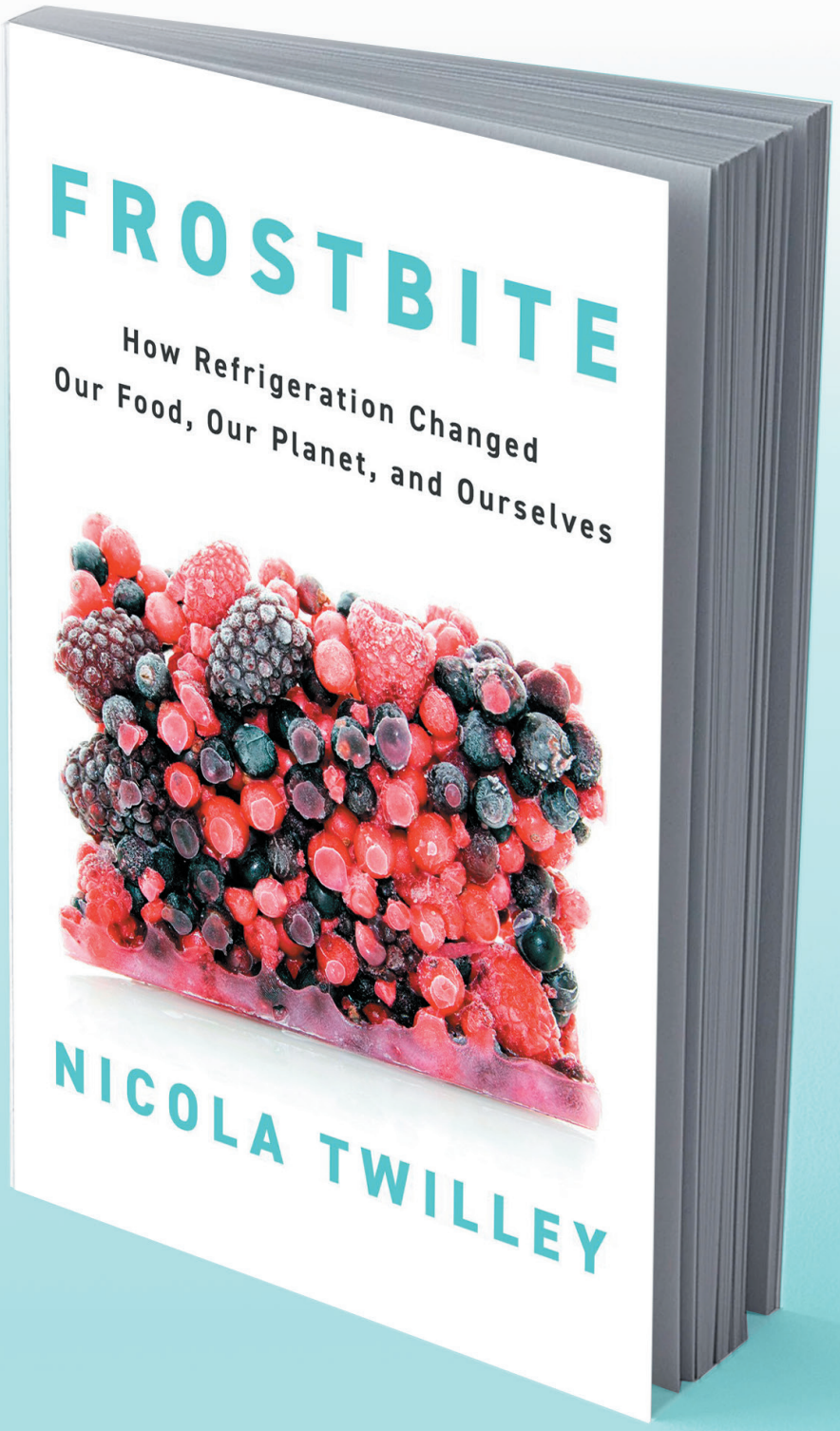
APPLIANCE & HVAC REPORT

Reaching Design Engineers at the OEM Level

October 2024 www.appliancehvacreport.com VOLUME 6 ➢ NUMBER 4



6 FEATURES COVERING

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HEAT PUMP FORUM

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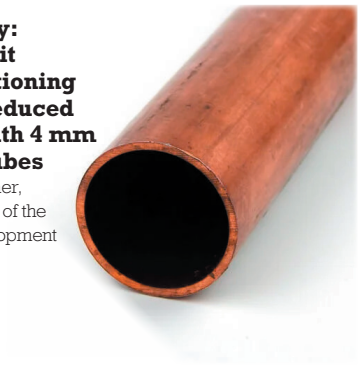


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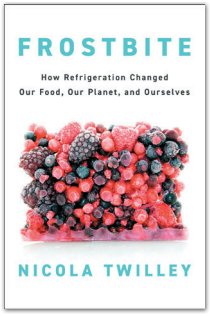
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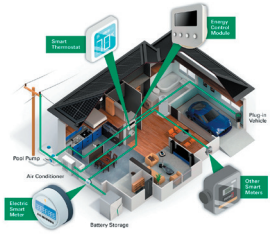
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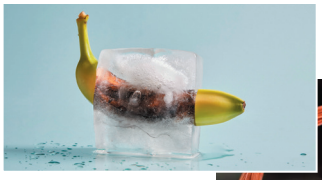
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CLOSING OUT 2024…

Welcome to our 4th quarter issue, our final edition of the year. And it marks our completion of 5 calendar years of THE APPLIANCE & HVAC REPORT.

Often, I look for articles that are a bit different from the norm. While our primary function is supplying important and timely info to our audience of design engineers, I hope to also provide something a bit different that will catch the readers' attention.

Take a look at our front cover. It's a picture of the non-fiction title FROSTBITE. For those of us in the world of refrigeration it's an interesting read. I came across it as it has received a lot of attention…a review in THE NEW YORK TIMES, an interview with the author Nicola Twilley on NPR, etc. So thru the wonders of our online world I was able to connect with Nicky and the Q&A we had begins on page 16. Hope you enjoy and benefit from it.

We close out the year on a high note. Our circulation is now at 27,000, the most in our history. And readership is strong. Our enewsletters are averaging 30% or more open rates. Publishing has changed mightily in the many years I've been in the industry and we move with that trend.

We don't have to look much for editorial material…companies and non-profit organizations come to us regularly with stories to tell, and want to have THE APPLIANCE & HVAC REPORT disseminate their NON-COMMERCIAL offerings to our audience.

In addition to our FROSTBITE coverage, we have articles from the following this issue: Plasmatreat (their first with us); International Copper Association/ Microgroove; the Copper Development Association (CDA), which has a Case Study regarding their work with their customer MIdea; Littelfuse and PPG.

This completes our publishing issue for 2024 (though you will continue to receive our bi-monthly enewsletters, eblasts from clients, etc.) We will return in January, which also has bonus distribution at the AHR show (February 10-12 in Orlando). As usual we will exhibit (sorry at this writing we don't have our booth number). Hope to see you there!

Last but certainly not least, we are looking for editorial contributions for next year. If you/your company has an interesting piece that would benefit the OEM design engineer, please contact me at brad@appliancehvacreport.com We publish these on a barter basis, but we do give editorial credit to the person and company submitting it.

Regards,
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APPLIANCE & HVAC REPORT
Reaching Design Engineers at the OEM Level

Reaching
Design Engineers
at the
OEM Level

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Case Study: Midea Split Air Conditioning System Reduced Charge with 4 mm Copper Tubes



As the industry shifts towards smaller-diameter tubing to improve heat transfer in heat exchangers, Original Equipment Manufacturers (OEMs) have increasingly adopted 5mm diameter copper tubes in recent years. These small-diameter tubes offer energy savings, work well with environmentally friendly refrigerants, and can reduce the weight of heat exchangers without compromising performance.

To address rising metal prices, OEMs, designers, and engineers are exploring innovative solutions to optimize manufacturing processes. The overall cost of heat exchangers is influenced by the core and frame materials, including tubes, fins, and sheet metal.

The Impact of Small-Diameter Copper Tubes on Performance and Cost

To stay competitive without sacrificing quality, manufacturers are exploring ways to reduce the weight of heat exchanger components. GD Midea Refrigeration Equipment Co., Ltd., a leading residential and commercial air conditioner manufacturer, aimed to miniaturize its heat exchangers. Given that the heat exchanger is the largest component of an air conditioner, reducing its size will significantly contribute to the overall miniaturization of the units.

One effective approach is replacing existing heat-exchanging tubes with small-diameter copper tubes. This shift to small-diameter tube fin-type heat exchangers in residential air conditioners offers substantial savings in manufacturing costs.

Research and Key Findings

GD Midea Refrigeration Equipment Co., Ltd. conducted research to demonstrate how air conditioning systems can be miniaturized without sacrificing performance. Midea designed a heat exchanger using 4mm copper tubes for performancetesting in split air conditioners. The results were promising: incorporating 4mm

Tube Diameter	R410A,2600W			R410A,3500W			R290,3500W		
	Capacity (W)	COP	Charge (g)	Capacity (W)	COP	Charge (g)	Capacity (W)	COP	Charge (g)
5mm	2635	3.36	680	3378	2.74	560	3288	2.73	400
4mm	2684	3.34	555	3390	2.7	450	3336	2.71	335
% Change	1.9%	-0.6%	-18.4%	0.4%	-1.5%	-19.6%	1.5%	-0.7%	-16.3%

copper tubes reduced the heat exchanger's volume and cost while significantly decreasing the refrigerant charge.

Midea explored various design configurations, focusing on capacity, refrigerant type, and volume. They examined three scenarios: a base design with a reduced capacity of 2600 W using R410A, an enhanced capacity of 3500 W with R410A, and another 3500 W capacity using R290 refrigerant. The primary objective was maintaining optimal performance levels while reducing internal volume and cost through weight reduction strategies.

Experiments on three models revealed notable differences when using the 4mm tube heat exchangers compared to the 5mm prototypes.

For the baseline model using R410A at a reduced capacity, refrigeration capacity increased by 1.9%, with a 2.55% rise in power consumption and a 0.6% reduction in the coefficient of performance (COP). The refrigerant charge decreased by 18.4%.

In the second scenario with R410A, refrigeration capacity increased by 0.4%, power consumption rose by 1.86%, COP decreased by 1.5%, and refrigerant charge decreased by 19.6%.

In the third scenario with R290, refrigeration capacity improved by 1.5%, power consumption rose by 1.99%, COP decreased by 0.73%, and the refrigerant charge was reduced by 16.3%. The reduction in tube diameter and reuse of the prototype manifold contributed to these variations.

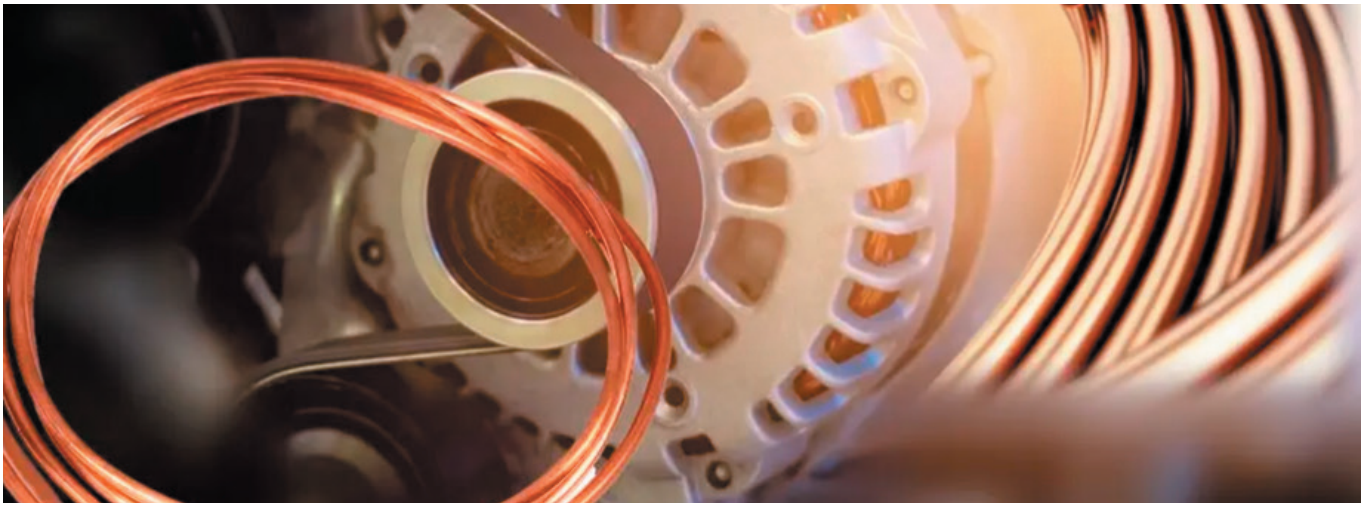
The experimental results with R410A and R290 refrigerants demonstrate that the newly developed heat exchanger with 4mm copper tubes provides superior cooling capacity compared to the 5mm prototype. While power consumption increases and COP decreases, the refrigerant charge is reduced by approximately 20%, offering notable economic and safety benefits.

To learn more about the Midea case study and Designing for the New Refrigerants, you can access the entire webinar with Cara Martin, COO of OTS R&D, Inc., here.

Get in touch with the Copper Development Association to partner on the research and development of air-conditioning, heat pump and refrigeration systems and components; in particular, design, analysis, and optimization of tube-fin, small-diameter copper tubes, and brazed plate heat exchangers. ■



Author bio: Marcus Elmer, Vice President of 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.



China Heat Pump Forum Heralds a Green Future



As average temperatures continue to rise globally and weather events becomes more extreme and erratic, demands for green policies are becoming more acute with each passing year. Mining, manufacturing and construction have been mastered. Whole cities can be built in a few years. Yet this very act of creating comfortable spaces is taking a heavy toll on our atmosphere. Now the survival of more than eight billion inhabitants of Earth depends upon harnessing and repurposing our know how to create green energy sources and net-zero living spaces.

Living standards can be raised while minimizing the release of greenhouse gases (GHGs) into our atmosphere. It may seem to be a daunting undertaking, but one need only look at what has been accomplished so far. Technologies in support of this massive undertaking include low-cost solar and wind energy as well as battery electric vehicles and energy storage. Heat pumps represent are yet another technology that can greatly improve energy efficiency and moderate climate change. The advances in heat pump technology have been at least as impressive as the celebrated advances in alternative energy sources and battery electric vehicles.

