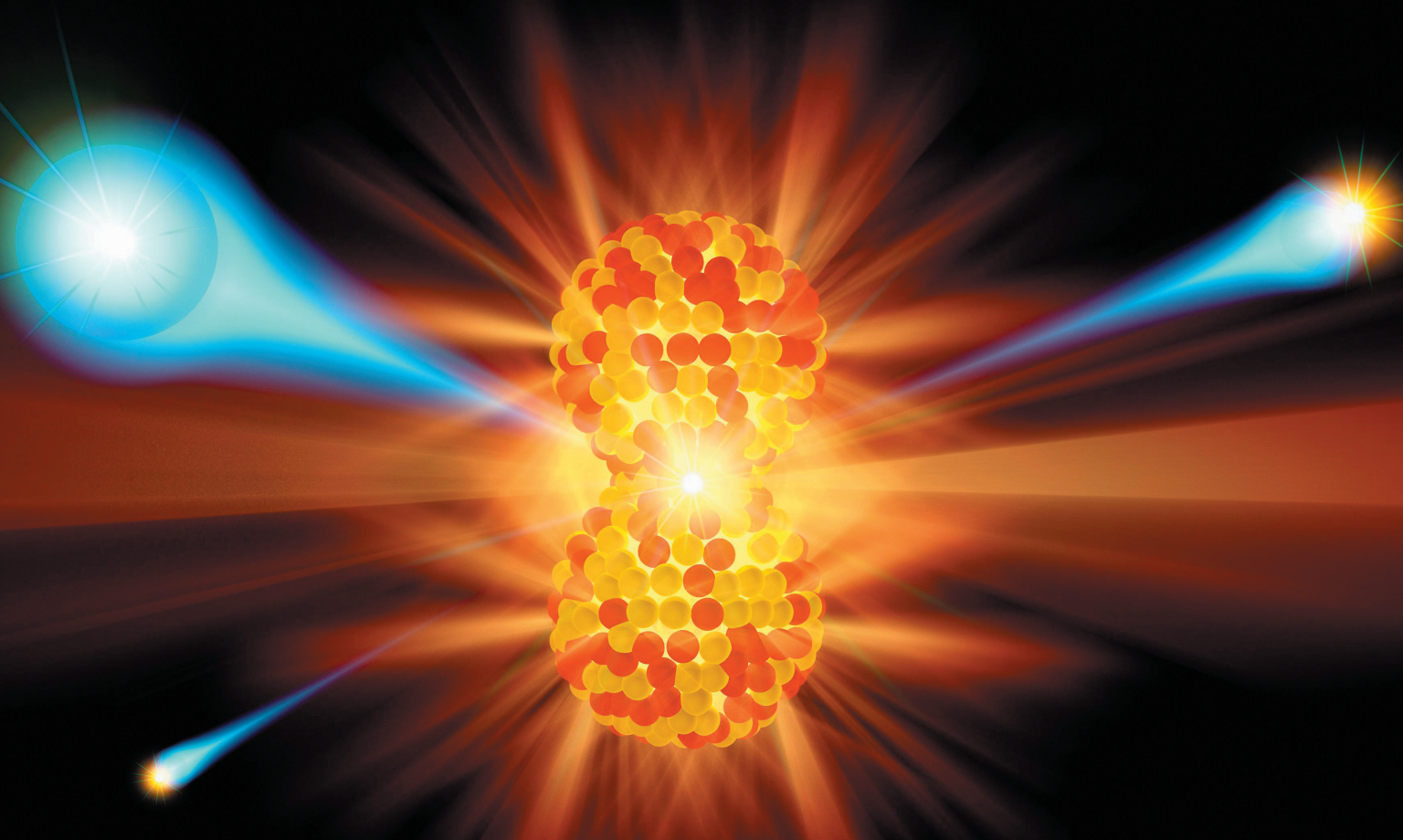
Mactac plans to add to the scored liner options and continue to enhance our capabilities to the product line in the future.

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#5 IN A SERIES

THE 6 HAZARDS OF PRODUCT SAFETY – **RISK OF RADIATION**

BY CERTIFIGROUP

“Designing for Compliance” is critical to getting your product certified on the first try. Designing for Compliance requires owning, knowing, and applying the standard(s) while designing your product. However, in order to successfully read and understand the standard, you have to know the intent of the requirements. Our “Designing for

Compliance” series of whitepapers will educate you on “The 6 Hazards of Product Safety”. The intent of the requirements in all UL/CSA/EN/IEC safety standards is to protect the user from the “6 Hazards of Product Safety”. This whitepaper covers Hazard #5 – Risk of Radiation.



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Risk of Radiation Definition: A “Risk of Radiation” exists when a product generates radiation that could present a health hazard to the user - Ionizing, Non-ionizing, Optical, RF, Microwave, and Acoustic radiation commonly found with X-ray, VLF, ELF, UV, IR, laser, magnetic, sonic, and ultrasonic technology. The objective is to protect the user from excessive radiation. Because radiation is usually invisible, many people are unaware when they are using or in the presence of a radiation emitting device. Even some product manufacturers are surprised to learn that their product emits radiation that must be limited and contained.

Products Involving a Risk of Radiation: Products that emit radiation are all around us. They include many medical products such as X-ray equipment and ultrasound devices. They also include several popular consumer products such as the microwave oven, suntan beds, laser tag guns, and the laser pointer. Many commercial products also function using technology that emits radiation, such as bar code scanners and fiber-optic cables.

Protecting the User from Radiation: In general, you want to avoid subjecting the user to radiation unless absolutely necessary for product functionality. In which case, you must limit the exposure level to as low as possible. Product specific requirements indicate exposure limits, user warning markings, user instruction contents, and in some cases, the need for personal protective equipment.

Product Radiation Requirements: In the U.S., products that emit radiation are

controlled by the CDRH (the Center for Devices & Radiological Health, a division of the FDA). The product compliance requirements are defined in the Code of Federal Regulations Title 21 (21 CFR).

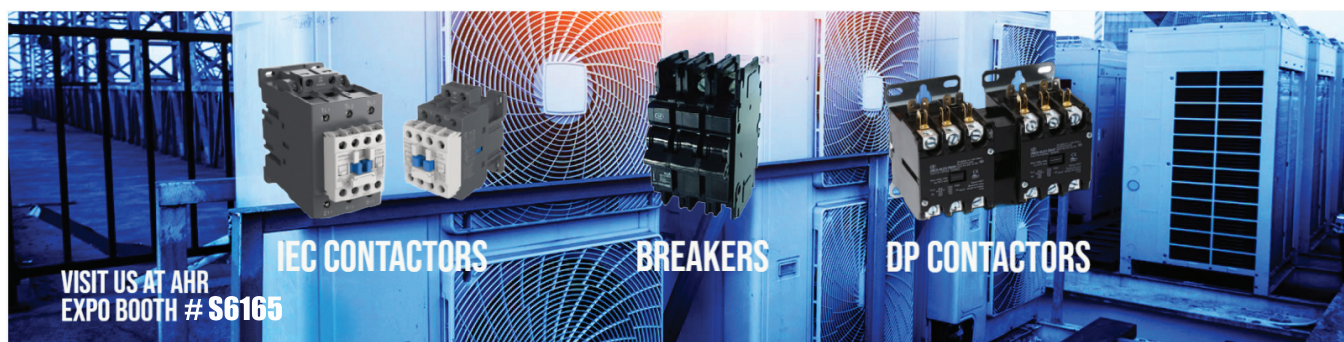
In the European Union, the applicable radiation hazard protection requirements for most commercial and consumer products are contained in the product specific standards identified under the applicable CE-Directives. Canada is similar with many CSA standards harmonized with EN/IEC standards. For other International countries, the product specific IEC standards should be consulted. Note that for medical products, additional government regulations may apply depending on the country of use.

Risk of Radiation – Summary: If you make a product that emits radiation, you must limit exposure as much as possible without defeating the purpose of the product – be sure to identify the radiation limits for your product for the countries of distribution. ■

William Bisenius is the Director of Technical Services for Eurofins MET Labs. “Bill” has worked in the regulatory compliance field for almost 40 years and is considered an international expert in the field of Product Safety. He has written and presented many training seminars providing guidance in understanding the safety standards, intention of the safety standards, how to perform the tests in the standards, and how to design products for compliance to the standards.