Growth of Heat Pumps in China

Several prominent global organizations recognize the essential role of heat pumps as part of broader plans to phase down dependence on fossil fuels. Heat pumps support decarbonization, electrification and energy efficiency. It is now broadly acknowledged by international organizations such as the International Energy Agency (IEA) and the International Institute of Refrigeration (IIR) that the challenge of residential and commercial heating is best met with heat pumps. Regional organizations such as the EHPA, HPTCJ and DBC also recognize that heat pumps offer a path to a green future.

This paper focuses specifically on the role of heat pumps as one part of the global strategy with a focus on China. Presently a major challenge is the deployment of heat pumps. Different regions of the world face common hurdles in deploying heat pumps on a massive scale. Chief among these challenges are providing heating in cold climates and the equitability of the deployment of heat pumps.

The Heat Pump Forum (HPF) is a major accelerator for the global deployment of heat pumps. It is an annual event organized by China Heat Pump Alliance (CHPA) and sponsored by its members. Since its founding 15 years ago, the CHPA has grown from six members to more than 600 members today. For many years, the HPF was a regional event attended mainly by members of the CHPA.

Today the HPF is an event of global importance. It is the only global event that is 100 percent focused on

heat pump technology, bringing together big HVACR appliance OEMs, successful startups focused on new heat pump technology, and policy makers and pioneers in new heat pump technologies from all over the world.

Considering its leading position in heat pump design and production, China is perhaps underrepresented at scientific conferences dedicated to heat pump technology. That is unfortunate because China has much to offer the heat pump community. China is already renowned for new products and manufacturing methods in the fields of solar panels and electric vehicles. The HPF is now a unique event for forming partnerships with the key stakeholders in the global heat pump industry. The HPF is widely recognized as the foremost event for discourse on the future of heat pumps not only for China but also for the world.

2024 Heat Pump Forum in Shanghai

The most recent HPF was held this past summer at the Convention Center in the Songjiang New City International Ecological Business District. This setting was appropriate because Shanghai is living proof of what can be accomplished in a short period of time. The rapid development of Shanghai and indeed all of China is a modern miracle [1].

More than a thousand heat pump professionals espoused the continual improvement and sustainable development of heat pump industry. See Figure 1. Speakers addressed the "hot topics" of markets, policy and technology in nine specialized sessions:

1. High-Temperature Heat Pumps and Industrial Applications
2. Heat Pump Market Growth and Breakthroughs
3. Clean Heating Development Forum
4. International Policies and Market Development for Heat Pumps
5. Heat Pump Exports and Refrigerant Substitution
6. Multi-Energy Complementary Technologies
7. Commercial Heating and Regional Energy Digitalization
8. Comfort Systems Development
9. Drying and Special Applications.

To facilitate communications, spoken words were translated in real time and projected onto screens along with the slideshow presentations. Simultaneous translators provided audio translations through headsets in select sessions as well. Technical papers were printed and bound with many of the abstracts, figure captions and charts translated into English.

CHPA executive general secretary Hengyi Zhao emphasized how heat pump technology is characterized by energy savings, low carbon emissions and other environmental benefits. According to Zhao, the reason for the rapid replacement of fossil fuels by heat pumps is that they optimize thermal energy production, especially in middle and low temperature ranges. "Heat pumps are the key to new, high-quality, productive forces in the thermal energy field. The technologies have significant implications for green, low-carbon transitions in heating sectors in China and globally," says Zhao. See Figure 2.

What is a Heat Pump?

One topic frequently discussed was the definition of a heat pump, especially in the context of industry statistics. It was noted by several attendees that the definition varies depending on the region of the world. In China, for example, split-type reversible residential appliances are not counted in heat pump statistics, even though the number of units sold is very large. Most split-type room air conditioners can now also provide heating by running them in a reverse cycle. These are not counted as heat pumps in market statistics for China. On the other hand, in the United States and other regions, these reversible split units would be considered heat pumps, which distorts the market statistics.



Figure 1 – The 2024 China Heat Pump Forum, Plenary conference, Shanghai, China. More than a thousand heat pump professionals espoused the industry's continual improvement and sustainable development.



Figure 2 – The General Secretary of CHPA Hengyi "Cooper" Zhao presented the 2024 China heat pump industry annual report at the China Heat Pump Forum.

In the most general sense, a heat pump is any machine that uses mechanical work to transfer heat-energy from one location or environment to another. Technically these are all heat pumps:

R: Refrigeration equipment removes heat from a freezer or refrigerated space. This heat can be redirected for space or water heating.

AC: Air-conditioning systems and chillers remove heat from indoor spaces or chilling fluid, respectively.

HP: A heat pump pumps heat from an outdoor ambient (air, water or ground) into a commercial or residential building, to raise the temperature of the indoor spaces or water supply; or pumps heat from an indoor space to the outdoors when in cooling mode.

"R" and "AC" are well established industries. The technology disruptor is the "HP" in RACHP. Heat pumps are known as *pompa di calore* in Italy, *pompe à chaleur* in France and *Wärmepumpe* in Germany. Whatever the language or country, OEMs are eager to enter markets with practical HP heating solutions for their region and for export. One of the remarkable things about the HP revolution is that no one size fits all. Heat pumps must be tailored to the climate and demographics of the region in which they are sold.

Air Source Heat Pump (ASHP) technology has greatly improved over the past decade. These systems are more economical than ground source heat pumps (GSHPs) especially with respect to installation costs. The heat collected at the outdoor evaporator of an ASHP can be used to raise the temperature of air in an air-to-air (ATA) HP; or more commonly in China, it can be used to raise the temperature of water in an air-to-water (ATW) HP.

In recent years, ATW heat pumps have become popular across residential, commercial, industrial and district heating applications in China. One of the main advantages of such ATW system is that the refrigerant stays in a sealed unit outdoors, and cold or hot water is sent to the building. This enables the use of flammable natural refrigerants such as propane at higher charge levels. ATW hot water output can be used to heat spaces as well as domestic hot water (DHW) which is stored in water tanks and comes in contact with humans. The versatility and environmental friendliness of ATW HPs has led to their high popularity and an accelerated rate of adoption across China's climate zones.

The IEA has provided a detailed schematic of all the major heat pump types and their applications [2]. *Schematic: Heat pump types and applications – The Future of Heat Pumps in China – Analysis - IEA*

Global Statistics for ATW Heat Pumps

JARN recently published a special issue on "The World ATW Heat Pump Market – 2024 Update." [3]

The update lists the major players in each region of the world including North America, Europe and Asia with further breakdowns by countries. Note that the JARN data is limited to ATW heat pumps. Nearly 5 million air-to-water (ATW) heat pumps were produced in 2023. China is the largest market for ATW heat pumps. The ATW market in China grew to 2.47 million units in 2023. See Figure 3. China not only manufactures heat pumps for its domestic use, but exports heat pumps, especially to Australia, France, Germany, Italy, the Netherlands and Spain.

In every year for eight years from 2014 to 2021, ATW heat pump sales in China exceeded the sales in all other countries combined. Meanwhile, sales of heat pumps in Europe caught up with and exceeded sales in Japan. This growth of heat pumps in Europe slowed in 2023.

The European Heat Pump Association was represented at the HPF by Mélanie Auvray, Policy Manager, who traveled to Shanghai to present in the session on International Policies and Market Development for Heat Pumps. Also, EHPA's new President Patrick Crombez shared his insights through a special video message. [4]

Auvray attributes the lower numbers in 2023 to natural gas prices, electricity prices, high interest rates, political debate, reduced ambition and uncertain subsidy schemes. EHPA released a four-page manifesto for the European Union in February 2024, stressing these five points:

1. Set Clear Policy Direction and Targets
2. Make Heat Pumps Affordable for All
3. Strengthen Industrial Leadership and Skills
4. Unlock the Full Potential of Large Heat Pumps
5. Use Heat Pumps' Flexibility to Support the Energy System

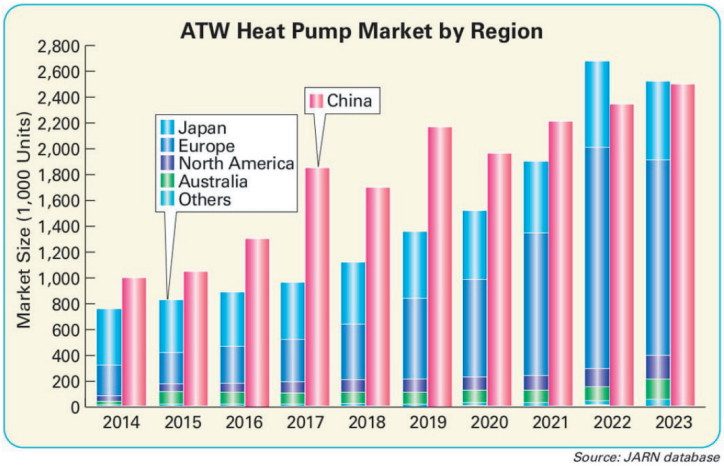


Figure 3 – The ATW market in China grew to 2.47 million units in 2023.

"Heat Pumps: The Heart of Europe's Energy Future: EHPA priorities for EU policy 2024-2029" is the title of the Manifesto, which serves as an excellent executive level briefing on European heat pump markets and policies. It is available for free download [5].

Novel ATW heat pumps from China have been exhibited at major expos such as Interclima (Paris, France), Chillventa (Nuremberg, Germany), ISH Expo (Frankfurt, Germany) and MCE Mostra Convegno Expocomfort (Milan Italy) as well as the AHR Expo (USA), China Refrigeration (Shanghai, China) and many other regional expos [6].

Jan Dusek, Co-founder, Group COO & Head of APAC, ATMOsphere traveled to the HPF to make the case for the use of natural refrigerants [7]. Dusek presented in the session on Heat Pump Exports and Refrigerant Substitution. He described the trend toward natural refrigerants over the past 15 years in parallel with the emergence of the heat pump marketplace. He pointed out the many models of heat pumps on display at the ISH in March 2023. Many models use ultralow-GWP propane refrigerant in residential heat pumps as well as commercial-sized heat pumps. Dusek also reviewed the success of the R744 residential hot water heat pumps in Japan, commenting on how the cost came down dramatically thanks to competition.

At the HPF, Panama Bartholomy reviewed the American heat pump markets and policy trends in a well-received presentation. Bartholomy is currently the Executive Director of the Building Decarbonization Coalition (BDC), a cross-sectoral initiative to eliminate greenhouse gas emissions from the built environment [8]. He worked for many years with the California Energy Commission before joining the BDC. Bartholomy concurs that the ATW market has not developed in the USA in part because blown-air furnaces are more prevalent in the USA compared to hydronic systems. He pointed to the importance of legislation at the state level in driving the adoption of heat pumps.

Caroline Haglund Stignor, manager of the Heat Pump Centre, the program office of the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP by IEA) delivered a second IEA presentation titled "The Heat Pump Global Market and Technology Development" in the session on "Heat Pump Export and Refrigerant Substitution Forum". See Figure 4.



Figure 4 – Caroline Haglund Stignor described existing IEA Heat Pumping Technology Annexes at the 2024 China Heat Pump Forum, Shanghai, China.

A Major New Global Market Report

A highlight of the HPF was the debut of The Global Heat Pump Market Report (2024). This major global report was jointly produced by the China Heat Pump Alliance (CHPA) and Beijing Zhixindao Sci-Tech Corp., Ltd. (ChinaIOL). The Report is available for free download [9]. See Figure 5.



Figure 5 – A new market report from the CHPA and ChinaIO debuted at the Heat Pump Forum and is now available for free download [9].

The Global Heat Pump Market Report draws on multiple research projects by both CHPA and ChinaIOL. It embodies the market research data and technical results accumulated over many years by the two parties. It systematically describes the current state of the global heat pump industry, elaborates on trends and predicts future developments. The report not only sets forth a global policy profile and technical standards but also analyzes local heat pump markets in Asia, Europe, North America and other regions, focusing on the development of the Chinese market. It is divided into five parts:

1. The global industry
2. Regional markets
3. The Chinese market
4. Global forecasts, and
5. Brand showcasing.

Its content is further subdivided into space heating, sanitary hot water, industrial and agricultural drying, upstream components, and industry forecasts. The

report reasonably predicts the scale of global demand for heat pumps, while focusing on specific markets and applications. The market research encompasses air-source heat pumps for water heaters and heating but excludes heat pump drying products and swimming pool heat pumps. Chinese market research includes household air-to-water heat pumps, VRF with hydronic heating modules, low-temperature air-to-air heat pumps, commercial air-to-water heat pumps, heat pumps and wall-hung gas boiler 2-in-1 systems, (water) ground source heat pumps, and absorption heat pumps.

The Procurement Process

The HPF would not be complete without the procurement exhibition. Next generation cold-climate heat pumps from innovative companies boasted good efficiency at ambient temperatures as low as – 36C (i.e., – 33F).

Manufacturers included Grundfos for water pumps; Highly, Danfoss and Copeland for compressors; and many others for expansion valves, distributors, pipe connectors, water tanks and much more. A designer could identify economical and reliable suppliers of high quality products for practically any heat exchanger system design.

More than one-hundred companies showcased premium heat pumps and heat pump components in spaces just outside the conference rooms. These companies typically have manufacturing plants on multiple continents. See Figure 6.



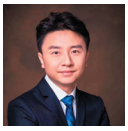
Figure 6 – Exhibit Floor at the 2024 China Heat Pump Forum.

Conclusion

China today is at the center of heat pump research, product development and manufacturing. The HPF is an annual event that typically draws more than 1500 participants from around the globe. Even more participants are expected in 2025 as the uptake of heat pumps accelerates globally. There is no question that traditional heating by fossil fuels will be replaced by heat pumps. It is now only a matter of when this will happen. Current models of climate change warn that this transition needs to be scaled up in a matter of years not decades. Already we are halfway through the decade of the heat pump, and the transition is just beginning. Anyone involved in decision making in the HP sector should make plans to attend the 2025 Heat Pump Conference. [10] ■

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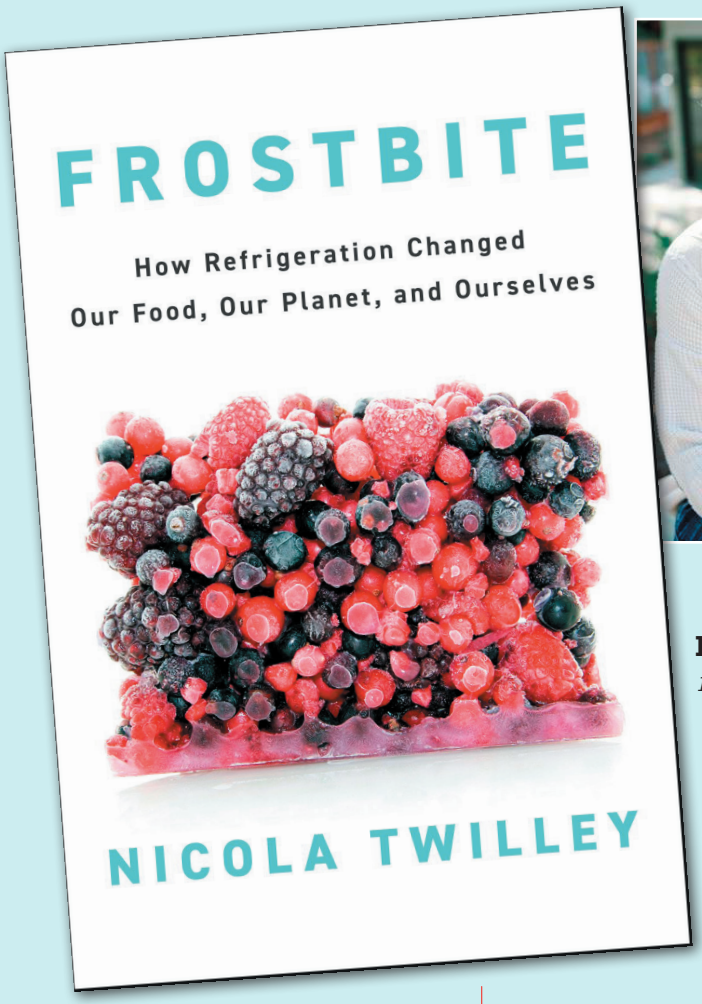
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JABS Media, LLC

Insight from FROSTBITE author Nicola Twilley

Editor's note: Below is an edited transcript of Editor Brad Glazer's discussion with FROSTBITE author Nicola Twilley.





BG: *Why did you choose the name FROSTBITE?*

NT: My husband, fellow writer Geoff Manaugh, actually came up with the name, and I love it. On one level, it encapsulates the idea of food (bite) and refrigeration (frost)—but it also gets at the more nuanced concept that our food system has been damaged by its exposure to cold. As a society, we've largely overlooked refrigeration's costs in favor of its benefits, and I wanted my book to provide the first balanced accounting.

BG: *Our brand reaches design engineers at appliance manufacturers. Why should they read FROSTBITE?*

NT: They are a perfect audience for this book! I think the story of how refrigeration has shaped the flavor and kinds of foods we eat will be thought-provoking, and the climate stakes of our cold chain are important. But I think they'll especially enjoy my deep dive into how fridge design has changed over the decades—and reshaped our diets, homes, and cities along the way. In that chapter, I meet a fridge-dating guru and a fund manager who bases his investments on peeping in fridges in the developing world; I take a deep dive into the cluttered fridges of the average dual-income middle-class American home and I profile a South Korean designer working to "save food from the fridge." It's one of my favorite sections.

BG: *Where did the idea for FROSTBITE come from?*

NT: I first became interested in exploring the artificial winter we've built for our food to live in when the "farm-to-table" trend was new. A lot of my colleagues were writing about the farms, showing American eaters the otherwise invisible reality of feedlots and slaughterhouses, and I wished I had written those books and articles myself. But then I started wondering about the "to" part in farm-to-table, and quickly realized that it was just as fascinating—and just as far-reaching in its impact on what we eat, where it's grown, and how good it is for us and the planet.

BG: *Did you speak to companies who manufacture refrigerators?*

NT: I did! I spoke to a handful of fridge designers at different companies, including the legendary Mary Kay Bolger, who first introduced the best-selling French door design, and I interviewed engineers at several refrigeration systems manufacturers too, like Emerson.

BG: *Who was M.E. Pennington?*

NT: She's a rockstar! Even though she's been forgotten today, in her time, she was known

as "the mother of refrigeration." I tell her amazing story in the book, but, in short, she's the person we have to thank for figuring out how to refrigerate food safely—as well as the reason that Americans, who initially mistrusted refrigerated food and thought it wasn't fresh, now see refrigeration as a guarantee of food safety and freshness.

BG: *Who was Frederick McKinley Jones?*

NT: Fred McKinley Jones is another unsung hero of refrigeration whose story I tell in the book. A self-taught African-American engineer, he invented the transport refrigeration unit—and with it, radically changed the geography of food production and distribution in America.

BG: *Got anything new coming up? Maybe you should do same with air conditioning.*

NT: I am currently working on a couple of feature articles for The New Yorker magazine, where I'm a contributing writer, and I co-host Gastropod, a popular, award-winning podcast about the history and science of food, so I'm keeping busy! Stay tuned…

BG: *I know people who used the term "icebox" for refrigerator. Where does that fit into the story?*

NT: Natural ice, harvested from lakes and ponds, paved the way for the invention and adoption of mechanical refrigeration, and the icebox is thus the domestic predecessor of the modern fridge. Blocks of ice had to be replaced multiple times a week by icemen, who provided door-to-door delivery and, if rumor was to be believed, more. (The title of Eugene O'Neill's 1939 play, "The Iceman Cometh," riffs on a common contemporary joke in which the husband calls upstairs to his wife to ask, "Has the iceman come yet?" The answer: "No, but he's breathing hard.")

BG: *How is the book selling?*

NT: I've been thrilled at the response
the book is receiving, both from reviewers and in terms of sales. Just to give one example, FROSTBITE was ranked as one of the best new nonfiction books in July by Amazon. After years spent working on the book, telling friends and family that although refrigeration might sound boring, it's actually way cooler (pun intended) than they could ever imagine, I'm so happy to find that readers agree!

BG: *Name 3 things that you want readers to come away with?*

NT: I want readers to come away with an entirely new understanding of how our food system works and why—and several readers have told me that, indeed, their trip to the grocery store is completely transformed after reading FROSTBITE. Most importantly, I want readers to have a new sense of the urgency and potential benefits of



rethinking our relationship with refrigeration—and some real optimism about how we might do that. And I've heard from dozens of folks that the book has also given them a huge stock of surprising and fascinating facts with which to entertain/irritate friends and family—everything from the origin of the hoodie to the surprising science behind salad bags.

BG: *Are there any downsides to refrigeration?*

NT: Plenty! That's why I wrote the book. The most significant are its climate implications, in terms of the global warming effects of energy usage and refrigerant gases. Some of the most overlooked are its impact on flavor and health. I spend some time in the book telling the story of the tomato, which has been bred to be harvested while green and shipped under refrigeration, and, in the process, has literally lost the genetic machinery that makes flavor. Some of its impacts are more subtle—for example, refrigerated trucking gave us the ability to slaughter meat at scale and far away from consumers or unionized urban labor, making it easier for many eaters to ignore the immense cruelty built into industrial meat production.

BG: *Do you see any technological developments as it relates to refrigeration?*

NT: I do, and they range from efficiency improvements to today's systems to radical rethinks that dispense with cooling all together and keep food fresh using coatings, super-critical carbon dioxide, or other innovative technologies. Exploring some of the most promising of these, and thinking through how their implementation will reshape our food system, forms the basis of my final chapter.

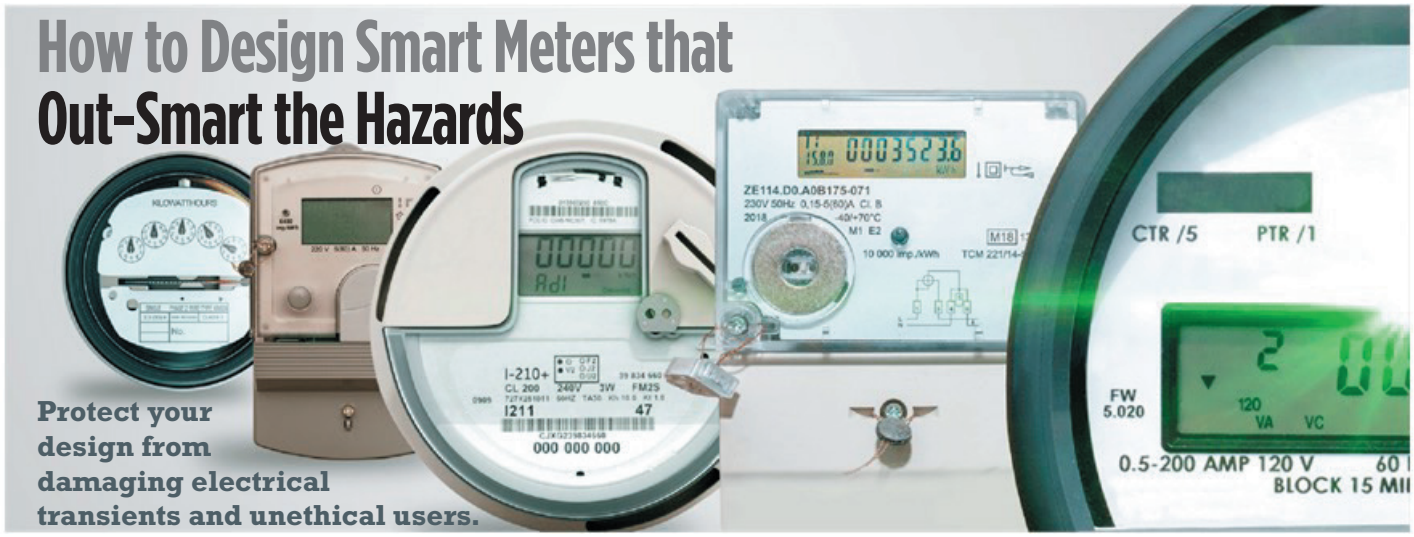
BG: *What do you think of "smart" appliances?*

NT: After talking with product designers, smart fridges ended up seeming pretty stupid to me. Consumers want their fridge to keep food fresh for as long as possible and they want that food to be visible and easily accessible. The ability to access the Internet or send texts via the fridge doesn't really help with those goals. The one legitimately helpful use case would be a fridge with the ability to maintain a remotely searchable real-time inventory and alert owners about food that's nearing its end of life. But that's proven impossible to implement because, as the fridge designers I spoke to pointed out, supermarkets have no incentive to provide checkout data (after all, it doesn't hurt their bottom line if people buy more food and then throw it out) and consumers aren't willing to scan in items themselves.

BG: *Last but not least, The New York Times Reviewed FROSTBITE. The review says a refrigerator is opened 107 times a day. Hard to believe. The Environmental Protection Agency says it's 33 times daily. Your thoughts?*

NT: mention that statistic in a footnote in my book discussing how British police use variations in the hum of the electrical grid to solve crimes—that's what Sallie Tisdale, who wrote the glowing review for The New York Times, is quoting. I interviewed the former senior product manager in charge of refrigerators at LG, who told me that the company developed its Instaview feature (a tinted glass panel that illuminates with two quick knocks, allowing you to see the fridge's contents without opening the door) after discovering, through their own internal research, that American households opened their fridges 107 times per day on average. They also found that the average U.S. adult spends 12 minutes a day just staring into the fridge—which adds up to 73 hours a year! I've never counted, but I'd guess my fridge gets opened closer to 50 times a day—but I don't have kids. ■

How to Design Smart Meters that Out-Smart the Hazards



Protect your design from damaging electrical transients and unethical users.

As buildings and other facilities work toward achieving a net-zero future, utility meters such as electricity meters and water meters must provide more functionality than just recording usage data. The meters must become part of the infrastructure of an integrated structure, as shown in Figure 1 for a building and Figure 2 for a residential home.

The latest generation of "smart" electricity, water, and gas meters offers commercial and residential customers the information they need to use these resources more wisely. They also allow utility companies to monitor usage remotely, essentially eliminating the need for manual readings. These intelligent meters also enable managing grid power peaks and identifying tampering.