Through his compliance career, Bill has worked closely with many emerging technology start-ups and large organizations including NASA, Dell, IBM, Phillips, and Siemens.

Bill is a NARTE Certified Engineer (NCE) & Certified Technician (NCT). He has written more than 100 whitepapers on Product Safety & Compliance and has published numerous articles in IEEE journals and other industry trade publications.



Practicing the “Three R’s” to Support Refrigerant Supply and Circularity

BY CHARLES ALLGOOD, PHD, TECHNICAL FELLOW, THE CHEMOURS COMPANY



For more than three decades, the HVACR industry has been embracing more environmentally friendly refrigerant alternatives to chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs)—both familiar under the brand name Freon™. The first of these alternative refrigerant solutions was hydrofluorocarbons (HFCs) which offered strong performance properties and, unlike CFCs and HCFCs, zero ozone depletion potential (ODP). HFCs saw accelerated adoption after the 1987 Montreal Protocol, which initiated a global phasedown of HCFC production and consumption in an effort to stop the destruction of the ozone layer.

However, as terms such as “global warming”



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and “carbon footprint” entered environmental conversations, the HVACR industry realized that zero ODP, while critical, wasn’t enough. Enter hydrofluoroolefin (HFO) refrigerants. Offering significantly lower global warming potential (GWP) than HFCs as well as stellar performance, energy efficiency, low toxicity, versatility, and more, these new-generation refrigerants are seeing increased use industrywide. As with HFCs, regulations are a major driver of this. The 2016 Kigali Amendment to the Montreal Protocol set in motion a gradual global reduction in HFC consumption and production. In addition, in the U.S., the American Innovation and Manufacturing (AIM) Act supports this strategic transition to HFOs through a progressive phasedown of HFC production and consumption.

Through the 2010s and into the 2020s, another critical concept—circularity—has taken root and finds itself on the priority list for every business in every industry. The sustainability of our planet depends on it. So does business strategy. Simply explained, circularity means putting practices



in place so that materials remain in circulation and never become waste. Circularity offers more than a demonstration of responsibility to our planet. Maximizing the efficient use of all our resources is essential for the strength of our industry and the businesses that support it. It drives everything from lower energy consumption

and better budget strategies to supply chain resilience and consumer preference.

In addition to the environmental and performance benefits of HFCs and HFOs, the drive toward circularity further elevates the importance and distinction of these valuable new refrigerants. For example, new-generation F-gas refrigerants, unlike

industrial gases such as hydrocarbons or carbon dioxide, represent a significant opportunity to advance circularity initiatives, since they can be recovered, recycled, and reclaimed.

Practicing these “Three Rs” of refrigerant management is becoming increasingly important for businesses throughout the HVACR industry, not only in terms of creating circularity pathways but for ensuring ample supply of HFCs are available for operating and servicing existing equipment. HFC production and consumption phasedowns—happening at different stages worldwide—are creating a gap between supply and what is needed.

Let’s break down key steps for employing a strong refrigerant management program to support refrigerant supply, circularity, and a more sustainable existence.

One: Understand the Three R’s.

Employing a strong refrigerant management plan starts with understanding the different ways each of the Three R’s contributes to your business and sustainability goals. First, we have **recovery**, which means taking refrigerant out of a system and moving it into a separate container. Next is **recycling**, achieved

by putting refrigerant back into the same system after it is recovered, often after some minor “cleanup” or filtering to reduce contamination. Perhaps the most important step of the three is reclamation. Recovered refrigerant that is not recycled should go to a certified reclaimer to be reprocessed and reintroduced into the supply stream as refrigerant that meets all virgin purity specifications.

Two: Respect the Impact of High Demand

Phasedowns are causing unprecedented demand for HFCs and, for the first time ever, original equipment manufacturers (OEMs) are depending on reclaimed product to meet some regional regulatory criteria. This means OEMs are increasing demand—in addition to the demand generated for service applications. Furthermore, stepping up reuse and reclamation efforts to ensure an adequate supply of certified product can help deter illegal refrigerant trading, which can lead to a whole host of other economic and safety issues.

Three: Prepare for recovery.