The switch from traditional electromechanical meters to smart meters presents various challenges for meter designers as they strive to develop solutions compatible with Advanced Metering Infrastructure (AMI). This approach allows for integrating smart meters into the fast-growing Internet of Things (IoT), which supports remote communication and fault detection. However, one thing that has remained the same is that the utility companies that install these meters need them to be robust enough to operate reliably for decades and provide accurate measurements over their lifetimes. They must incorporate a growing array of circuit protection, sensing, and power control components to do that. This article offers an overview of the various component options

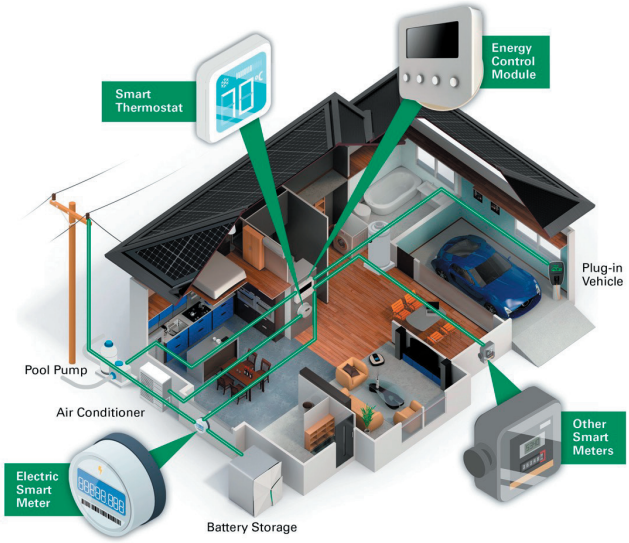


Figure 2. Smart metering accumulates information on energy generation and consumption

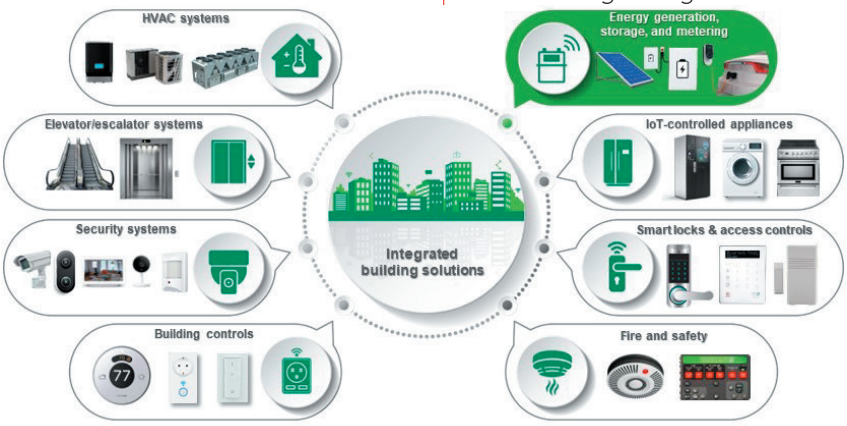
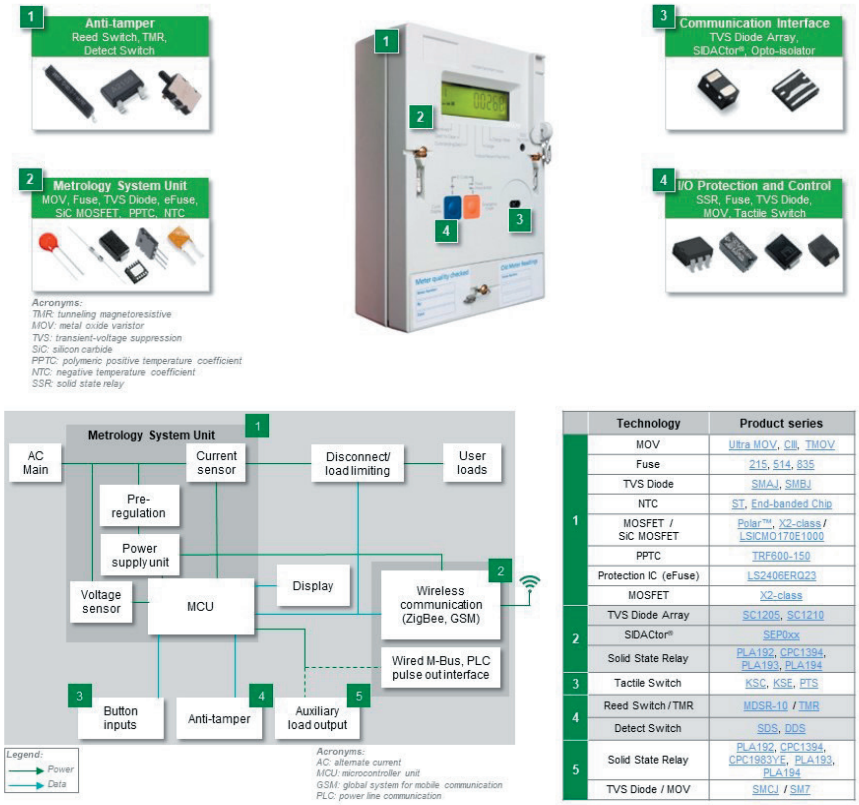


Figure 1. Building electric and electronic systems to help reach net-zero goals



	Technology	Product series
1	MOV	Ultra MOV, CB, TMOV
	Fuse	215, 514, 835
	TVS Diode	SMAJ, SMBJ
	NTC	ST, End-banded Chip
	MOSFET / SiC MOSFET	Polar™, X2-class / LSICMO170E1000
	PPTC	TRF600-150
	Protection IC (eFuse)	LS2406ERQ23
	MOSFET	X2-class
2	TVS Diode Array	SC1205, SC1210
	SIDACtor®	SEP0xx
	Solid State Relay	PLA192, CPC1394, PLA193, PLA194
3	Tactile Switch	KSC, KSE, PTS
4	Reed Switch / TMR	MDSR-10 / TMR
	Detect Switch	SDS, DDS
5	Solid State Relay	PLA192, CPC1394, CPC1983YE, PLA193, PLA194
	TVS Diode / MOV	SMCJ / SM7

Figure 3. Smart electricity meter, its circuit blocks, and recommended component options

and how utilizing them in the design can improve the operation of the meters.

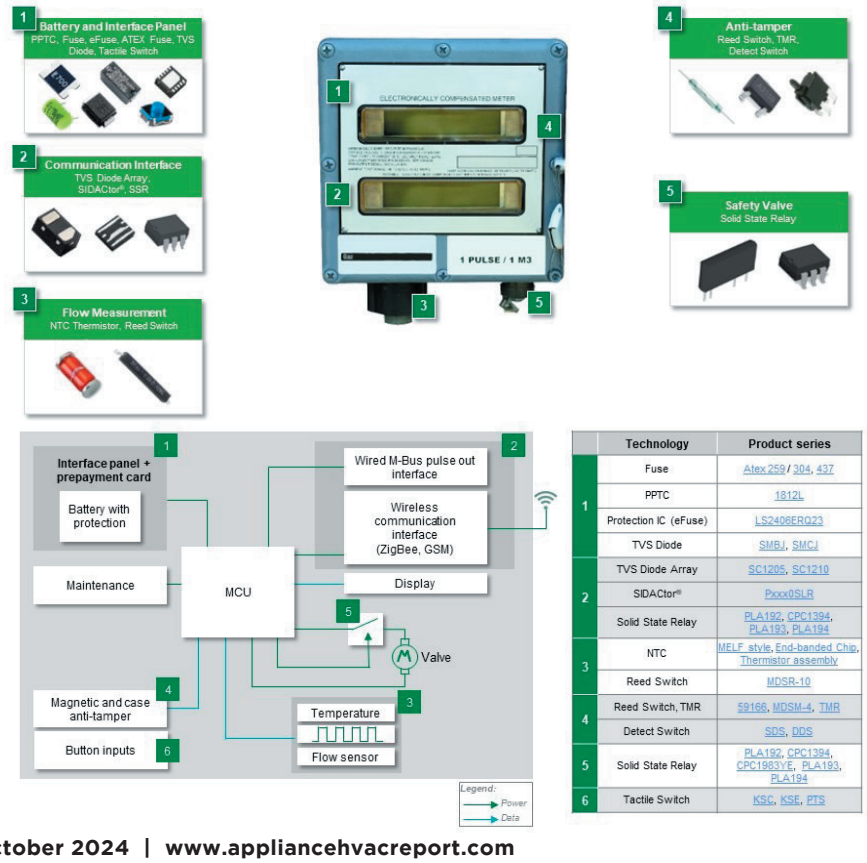
Smart Meter Overview

The sophisticated electronics in today's smart meters require even greater protection from electrical transients such as electrostatic discharge (ESD), power surges (such as from lightning strikes), and other occurrences than in earlier designs. Figure 3 shows an example of a smart electricity meter and presents a high-level block diagram of the subsystems within the meter. Figure 4 illustrates a smart gas or water meter and its block diagram. The smart electricity, gas, and water meters have multiple common functional blocks. Each Figure highlights multiple component options for protection, sensing, and efficient control of the smart meter circuit blocks.

Protecting the Electricity Meter

Electricity meters draw their power from the electrical grid, which is subject to high energy transients resulting from lightning, inductive load switching, or capacitor bank switching. The AC power lines have, by necessity, high current capacity to support the loads in a home or building. A fuse and a metal oxide varistor (MOV) placed at the AC power input can be the first line of defense against an overcurrent condition and high energy transients. A fuse provides protection from the high current capacity AC line that can flow if an internal short circuit develops. Recommended fuses can be either a fast-acting or a time-lag type. A time-lag fuse will be less susceptible to opening due to in-rush current and will avoid nuisance shutdowns. In addition to sizing the fuse for the smart meter's normal

Figure 4. Smart gas and water meter, their circuit blocks, and recommended component options



	Technology	Product series
1	Fuse	Atex 259 / 304, 437
	PPTC	1812L
	Protection IC (eFuse)	LS2406ERQ23
	TVS Diode	SMBJ, SMCJ
2	TVS Diode Array	SC1205, SC1210
	SIDACtor®	Pxxx0SLR
	Solid State Relay	PLA192, CPC1394, PLA193, PLA194
3	NTC	MELF style, End-banded Chip, Thermistor assembly
	Reed Switch	MDSR-10
4	Reed Switch, TMR	59166, MDSM-4, TMR
	Detect Switch	SDS, DDS
5	Solid State Relay	PLA192, CPC1394, CPC1983YE, PLA193, PLA194
6	Tactile Switch	KSC, KSE, PTS

current draw, ensure the voltage rating exceeds the line voltage. Also use a fuse with a high interrupting rating of at least 1000 A so failure in a shorted state is avoided even under the most extreme conditions. Always use UL and CSA-approved fuses to save standards compliance test costs and time.

An alternative to a one-time fuse is a polymer resettable fuse. These fuses offer fast trip times with UL and CSA certification.

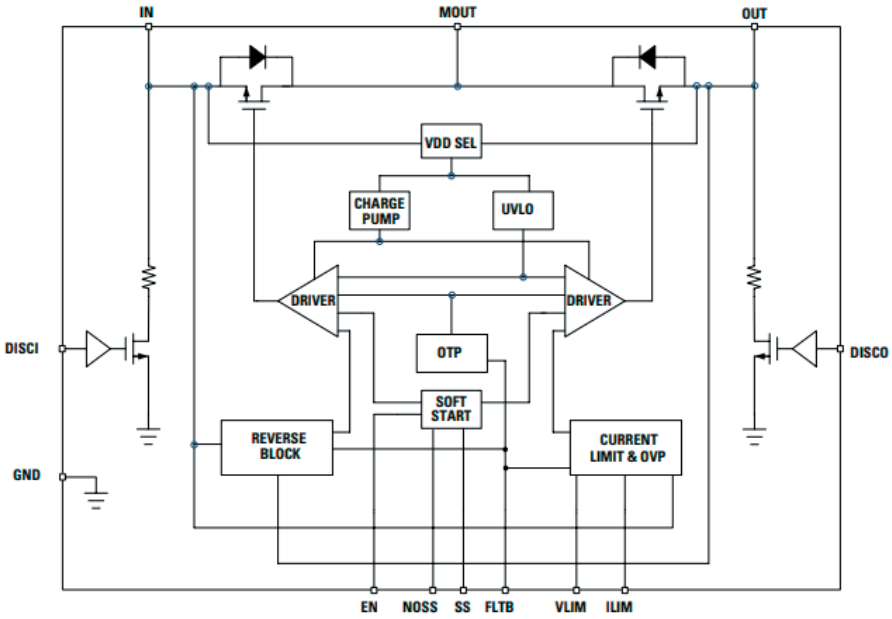
When an overvoltage transient impinges on the meter, the MOV quickly clamps the transient to a suitable voltage level. However, if the MOV is subjected to a sustained, low current overvoltage, the MOV can go into thermal runaway, resulting in overheating, gaseous emission, and potentially fire. In cases where this is likely to occur, such as in electrical meters, the designer can choose a thermally protected varistor (TMOV, Figure 5), which integrates a thermally responsive element within the body of the device that will open-circuit the varistor in case of overheating. A version of this type of MOV shown in Figure 5 includes a third terminal that can connect to a circuit that displays the status of the MOV.

The required level of surge immunity dictates the rating and size of the MOV. For basic surge protection between 2 kV and 4 kV, a 14 mm MOV can be adequate. However, for protection levels of 20 kV, a larger MOV or TMOV would be needed. Furthermore, MOVs have a finite number of surges they can absorb, and once the MOV has reached its end-of-life, it can no longer protect the meter. Thus, to ensure that the MOV remains operational during the specified lifetime of the smart meter, derating the MOV is essential.

For further protection, designers can supplement the MOV with a transient voltage suppression (TVS) diode. TVS diodes offer secondary protection for sensitive downstream electronic components. They have under-picosecond response to voltage overloads and do not have lifetimes dictated by the number of surge strikes. These devices clamp the fast-rising transients to low voltages while the front-end MOV absorbs the bulk of the high energy in those transients.

As an alternative to discrete fuses and TVS diodes at the smart meter input, Littelfuse has a single-device solution for overcurrent and transient voltage conditions. In addition to current overload and input voltage surge protection, the chip protects against inrush currents, excessive temperature, undervoltage, and reverse currents. These Littelfuse components are known as eFuses. The recommended eFuse shown in Figure 6 shows the source-to-load pathway controlled by a MOSFET with ultra-low RDS(ON) resistance of 24 mΩ for minimal power loss during normal operation. The chip works in circuits with operating voltages ranging from 3 V to 24 V, and the eFuse allows a programmable current limit up to 6 A. Discharge control lines limit the voltage rise on the input and output lines. With all this capability, an eFuse can save designers

Figure 6. eFuse multiple protection function IC



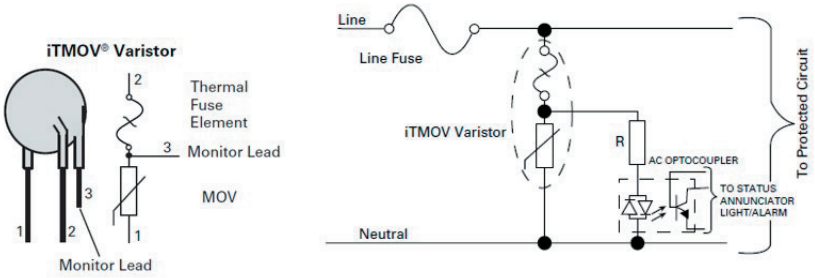


Figure 5. Indicating TMOV with annunciator circuit

development time and printed circuit board (PCB) space while providing robust protection.

Protecting the Microcontroller

A microcontroller unit (MCU) controls a smart meter's energy measurement and processing functions. The MCU is very sensitive to transients. Fast-rising transients can sometimes pass through the input protection and the filters on input signal lines. To prevent damage to the microcontroller, use TVS diodes on the signal input lines. In addition, the microcontroller I/O communication lines require surge suppression, typically from ESD. TVS diodes, such as the Littelfuse SMAJ or SMBJ, can ensure the necessary level of protection. These diodes can respond in under 1 ps and withstand ESD strikes up to 30 kV.

To further enhance the microcontroller's protection, designers can use Littelfuse opto-isolated solid-state relays for galvanic isolation between the microcontroller and external circuitry. An optically coupled solid-state relay isolates the pulse-out signal between the MCU and the M-Bus. These components have low drive power requirements for minimum power consumption and do not generate any electromagnetic interference (EMI).

Industrial electricity meters employ optically isolated solid-state relays (SSRs) for control by programmable week calendars, dynamic commands, or Active Information Management Systems. Other smart meter applications of SSRs include:

- Custom load output.
- Active/reactive power.
- Tariff switching.
- Alarm outputs.
- Limiting power consumption.
- Energy-direction contact.

Protecting the Communication Interfaces and Auxiliary I/O Lines

The meter uses wireless communication ports with either the GSM cellular protocol or the Zigbee mesh network protocol to transfer usage and other data back to the utility company. These communication ports interface with the external environment and need protection from ESD due to transients such as lightning. TVS diode arrays can provide the necessary protection from ESD. In addition, components with low capacitance will minimize distortion to the transmitted and received RF signals. TVS diode arrays such as the SC1205-01ETG (Figure 7) can absorb ±30 KV ESD strikes and safely dissipate a 7A 8/20us surge event as defined in IEC 61000-4-5. It safely clamps transient voltages to, typically, 10 V and has a maximum capacitance of 9 pF.

Protecting the Battery



Figure 7. SC1205-01ETG bidirectional TVS diode array for ESD protection on transceiver lines

Smart gas and water meters are usually powered by a fixed internal battery pack designed to last 10 years. The most used battery chemistry is lithium-ion (Li-ion). These battery packs have significant capacities; the most important is protecting the battery against short-circuit failures caused by faults in the pack or the meter's circuitry. A PCB space-saving, surface-mount resettable fuse can quickly remove the battery pack from its load in case of an internal or external failure. Miniature resettable fuses are available with low internal resistance under 150 mΩ and fast trip times.

Efficient Sensing Components

One use for sensors in utility meters is flow measurement. Reed switches like the Littelfuse MDSR-10 series offer an accurate and proven technology for flow counting and offer the advantage of not drawing any power.

Unfortunately, there will always be a certain percentage of utility customers who want to "game the system" by tampering with their meters to manipulate the readings and reduce (or eliminate) the amount they will be charged. Smart meter designs include a variety of tamper-detection strategies to help combat the problem. The most common tampering method is simply to open the meter cover and damage the circuitry. Using a detect switch in the design allows the meter to determine when the cover is opened and send a signal to the microcontroller. Versions of detect switches can have a very low activation force, either under 40 grams or 75 grams. These switches allow 2 mm of overtravel, a valuable feature for detection applications. Side-activated detect models can have a minimal profile of 2 mm above the PCB. In low voltage 1.8 V logic circuits, versions can switch current as low as 10 µA.

Another method of meter tampering involves bringing a powerful electromagnet close to the meter's body, which can cause a magnetic transformer to saturate or affect other components. However, by employing a sensitive tunneling magnetoresistance (TMR)/CMOS logic sensor in the design, the meter can detect a small magnetic field and send a trigger to the MCU to record the tampering event. With either tampering method, after recognizing the attempt, the microcontroller notifies the monitoring support staff at the utility company, which can schedule an on-site follow-up and potentially impose a tampering penalty on the user.

Efficient Power Control Components

Many smart meter designers are turning to power MOSFETs for power conversion functions like input voltage pre-regulation and step-down conversion. Although the internal power supplies that feed the meter electronics typically use simple, inexpensive flyback converters, the latest high voltage silicon carbide power MOSFETs allow power supplies to work with a very wide input voltage range from 85 Vac to 440 Vrms or even higher for polyphase meters. SiC MOSFETs improve the reliability and robustness of the power converter. Power MOSFETs with voltage ratings of more than 600 V (see the Sidebar) are essential to accommodate wide AC input voltage ranges combined with the primary transformer's reflected voltage and lightning surges coming from the grid.

Manual Controls

Regardless of the application, smart meters require manual interfaces. For a reliable switch, look for sealed switches that prevent moisture from entering the switches' internal structure. Also, investigate switches with a long operating life. The Littelfuse C&K line of switches offers a number of options for

Table 1. Safety standards for electricity meters

Standard	Title	General Scope	Market
UL 2735	Safety standard for Electric Utility Meters	These requirements cover the electrical safety of electric utility (revenue) meters rated up to 600 V, which measure, monitor, record, transmit, or receive electrical energy generation or consumption information	United States
ANSI C12.1	Code for Electricity Metering	This Code is a reference for utilities, manufacturers, and regulatory bodies. It establishes acceptable performance criteria for new types of AC watthour meters, describes acceptable in-service performance levels for meters and devices used in revenue metering, and includes information on related subjects such as recommended measurements, installation requirements, test methods, and test schedules	United States
ANSI/IEEE C62.41.1	Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits	Describes the mutual interactions between surge protective devices (SPDs) and power system disturbances	United States
ANSI/IEEE C62.41.2	Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits	Provides guidance on how to assess by testing the effects of surges	United States
EEE C62.45	IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits		United States
UL 2735C	Electric Utility Meters for Canada	Similar to UL 2735	Canada
CAN3-C17-M84	Alternating-Current Electricity Metering	Applies to the types of meters and associated devices normally used in the measurement of energy, power, or both in the supply and distribution of electricity as a commodity	Canada
EN 62052 Series	Electricity metering equipment – General requirements, tests, and test conditions	Similar to IEC 62052 Series	Europe
EN 62053 Series	Electricity metering equipment – Particular requirements	Similar to IEC 62053 Series, with the exception of DC (part 41), not yet published by CENELEC	Europe
IEC 61000-4-2	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test	This standard is made to check the capability of the equipment to survive repetitive electrical fast transients and bursts	Global
IEC 61000-4-4	Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test	Evaluating the immunity of equipment when subjected to electrical fast transient/bursts on supply, signal, control, and earth ports	Global
IEC 61000-4-5	Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test	Evaluate the immunity of equipment when subjected to surges	Global
IEC 62052 Series	Electricity metering equipment – General requirements, tests, and test conditions	This part of IEC 62052 covers type tests for electricity metering equipment for indoor and outdoor application and applies to newly manufactured equipment designed to measure the electrical energy on 50–60 Hz networks, with a voltage up to 600 V	Global
IEC 62053 Series	Electricity metering equipment – Particular requirements	Part 21: Static meters for active energy (classes 1 & 2) Part 23: Static meters for reactive energy (classes 2 & 3) Part 24: Static meters for reactive energy at fundamental frequency (classes 0.5 S, 1 S, and 1) Part 41: Static meters for DC energy (classes 0.5 & 1) Part 61: Power consumption and voltage requirements	Global

		Standard	Title	General scope	Market
Component	Surge protection	UL 1449	Surge Protective Devices	Surge protective devices including MOVs shall comply with the requirements in the Standard for Surge Protection Devices.	United States
		UL 497B	Standard for Safety Protectors for Data Communications and Fire-Alarm Circuits	These requirements apply to TVS Diodes.	United States
	Overcurrent protection	UL 1434	Thermistor-Type Devices	Thermistors (PTCs and NTCs) shall comply with Standard for Thermistor-Type Devices.	United States
		UL 248-1	Standard for Safety Low-Voltage Fuses – Part 1: General Requirements	Fuses shall comply with Standards for fuses.	United States
		UL 248-14	Standard for Low-Voltage Fuses - Part 14: Supplemental Fuses		United States
	Battery	UL 1642	Lithium Batteries	Applicable standards that Li-ion batteries shall comply with.	United States
		UL 2054	Household and Commercial Batteries		United States
		IEC 62281	Safety of Primary and Secondary Lithium Cells and Batteries During Transport		Worldwide

Table 2. Safety standards for smart meter components

environmentally protected and long-operating-life switches.

Applicable Standards

Table 1 below list the national and international standards that define the safety requirements for electricity meters. Table 2 covers safety standards for many of the compnents used in smart meters. These tables can help designers determine the standards their product must comply with based on the markets where the product is intended for sale.

Support for the Wide Range of Protection, Control, and Power Components

By consulting with component manufacturers' application engineers, designers can save precious development time and development costs. They can help with:

- Appropriate component selection,
- Identification of the appropriate standards with which the product must comply,
- Pre-compliance testing services which some manufacturers (such as Littelfuse) offer.

With applications engineering assistance, designers can optimize their design for rugged, reliable, and efficient performance. To learn more about emerging circuit protection, sensing, and power control technologies shaping the next generation of smart meters, visit www.littelfuse.com. ■

Download the Building and Home Automation Application Guide, courtesy of Littelfuse, Inc.





Barry Brents is a Field Application Engineer at Littelfuse. He is a former U.S. Navy nuclear submarine officer and a licensed professional electrical engineer in Colorado and California. He has been with Littelfuse for 35 years (including acquisitions), and his current responsibilities include technical support, design assistance, and training for customers and salespeople. Barry received his B.S.E.E. from Texas Tech University.

What's Happening

Wacker Chemical Corporation Under New Management



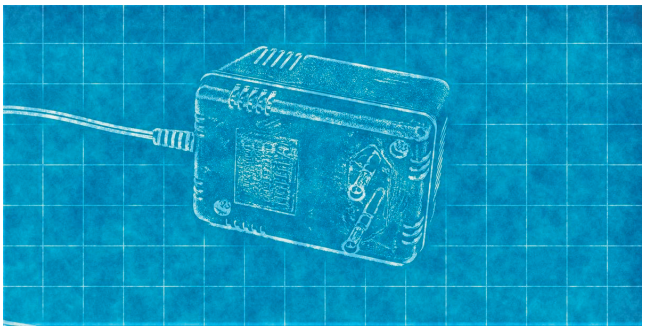
Christoph Kowitz, currently head of WACKER's Corporate Research Department, takes charge of the Group's U.S. subsidiary Wacker Chemical Corporation (WCC) at the beginning of May. He succeeds David Wilhoit who has been responsible for WACKER's North and Central American business since 2015 and is now retiring.

Wacker Chemical Corporation's new President & CEO Christoph Kowitz will take up his new position at the beginning of May. He oversees WACKER's North and Central America business.

WCC's future President & CEO has headed WACKER's Corporate R&D for six years. ''I'm looking forward to my new job in the U.S.,'' says Kowitz, a Ph.D. chemist, who, as a senior manager for WACKER SILICONES, has already been in close contact with silicone production and application technology at WCC sites in Adrian and Ann Arbor, both located in Michigan. ''The U.S. is and will remain one of WACKER's most important markets. With our products from all business divisions, we are ideally positioned to support the climate-neutral transformation of U.S. industry with innovative solutions. The U.S. government is driving this development forward with several investment programs. My aim is to make the best possible use of these opportunities for our growth.''

Christoph Kowitz has already held various management positions. After obtaining his doctorate in organic chemistry and polymer chemistry, he began his professional career as a product developer at BASF AG in Ludwigshafen in 1996. From 1997 onwards, he worked for several years as a management consultant for McKinsey in Asia and Europe. After several management positions in the chemical industry, including Germany-based specialty chemicals manufacturer Cognis, Kowitz moved to WACKER in 2013, where he headed the Performance Silicones unit within the WACKER SILICONES division. Since 2018, he has been Head of Corporate R&D and thus also responsible for innovation management within the Group.

DOE Appliance Standards for External Power Supplies



The U.S. Department of Energy (DOE) has recently proposed new energy conservation standards for External Power Supplies (EPSs). These proposed standards, known as Trial Standard Level 4 (TSL4), aim to tighten energy efficiency requirements across all types of EPSs.

Understanding Trial Standard Levels (TSLs)

TSLs are a tool used by the DOE to set energy conservation benchmarks. Each TSL signifies a specific level of energy efficiency, with higher numbers indicating stricter requirements. These levels are determined through comprehensive analyses that consider factors like technological feasibility, economic impact, energy-saving potential, and environmental considerations.

Efficiency Levels Explained

Each TSL corresponds to a set of Efficiency Levels (ELs) for different categories of EPSs. For example, Efficiency Level 1 (EL1) aligns with the EU Code of Conduct Tier 2 for basic and low single voltage power supplies. On the other hand, Efficiency Level 4 (EL4) represents the highest level of stringency, with only 1%-5% of products meeting the criteria.

Historical Context

The Energy Independence and Security Act (EISA) of 2007 laid the groundwork for energy conservation standards for EPSs. The most recent update was in 2014, known as Level VI standards. The proposed DOE Level VII standards are as follows:

Advocacy and Future Directions

While the DOE believes the proposed standards are the most stringent and are both technologically feasible and economically justified, some advocates argue for even higher standards. The DOE acknowledges that products meeting these proposed standards are already commercially available, thanks in part to advancements in wide bandgap technologies like silicon carbide and gallium nitride (GaN).

Additional Benefits

Higher efficiency EPSs offer more than just energy savings. They are also smaller, cooler, and more reliable, features that will become increasingly important as the industry evolves.

Further Information

For more details on the proposed EPS standards, you can visit the regulations.gov website and refer to docket EERE-2020-BT-STD-0006.

ebm-papst inaugurates new Chinese headquarters



ebm-papst has inaugurated its new local headquarters in China. The 33,000 m² building complex brings together ebm-papst's previous four locations in Shanghai.

To ensure sustainable growth in the Chinese market and offer an attractive location, ebm-papst commissioned the construction of a new local headquarters in 2021.

Previously, ebm-papst China was spread across four locations in Shanghai. In addition to a headquarters with the administrative departments, there was a separate production plant and two external warehouses. In the new local headquarters "ONE Shanghai", all locations are combined under one roof.

Thomas Nürnberger, CSO of the ebm-papst Group and CEO Air Technology APAC & MEA, explains: "With the new headquarters, we have laid the foundation for the further expansion of our business in China. For years, the ebm-papst Group has been pursuing the 'local for local' strategy to respond to customer needs and local market requirements in the best possible way, as well as to establish independent supply chains. The new location enables us to achieve efficient and agile collaboration between all employees and offers us an attractive working environment."