Given the increase in recovery and reclamation

efforts, it’s advisable for contractors and technicians to refresh their training and make sure proper recovery machines are in place. Ensuring teams are properly trained and have the correct equipment to practice the Three Rs is imperative for maintaining the integrity of the product and preventing it from leaking into the environment. Moreover, this will support optimal equipment performance and safety for technicians and end users.

Being properly prepared for recovery applies to HFCs as well as new-generation, mildly flammable A2L refrigerants, which are finding greater use as lower-GWP replacements. Training topics should cover the following:

- Properties, uses, safety, and proper handling during recovery and reclamation
- A2L flammability
- Ensuring you have properly rated recovery machines
- Regulatory updates

Best practices and training resources are available from Chemours at [opteon.com](https://www.opteon.com).

Four: Practice the Three R’s Collaboratively

As phasedowns continue, it’s important for contractors to regain every possible pound of refrigerant during

equipment maintenance and at end of life, and for companies at every level of the HVACR industry to employ a strong refrigerant management program. In addition, collaboration in environmental practices must occur all along the value chain to support industrywide circularity and establish long-term processes that help drive global reductions in CO2 emissions, waste generation, and resource usage.

For example, Chemours is seeing increased use of our Opteon™ HFO/HFO-blend refrigerants, due to their criticality in the industry's transition to significantly lower-GWP solutions. Consequently, HFOs have tremendous value in the opportunity they offer to advance circularity through optimal resource efficiency. As collaborators in the process, we manufacture these products responsibly. We work to reduce our own carbon emissions, waste, and use of resources such as energy and water—to create sustainable pathways to circularity and support proper recovery, recycling, and reclamation of all our refrigerants.

Across the board in HVACR—from major OEMs to independent service contractors—we have the ability and responsibility

to positively impact the environment. Moreover, while supporting the health of our planet, you can support the health of your businesses. Practicing the Three R's of refrigerant management, consistently and properly, is a solid place to start. ■



Charles Allgood,
PhD, Technical
Fellow, The
Chemours
Company

Charles "Dr. Chuck" Allgood holds a PhD in chemistry, has more than 30 years of experience in the HVACR industry, and is a respected speaker at many industry events. In addition to Chemours, he's worked for the National Institute of Standards and Technology. Dr. Allgood has held a variety of research, development, business, technical service, training, and applications development positions with Chemours. Most recently, he has focused on the development of low-GWP refrigerants—including Chemours Opteon™ brand refrigerants—and educating industry professionals about the changing regulatory landscape and A2L refrigerants on the market.

The advertisement features a collage of various industrial fans, including axial and centrifugal impellers, in different sizes and colors (black, silver, blue). The CFM Continental Fan logo is prominently displayed in the center. Below the logo, the text "OEM SOLUTIONS & CUSTOM FANS" is written in large, bold, blue letters. At the bottom, a banner reads "Axial & Centrifugal Impellers with EC, DC & AC Motors". To the right, a box contains the AHR Expo logo and the text "JAN 22-24, 2024 / CHICAGO Continental Fan Booth N2600". The website "continentalfan.com" is listed at the bottom right of the ad.

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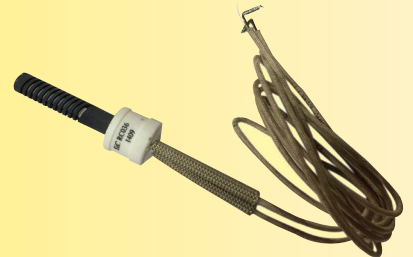
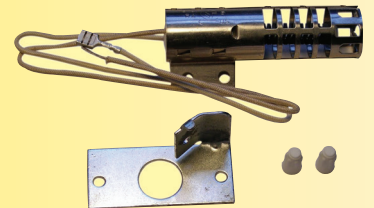
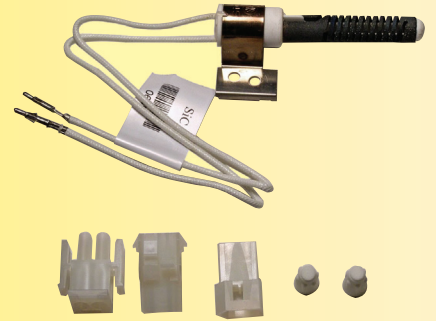
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