The building was custom-built by the Shanghai Jingiao Group to meet the needs of the fan manufacturer. "ONE Shanghai" covers more than 33,000 m², consisting of a logistics center and a 4-storey building for production, research and development laboratories, offices, and a canteen. Around 900 employees work at "ONE Shanghai".

The move to the new headquarters was carried out in stages to minimize the impact on the production of energy-efficient fans.

"We think globally and act locally – this is how we are continuously expanding our sites in the Asia-Pacific, Americas and Europe regions and focusing on local markets. In the Asia-Pacific region, we are currently investing in Singapore as well as China and further expanding our production capacities in India. Our 'local for local' strategy has three clear advantages for us: Customer proximity, independence in the supply chain and the reduction of emissions," says Dr. Klaus Geißdörfer, CEO of the ebm-papst Group.

The opening ceremony was attended by representatives from politics and industry, ebm-papst shareholders and top management. The shareholders Jan Philippiak and Ralf Sturm welcome the local investment: "This is another milestone in the success story of the ebm-papst Group and our long-standing commitment in China. We can reflect on almost 30 years of successful cooperation between our German and Chinese teams. With this investment, we are further expanding our innovation leadership and our long-term development in the Chinese market."

In China, the company is also investing in the continuous expansion of its local development areas to be able to optimally adapt products and new developments to regionally varying market requirements. ebm-papst China employs around 80 engineers at its own research and development center.

There are also plans to expand the production area at the Xi'an site.

ebm-papst has been represented in China since 1996 and currently employs around 1,900 people at locations across China including Shanghai, Qingdao, Xi'an, Beijing and Hong Kong, with a turnover of around 380 million EUR (fiscal year 2022/2023). In China and the Asia-Pacific region, the cleanroom, renewable energy, and data center sectors are important markets for ebm-papst.

Mauro Gregorio to retire from Dow; Brendy Lange named president of Dow Performance Materials & Coatings

Dow announces today Brendy Lange, business vice president of Dow Industrial Solutions, has been named President of Performance Materials & Coatings (PM&C). He succeeds Mauro Gregorio who will retire at the end of September with 40 years of dedicated service. The transition will begin immediately.

Lange brings a wealth of experience and expertise to the role. During his career with Dow, Lange has held several leadership and strategy-development positions across the Company. In his most recent role, he maximized profitability and implemented a growth strategy for Dow's Industrial Solutions global asset footprint. Prior to Industrial Solutions, Brendy held roles in Corporate Development, Electronic Materials business in Tokyo, and was instrumental in the DowDuPont Joint Integration Management Office during the merger transaction.

"Brendy's proven ability to drive profitable growth and his commitment to leading people make him the ideal choice for this critical role," said Jim Fitterling, Dow chair and CEO. "Under Brendy's leadership, I am confident that Performance Materials & Coatings will continue to thrive and innovate, delivering exceptional value to our customers and stakeholders."

Prior to joining Dow in 2010, Lange worked as a consultant at Deloitte Consulting in Chicago. He holds an MBA with honors from The Wharton School at the University of Pennsylvania and a bachelor's degree in finance and accounting from Indiana University.

Gregorio's tenure at Dow began in 1984, and in the years that followed, he held a variety of key leadership roles across the company.

"Mauro's strategic vision, understanding of our customers, and commitment to excellence have been instrumental in driving our success. His remarkable journey at Dow leaves an indelible mark on our company and the industries we serve," said Fitterling.

Gregorio's leadership was pivotal during the integration of Dow Corning's silicones business into Dow.

Gregorio's impact extends beyond business. He has been a strong advocate for inclusion and diversity, serving as the executive sponsor of Dow's Hispanic & Latin Network employee resource group. His commitment to community engagement is evident through his service on the Board of Directors for United Way of Midland County and MyMichigan Health Foundation.

Fitterling adds, "As Mauro embarks on this new chapter, I extend my deepest gratitude for his unwavering dedication, vision, and leadership. His legacy will continue to inspire us as we forge ahead, guided by the principles he championed."

About Dow

Dow (NYSE: DOW) is one of the world's leading materials science companies, serving customers in high-growth markets such as packaging, infrastructure, mobility and consumer applications. Our global breadth, asset integration and scale, focused innovation, leading business positions and commitment to sustainability enable us to achieve profitable growth and help deliver a sustainable future. We operate manufacturing sites in 31 countries and employ approximately 35,900 people. Dow delivered sales of approximately $45 billion in 2023. References to Dow or the Company mean Dow Inc. and its subsidiaries. Learn more about us and our ambition to be the most innovative, customer-centric, inclusive and sustainable materials science company in the world by visiting www.dow.com.

DiversiTech® Enters Into Distribution Agreement With Sanhua®

Company Enhances Product Offering As Exclusive Supply Chain Partner

DiversiTech Corporation, manufacturer and supplier of parts and accessories for heating, ventilation, and air conditioning ("HVAC") equipment has signed an agreement to be the exclusive North American supply chain partner with Sanhua®, the world's leading manufacturer of high-quality refrigeration products and components. DiversiTech will hold all aftermarket stock for Sanhua, allowing the company to further provide a complete product line solution to their customers.

Effective at the beginning of the year, the new arrangement allows customers a more convenient and flexible way to include Sanhua products within their ongoing DiversiTech shipments. "Our partnership with Sanhua further demonstrates our commitment to simplifying how our customers and technicians do business, bolstering our comprehensive "one-stop-shop" approach. Given Sanhua's focus on advancing both present and upcoming refrigerant technologies, their HVAC/R industry expertise will enable DiversiTech to deepen our already extensive product portfolio in the refrigeration segment," said Jim Mosman, Director of Product Management--Electrical.

While customers will still have the ability to order product directly from Sanhua, minimums and terms may be more stringent. According to Cyrus Gardner, Sanhua National Sales Manager for North America, "I'm excited to partner with DiversiTech and witness how

the combined power of our production, supply chain, and R&D will pair with their expertise in distribution, support, and sales network to benefit the end user. Together, I believe both companies are in a prime position to make sure that high quality, cost competitive refrigeration components are ready and available to the wholesale and distribution HVAC industry to support our extensive OEM install base.''

DiversiTech's Sanhua product catalog is available at diversitech.com.

Kauffman Engineering is pleased to announce the launch of its brand new website: www.kewire.com

Our team has been working hard to create a fresh, user-friendly site that provides all the information you need about Kauffman Engineering and our services.

We believe this new website reflects our commitment to innovation and our dedication to providing the best possible experience for our customers as well as celebrates our ''One Kauffman, One Team'' culture for our employees as an Employer of Choice.

We invite you to explore the site and discover all the new features we've implemented to better serve you.

Thank you for your continued support, and we look forward to connecting with you on our new platform!



L60QS Series – High-Speed Semiconductor Fuse

The Littelfuse QS series of High-speed Semiconductor Fuses is designed to safeguard power semiconductor devices. These cylindrical-shaped, 10x38 mm fuses with higher current ratings, are fast-acting and extremely current limiting. They provide balanced performance and reliable short-circuit protection to extend product longevity while lowering potentially damaging heat energy to the device being protected.

Features and Benefits:

- High ac and dc interrupting rating provides fast and reliable short circuit protection
- Fast acting fuse responds quickly to a range of fault currents to safeguard device
- Excellent cycling capability to handle on/off switching increases product reliability and longevity
- Compact case size with common dimensions saves space and can be used in a variety of applications
- Compliant with UL and IEC standards supports global market applications and streamlines inventory

Applications:

- Ac-dc power converters
- Control circuits
- Data center and other power distribution units (PDUs)
- EV charging stations
- Power supplies
- Variable speed drives

Uninterruptible power supply (UPS)

Soler & Palau Appoints Walter Doll III as New CEO of North America

Effective January 1, 2024, Soler & Palau Ventilation Group is pleased to announce the appointment of Walter (Buddy) Doll III as the new Chief Executive Officer of the North American Division (S&P USA Ventilation Systems, LLC, S&P Canada Ventilation Products, Inc., and RenewAire, LLC) of the Soler & Palau Ventilation Group.

In only a short period of time, Buddy Doll has made a very positive impact at S&P USA Ventilation Systems LLC (based in Jacksonville) and now has the opportunity to extend his skill sets and experience across the North American Group.

Buddy has expressed his excitement about working with the talented and now extended team across Renewaire and S&P Canada to continue to drive the company's success. ''I am honoured to be working with such a dynamic and innovative company,'' said Buddy. ''I look forward to working with the team to continue to build on the company's strong foundation and drive growth and profitability.''

In his new role as CEO, Buddy will report directly to the Soler & Palau Group - Regional Managing Director (Eugene Scotcher). Eugene commented ''We are delighted to welcome Buddy in this new expanded and important role at S&P Ventilation Group. Buddy is an experienced and successful HVAC professional and we look forward to him leading our North American Group into our next phase of growth.



Renewaire Names David Rice VP of Sales and Marketing

VP brings a wealth of national technical sales leadership and project engineer experien

RenewAire®, a Waunakee, WI-based manufacturer of HVAC and indoor air quality (IAQ) products, has named David Rice as its Vice President of Sales & Marketing.

Rice brings more than 37 years of diverse work experience that includes product development/ marketing as well as consulting engineering for industry-leading mechanical and electrical companies. Rice is responsible for leading the ongoing development and implementation of RenewAire's energy recovery ventilator (ERV) and dedicated outdoor air systems (DOAS) sales channels and marketing strategies. ''David is an outstanding sales executive and a talented project engineer, which will help RenewAire and its channel partners continue growing and expanding market share,'' said Scott Forest, President, RenewAire.

Much of Rice's career was spent at Eaton Corp. divisions. He served the Eaton Bussmann Division, Ellisville, MO, the industry leader in circuit protection in various sales, marketing and product management positions including Senior Product Manager and earlier as Business Development Manager. He was also VP of Marketing and Product Development for electrical accessories manufacturer, Eaton B-Line, Highland, IL. Rice has also held COO positions at high power battery test and formation equipment manufacturer, Bitrode Corp, St. Louis; and lighting fixture manufacturer, Baero North America, St. Louis. Rice began his career at consulting engineering firm, R. H. George & Associates and later joined CHP & Associates, Houston, where he was project engineer on a variety of performing arts centers, hospitals, education buildings and other commercial projects.

Rice holds a BS degree from the University of Houston; and was a Charles Knight Scholar recipient while receiving his MBA at Washington University, St. Louis. His Rice Ventures LLC, St. Louis, offered business consulting services especially in the electrical field where he's a recognized expert consultant in National Electric Code (NEC) issues and compliance.

Lorin Highlights Black and Bronze Anodized Aluminum Finishes

Lorin Industries, Inc. highlights its range of architectural black and bronze anodized aluminum finishes. These captivating finishes offer architects



y of options to elevate their
to new heights of elegance and
stication.
in's black anodized aluminum
es include ColorIn® BlackMatt,
Brite®, Black Satin, and Black
ess. Lorin's high-quality anodized
num black finishes go beyond
ess with an industry leading, deep,
ack color that is both attractive and functional. Whether you prefer a matte, satin, or bright finish, Lorin has the perfect solution for projects that warrant the black look. UV stable anodized ColorIn Black by Lorin is more resistant to fading than black colors made through other finishing or coating processes, making it a popular choice for architectural applications where a long-lasting, low-maintenance finish is desired.

Lorin's ColorIn® Bronze range of anodized aluminum finishes include Subtle Light Bronze, Light Bronze, Medium Bronze, Dark Bronze, and LA Extra Dark Bronze. All of these finishes are UV stable and have been developed for exterior applications where UV fade resistance is critical to the designer. Lorin's high-quality anodized aluminum bronze finishes offer a deep, rich color that is both elegant and sophisticated.

Lorin's black and bronze anodized aluminum finishes offer architects and designers an unparalleled combination of beauty, durability, and performance.

H.B. Fuller Acquires ND Industries Inc.



Strategic acquisition expands service and product offering in fast-growing, high-margin segments

H.B. Fuller Company recently announced that it has acquired ND Industries Inc., a leading provider of specialty adhesives and fastener locking and sealing solutions serving customers in the automotive, electronics, aerospace, and other industries.

The acquisition is expected to accelerate the realization of H.B. Fuller's top growth priorities, consistent with the company's strategy to proactively drive capital allocation to the highest margin, highest

growth market segments within the functional coatings, adhesives, sealants and elastomer (CASE) industry. As part of the acquisition, products under ND Industries' Vibra-Tite® brand will be added to H.B. Fuller's existing epoxy, cyanoacrylate, UV curable and anaerobic product range.

"ND Industries has been a very profitable, family-owned business for several decades and has impressively built one of the most extensive product portfolios in the pre-applied fastener industry," says President and CEO Celeste Mastin. "Their products are a natural fit with our existing market segments and bring new technology to our portfolio — combining the benefits of an adhesive and a mechanical fastener within extremely demanding applications — resulting in a powerful advantage for our customers."

ND Industries specializes in formulating and manufacturing a wide variety of materials applied on fasteners and assemblies to aid in critical functions such as locking, sealing, masking, lubricating, and noise and vibration dampening. The company also has a network of processing centers providing in-house engineered coating application services to help increase the safety and reliability of fastener assemblies, and a world-leading line of small pack technologies for maintenance, repair, and operations (MRO). The combination of innovative adhesives, custom equipment, and pre-applied processing centers expands H.B. Fuller's already extensive adhesive application expertise.

"With more than 55 years of excellence and a strong customer base, ND Industries has been at the forefront of technological advancements for decades," added Richard Wallace, chairman of ND Industries Inc. "Both companies have worked closely over the past several months to ensure a smooth transition and share many of the same values, including close customer collaboration and innovating with speed."

Headquartered outside Detroit, Michigan, ND Industries serves a global market with facilities in the United States and Asia, and pre-applied coating partners around the world. The company generated approximately $70 million in revenue in fiscal 2023. The new business, which includes five U.S. locations and 300 employees, will operate within H.B. Fuller's existing Engineering Adhesives global business unit.

CASPR Technologies Introduces New HVAC Division

Division Will Help Meet Growing Demand for Advanced Air and Surface Disinfection Solutions Delivered Through HVAC Systems

CASPR (Continuous Air and Surface Pathogen Reduction) Technologies, a leader in advanced air and surface purification solutions introduced its new HVAC division, which will build manufacturing partnerships and sales networks to bring CASPR's innovative disinfection technology to multiple industries.

CASPR's natural catalytic converter technology uses safe levels of gaseous hydrogen peroxide to continuously disinfect air and surfaces, providing an additional layer of protection against viruses, bacteria and other pathogens. Additionally, the implementation of CASPR systems can reduce energy usage through outside air reduction, reduce absenteeism, and increase productivity. The technology has already been widely deployed in facilities across the United States, and now this new division will extend CASPR's ability to create safer and healthier interior environments.

"As businesses and institutions prioritize cleaner indoor air quality, the demand for CASPR's advanced disinfection solutions has skyrocketed, and we have successfully helped make indoor environments safer and healthier in everything from buses to schools to hospitals," said Nick Licata, CEO of CASPR Technologies. "With our new HVAC division, we intend to leverage our HVAC-based products to reach a new level of growth, working with the professional network of engineers, specifiers and manufacturing representatives who can bring our solutions to the broader marketplace."

With the launch of the division, CASPR also seeks sales partners who have established relationships with facility managers, contractors and ownership groups in markets such as healthcare, education, hospitality, commercial real estate and others.

"CASPR is always looking for partners in the fight for safer indoor environment, and we work with design engineers, original equipment manufacturers (OEMs), HVAC companies, architects, and facility owners to help make the world indoors safer," added Licata. Those interested in pursuing a partnership opportunity with CASPR Technologies should contact Scott Yerby, VP of Sales at scott@casprtech.com or (844)-717-8819.



Chemours Announces Appointment of Denise Dignam as President and Chief Executive Officer of the Company

The Chemours Company a global chemistry company with leading market positions in Titanium Technologies, Thermal & Specialized Solutions, and Advanced Performance Materials, announced the appointment of Denise Dignam, current Interim Chief Executive Officer, to the positions of President and Chief Executive Officer and a member of the Board of Directors, effective immediately.

Ms. Dignam joined Chemours in 2015. She brings over 35 years of experience in the chemical industry where she has held senior roles in business and operations, sales and marketing, commercialization, and supply chain. She had served as Interim Chief Executive Officer since February 2024, and prior to that held the positions of President, Titanium Technologies (TT) segment, and President, Advanced Performance Materials (APM) segment---two businesses that represent over 68% of Chemours' net sales in 2023. As President of Titanium Technologies, Ms. Dignam stood up the TT Transformation Plan, delivered significant operational savings in 2023, refocused the portfolio to deliver more customer value, and developed process improvements for better resource utilization across the manufacturing circuit. During her tenure on Advanced Performance Materials, she reshaped the portfolio to focus resources on secular growth opportunities in Clean Energy and Advanced Electronics. To further accelerate growth, she drove strategic partnerships and initiatives across the globe, and improved the overall cost structure of the business, laying the foundation for further cost optimization.

Commenting on her appointment, Ms. Dignam said, ''I am excited and honored to take on the role of President and CEO. Chemours is defined by its leading chemistries, the customer applications that our chemistries enable, our manufacturing capabilities, and as importantly, our people and core values. Looking ahead I will be focused on strengthening our portfolio with high-value and emerging growth opportunities, and ensuring we are operating as efficiently, effectively, and safely as possible. I am committed to continuing to lead with transparency as we do the hard work required to keep building our businesses for today and into the future. I want to thank our Chemours employees around the world, who are the cornerstone of our success, and our customers and partners for their continued support.''

Dawn Farrell, Chair of the Board of Chemours, added, ''Denise has the full support of the Board, and we are pleased to have an experienced and capable executive who is so highly regarded inside and outside Chemours for her track record leading the APM and TT business segments. Denise is a high-caliber leader who has the experience and capability to build value for shareholders while upholding our core values and serving our valued customers.''

Additional Leadership Changes

Matthew S. Abbott, Interim Chief Financial Officer (CFO), will continue in his role while we commence a comprehensive search for a permanent CFO.

''Matt is an incredible partner,'' said Ms. Dignam. ''His tireless efforts and leadership have been integral to Chemours' progress to this point and will continue to be critical as we navigate the road ahead of us. Matt has made it clear that he is committed to leading the Finance organization, building a strong controls environment, and ensuring the delivery of our financial reporting and disclosures, while we conduct our search for a permanent CFO to further enhance our capital structure and achieve shareholder value.''

Diane Iuliano Picho, Vice President of Human Resources and Chief of Staff, Titanium Technologies, will step in as Interim President, Titanium Technologies while we conduct a comprehensive search for a permanent segment President. Diane brings to the role demonstrated business acumen over a 40-year career that includes experiences in R&D, operations, HR, sales, marketing, and commercial leadership. Previously, Diane was the Vice President of Commercial Operations for the Advanced Performance Materials segment where she led product management, supply chain and demand planning, and competitive intelligence. Before Chemours, Diane held business roles of increasing responsibility at E.I. du Pont de Nemours, which she joined in 1983. During that time, as Global Business Manager of Refrigerants, she led the product development, IP strategy, commercialization, and launch of the company's Opteon™ low global warming potential refrigerant offering. She received her Master of Business Administration from Widener University and her Bachelor of Science in Mechanical Engineering from Villanova University.

Samsung Names Victor Gomez as New COO



Victor Gomez is the new senior vice president and chief operating officer at Samsung HVAC America. Gomez brings extensive experience from prior senior executive roles in sales, supply-chain management, and business strategy and contributes a wealth of expertise to strategically position Samsung for ongoing growth and success in the North American market.



Achieving Superior Surface Quality: The Essential Role of Pretreatment in Electronics Coating

Rooftop commercial HVAC system.

Electronics within HVAC systems require meticulous protection to ensure reliability and prevent costly failures. This is especially crucial in environments exposed to high humidity, temperature fluctuations, and corrosive conditions such as rooftop installations, seacoast climates, and industrial settings. Neglecting proper surface pretreatment before applying protective coatings can lead to significant issues, including frequent repairs and elevated failure rates.

One effective method to enhance the performance of conformal coatings without relying on harmful chemicals is plasma pretreatment. Before delving into this method, let's establish what conformal coating entails and the importance of pre-treatment.

Understanding Conformal Coatings in HVAC Systems

Conformal coating is a protective coating applied to electronic circuit boards to protect them from environmental factors such as moisture, dust, chemicals, and temperature extremes. In HVAC systems, electronics are often exposed to varying environmental conditions, including humidity and temperature fluctuations, making them susceptible to damage over time.

The choice of conformal coating material depends on factors such as the environmental conditions (temperature, humidity, chemicals), mechanical stress, and electrical properties required for the HVAC electronics. Manufacturers typically select the coating material that best meets the specific performance and protection needs of their electronic components in these systems.

Typically, conformal coating is applied as a liquid through various methods, including spraying, dipping, or brushing. Once applied, the coating conforms to the surface contours of the components and circuitry. Common materials used for conformal coatings include acrylics, silicones, urethanes, and epoxies.

Benefits of Conformal Coating:

- ***Environmental Protection:*** Conformal coatings provide a protective barrier against environmental factors such as moisture, dust, dirt, and chemicals. In HVAC systems, which operate in varied conditions including high humidity and temperature changes, this protection helps prevent corrosion and electrical shorts that could otherwise occur due to exposure.
- ***Improved Reliability:*** By preventing moisture ingress and corrosion, conformal coatings enhance the reliability of electronic components in HVAC systems. This can lead to longer operational lifetimes and reduced maintenance needs.
- ***Enhanced Durability:*** Conformal coatings provide a layer of

insulation that protects electronic circuits from physical damage, vibration, and thermal cycling. This helps maintain the integrity of the electronics over time, even in harsh operating environments.

- ***Reduced Downtime and Maintenance Costs:*** With improved reliability and durability, HVAC systems benefit from reduced downtime due to electronic failures. This translates to lower maintenance costs and improved system uptime, which is crucial for both residential and commercial HVAC applications.
- ***Compliance and Safety:*** Conformal coatings can help meet regulatory requirements for safety and reliability in electronic components used in HVAC systems. They can provide additional insulation and protection against electrical hazards, ensuring compliance with industry standards and regulations.
- ***Flexibility in Design:*** Conformal coatings are typically applied in thin, uniform layers that conform to the contours of complex electronic assemblies. This allows for design flexibility and protection of sensitive components without adding significant weight or bulk to the system.

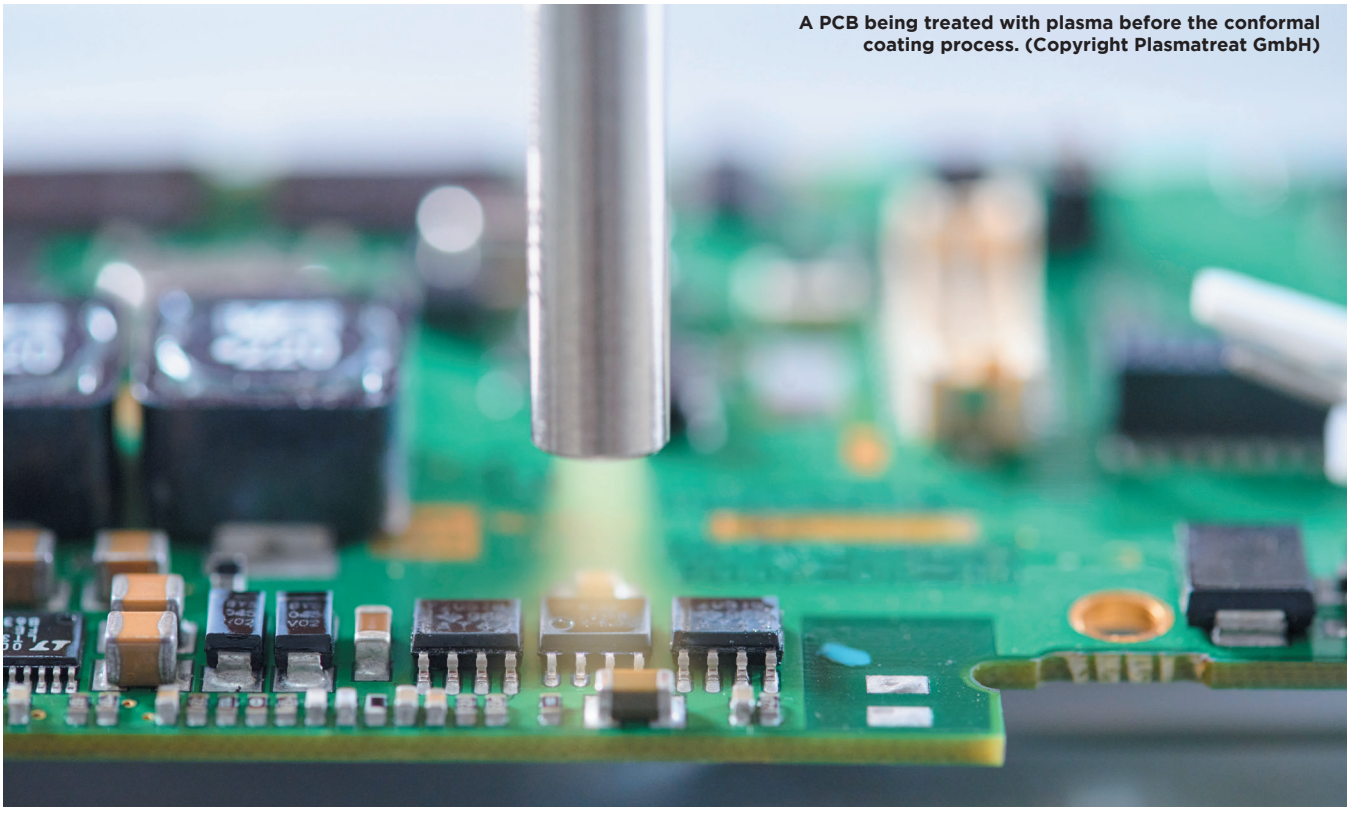
Industries such as automotive, aerospace, medical devices, and industrial electronics rely on conformal coatings for their robustness and performance in demanding conditions.

Preparing Surfaces for Coating: The Importance of Effective Pretreatment

Proper pretreatment is vital before applying conformal coatings to ensure the coating's effectiveness and to maximize protection. This preparatory phase typically involves several steps aimed at cleaning, preparing, and conditioning the surfaces of electronic components.

Common Pretreatment Steps:

- Cleaning: Prior to applying conformal coating, it's essential to thoroughly clean the surfaces of the electronic components. This removes contaminants such as dust, oils, flux residues, and other particles that could interfere with adhesion or cause defects in the coating. Cleaning methods can include solvent cleaning, aqueous cleaning, vapor degreasing, plasma cleaning or ultrasonic cleaning depending on the type of contaminants and the material compatibility of the components.
- Surface Preparation: After cleaning, surface preparation may involve techniques to promote adhesion of the conformal coating. This can include mechanical abrasion (such as brushing or sanding) to roughen smooth surfaces, or plasma treatment to improve surface wettability and adhesion.



A PCB being treated with plasma before the conformal coating process. (Copyright Plasmatreat GmbH)

- Masking: In some cases, components or areas that do not require coating (such as connectors, mounting holes, or sensitive components) are masked off using tapes, plugs, or other masking materials. This ensures that the conformal coating is applied only to the intended areas, preventing potential issues like interference with mating surfaces or functionality.
- Drying: After cleaning and preparation, it's important to ensure that the components are thoroughly dried. Moisture left on surfaces can compromise the adhesion and effectiveness of the conformal coating. Drying methods can include air drying, baking, or using specialized drying equipment depending on the materials and cleaning agents used.

Consequences of Neglecting Pretreatment

Failing to properly pretreat surfaces can lead to issues like incomplete coating coverage, blistering, cracking, and detachment of the coating. Contaminants can undermine the coating's effectiveness, leading to costly repairs or high rejection rates.

Overall, proper pretreatment before applying conformal coating is crucial to ensure that the coating provides the intended protective benefits. It enhances adhesion, prevents defects, and maintains the integrity of electronic components in HVAC systems, ultimately contributing to their reliability, durability, and safe operation in diverse environmental conditions.

Advancing Coating Preparation: The Advantages of Plasma Pretreatment

Plasma pretreatment offers several advantages when preparing surfaces for conformal coating in HVAC electronics:

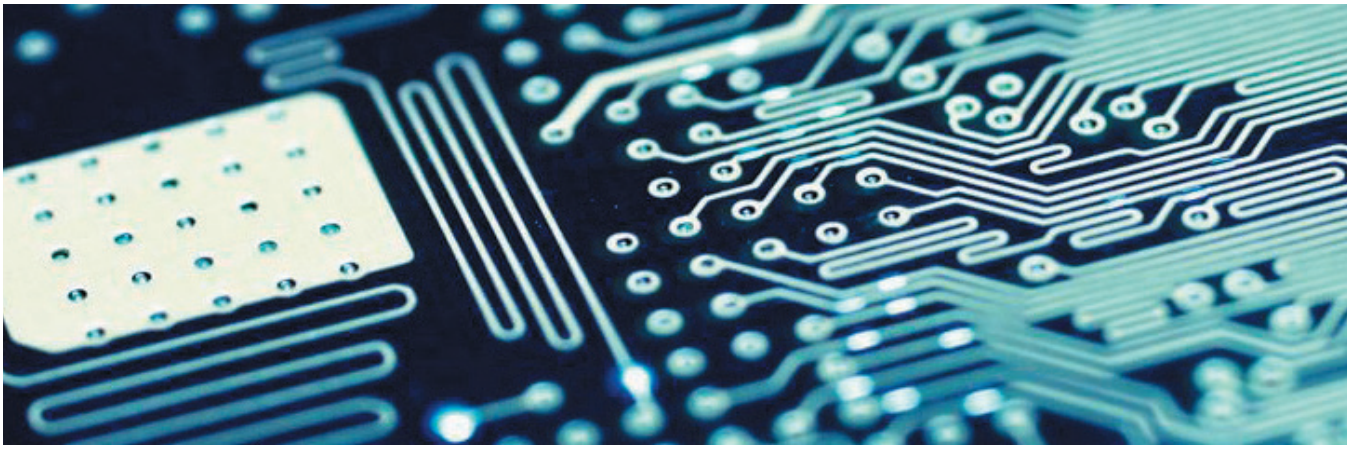
- ***Enhanced Surface Cleanliness:*** Plasma treatment effectively removes organic contaminants, oils, and residues from surfaces. This results in a cleaner surface compared to conventional cleaning methods, ensuring better adhesion of the conformal coating.
- ***Improved Surface*** Wettability: Plasma treatment modifies the surface energy of materials, increasing their wettability. This means that the conformal coating can spread evenly and adhere more strongly to the treated surface, reducing the likelihood of defects such as pinholes or delamination.
- ***No Residue:*** Unlike some solvent-based cleaning methods, plasma treatment does not leave behind residues that could potentially interfere with the conformal coating or affect the performance of electronic components. It leaves the surface clean and ready for coating.
- ***Selective Treatment:*** Plasma treatment can be selective, targeting specific areas or materials without affecting adjacent components or surfaces. This makes it particularly suitable for complex assemblies where precision is required in surface preparation.
- ***Environmentally Friendly:*** Plasma pretreatment is often considered environmentally friendly compared to solvent-based cleaning methods because it typically uses inert gases such as nitrogen or argon. It does not involve harsh chemicals or generate hazardous waste, contributing to a cleaner manufacturing process.

- ***Fast Process:*** Plasma treatment is a relatively quick process compared to some other surface preparation methods. It can be integrated into automated production lines, allowing for efficient and consistent treatment of electronic components before conformal coating application.
- ***Enhanced Adhesion and Coating Performance:*** By improving surface cleanliness and wettability, plasma pretreatment ensures strong adhesion of the conformal coating to the substrate. This enhances the coating's protective properties, durability, and resistance to environmental factors in HVAC applications.

Evaluating Plasma Pretreatment for Optimal Results

When assessing plasma pretreatment solutions, consider the following factors:

- ***Technology and Solutions:*** Ensure the plasma technology aligns with your needs for conformal coating.
- ***Application Expertise:*** Look for expertise and case studies relevant to electronics manufacturing.
- ***Compatibility:*** Verify that the solutions are compatible with your materials and coating types.



- ***Customization:*** Check for flexibility in system configurations and settings.
- ***Reliability and Reputation:*** Research the company's track ***record and customer feedback.***
- ***Support and Service:*** Evaluate the level of technical support and training provided.
- ***Regulatory Compliance:*** Ensure adherence to industry standards and regulations.

Plasmatreat stands out as a leader in plasma surface treatment solutions. Their Openair-Plasma® technology has a long history of successful application in electronics manufacturing, including conformal coating preparation.

In addition, Plasmatreat has developed a pioneering method of applying nano-thick, solvent-free plasma hybrid polymer/ceramic coatings under atmospheric pressure conditions, which could eventually replace the traditional conformal coating process. The process resembles traditional vacuum plasma-enhanced chemical vapor deposition (PECVD) but operates under atmospheric conditions. Coating characteristics are influenced by a precursor fluid vaporized in the plasma, offering properties such as hydrophobicity, hydrophilicity, isolation barriers, moisture resistance, corrosion protection, and bonding layers.

A notable capability is its application of dielectric barrier coatings on electronic devices, marking a breakthrough in protecting components. This innovation provides effective anti-corrosion shielding which is crucial in rooftop applications, industrial and food processing environments and those with temperature fluctuations and high humidity such as seacoast climates.

Plasmatreat's dielectric barrier coating technique offers area-selective capabilities, allowing precise nanocoating application to specific areas of compact electronic devices, including those utilized in outdoor HVAC systems. It can replace harmful chemical cleaning processes.

For tailored solutions and the latest advancements, contact Plasmatreat directly. ■

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Mary is a seasoned marketing leader with a strong academic foundation, holding a Bachelor's degree and an MBA from Loyola University Chicago. With a focus on developing impactful brand and marketing strategies, she specializes in leveraging market research and consumer insights to drive business objectives. Her expertise spans across product marketing, go-to-market strategies, performance marketing, content strategy, sales enablement, lead generation, and distributor strategies.

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Energy-Curable Technologies in Coil Coatings



Industrial coatings made with advanced polymers, pigments and additives perform a variety of important functions, including UV protection, chemical and corrosion resistance, and durability that can extend the lifecycle of a product. These coatings are crucial for a variety of industries, including products made for appliance and HVAC applications. However, when it comes to performance, the quality of the coating formulation is only half of the equation. Coatings have to be cured properly as well—with strict adherence to the specifications provided by the coatings manufacturer—for optimal protection performance and aesthetics.

Curing, or crosslinking, is the chemical process that enables a coating to harden and bond to a substrate. A good curing process is essential for chemical resistance, color, resiliency and other important performance characteristics. However, curing methods vary based on the specific chemistry of the protective coating. Conventional liquid and powder coatings typically cure with air or heat, but alternative solutions exist that use radiant energy sources to initiate the cross-linking process instead.

Energy-curable technologies, such as ultra-violet (UV) and electron beam (EB) curing, represent a significant advancement in the coating technology. These methods use UV light or electron beams to trigger the curing reaction, resulting in faster processing times and improved efficiency.

Energy-curable coatings were introduced in the wood products industry more than 50 years ago. Due to innovations in formulations, processes and equipment, these high-technology solutions are now used on substrates such as vinyl, composites and even pre-painted metal.

Thanks to significant investments in research and development, a new frontier has emerged for these advanced solutions: coil coating applications.

Energy-cure coatings are expected to produce revolutionary changes in coil-centered industries like building materials, appliance and HVAC. The use of these technologies will not only enhance the longevity and performance of a wide range of products, but also aligns with the push towards more sustainable and energy efficient practices.

Energy curable coatings explained

The two primary types of energy-curable coatings are ultra-violet (UV) and electron beam (EB), each with their own performance attributes. While the curing mechanism varies between the two, they both convert liquid paints to solids that fully cure and bond with the substrate in seconds to form a hard, durable finish.

Unlike thermal curing that requires heat, energy curing is performed at or near ambient temperature using photons of light or electrons to polymerize materials onto a substrate. This method, often called cold curing, is attractive to manufacturers that use wood, plastic and other heat-sensitive materials because these substrates can be damaged when exposed to the higher temperatures required to rapidly cure most conventional coatings. UV formulations are comprised of liquid monomers (small molecules), oligomers (a molecular complex comprised of a few monomer units) and additives with a small percentage of photoinitiators that convert light energy to chemical energy. When UV-curable formulations are exposed to electromagnetic energy from UV lamps, photochemical processes are initiated that result in the rapid polymerization of the monomers and oligomers.

EB formulations also use liquid monomers, oligomers and additives, but they do not require photoinitiators. These formulations are cured by an electron beam device which emits electrons at a controlled rate that rapidly polymerize the monomers and oligomers in the formulation. Like UV coatings, the technology requires no heat source to cure.

Both UV- and EB-curable solutions can be used on various substrates that can be rolled, such as paper, PVC foils or coils, because curing is immediate. They can be applied with a variety of methods, including roller coating, curtain coating, spraying and vacuum coating.

The performance, sustainability and other advantages of UV- and EB-curable coatings, coupled with advancements in the technology, are making these solutions viable for a broader range of substrates and industries.

The sustainability benefits driving adoption of UV/EB-curable solutions

One factor driving global growth in energy-curable coatings is rising interest in more sustainable solutions and manufacturing practices.

Most conventional liquid paints contain solvents that dissolve and disperse ingredients such as pigments, resins and additives. Energy-curable solutions allow manufacturers to use 100% solid content solutions that contain no solvents, which leads to low, or even no, VOC emissions and lower flammability risks.

This class of coatings is also considered to be more energy efficient since curing is nearly instantaneous. Less energy is needed for drying from UV lamps or electron beams than conventional thermal drying ovens.

With increasing regulatory oversight of VOC emissions and



efforts to lower energy consumption, UV/EB technologies appear poised to meet the current and future environmental challenges of our time and grow in prominence in the coatings industry.

Gains in costs, time and efficiency

Manufacturing is driven by productivity and ways to improve turnaround time and cost efficiency. The finishing process can play a significant role in these efforts. Conventional liquid coatings require time and temperature to cure. Typically, lower temperatures require more time to dry and cure the paint.

While the level of light or energy needed to cure UV/EB coatings varies depending on film thickness and chemistry type, these technologies contribute to higher productivity from faster finishing since no time is needed to preheat the substrate or for water or solvents to evaporate before curing.

Another advantage is that no thermal ovens are required for curing because the polymerization reaction takes place at room temperature—which can produce impressive cost and time savings. Additionally, UV/EB equipment is less capital intensive and has a more compact footprint than thermal ovens.

These alternative technologies cure in seconds or even faster with immediate conversion rates of 90% or more. Parts can be handled almost immediately for packing, storage and shipping, which reduces the need for floor space to hold inventory at various stages of the finishing process.

In multilayer systems, it is also possible to consider wet-on-wet application in order to further reduce the length of the line and increase productivity. With EB solutions, for instance, a single cure is possible with up to three different layers of wet-on-wet paint of 80 microns each. With EB technology, film opacity has a negligible impact on curing as the electrons are not absorbed by pigments in the way that UV radiation is. Thick, multilayer coatings can even be done at high speed.

In contrast, UV curing for wet-on-wet application can be more challenging when the paint is not clear or transparent, as it is more difficult for photons of light to penetrate the paint.



Boosting performance

Energy-cured coatings deliver on protective performance by offering exceptional hardness, scratch and chemical resistance, and high flexibility. This is an important advantage for equipment used in high impact areas or those exposed to the elements.

While energy-curable coatings were once considered to be brittle, that is no longer the case. In the technology's early years, these coatings were ideal for flat surfaces that didn't require "flexible" paint. The latest energy-cure formulations meet the requirements for flexible substrates, good bonding strength and resistance to twisting and bending.

Because these coatings are made with 100% solid content and do not contain water or solvents, these solutions maintain nearly the same film thickness before and after the cure, with virtually no loss in weight.

With modifications to formulations, processes and curing equipment, sheen levels from deep matte to very high gloss can be achieved. While both technologies offer distinct advantages, the decision between UV- or EB-curable coatings includes factors such as initial equipment start-up costs, application requirements and ongoing operational costs.

The future of energy-curable innovations

Wood manufacturing remains one of the primary industries for energy-cure technologies today, but that is quickly changing thanks to a growing, global interest in more sustainable finishing solutions.

Through investments in research and development, including pioneering work done by PPG, these advanced coatings are now available for a broader range of applications and industries.



Historically, the shape or design of the substrate was a major consideration in whether UV/EB technology was an option, as it was more suitable for flat, linear shapes. Today, new curing formulations, equipment and processes are making the technology more applicable for complex 3D shapes, creating new opportunities in industries such as automotive and general finishing.

Interest among coil applicators and manufacturers is growing primarily due to energy-efficiency advantages, low-VOC content and a lower carbon footprint via the elimination of high-temperature, gas-fired curing ovens. With energy curing, manufacturers of coil-coated HVAC and appliance related products can expect to lower their processing costs significantly.

PPG's commitment to energy-curable solutions and innovations

With ongoing investments in R&D, newer generations of UV/EB-curable coatings and advancements in equipment will continue to drive adoption of these solutions across a wider range of industries and end-use applications.

PPG's extensive history with UV/EB technologies is helping the global coatings company accelerate the development of new energy-curable coatings for coiled metal, including cutting-edge solutions that offer the durability and performance needed for exterior applications and a wider range of gloss levels.

PPG's newest energy-curable innovation

PPG was among the first to offer UV-curable solutions for the wood industry and remains a global leader in energy-cure technologies. Today, PPG offers a wide range of 100% solids water-borne and solvent-borne formulations, suitable for a wide range of industries including coil, automotive, packaging and specialty materials.

The newest products in the company's energy-cure portfolio are PPG DURANEXT™ UV/EB coatings, an alternative to traditional coil coating systems. It is PPG's first UV/EB product family for metal.

PPG DuraNEXT solutions include a line of primers, backers, topcoats and clearcoats for interior and exterior applications, and are engineered to maintain the finish durability and beauty of coil-coated products. With near-zero VOCs and instant, non-thermal curing, PPG DuraNEXT UV/EB coatings are a sustainably advantaged product line with a lower carbon footprint than traditional thermally cured building product coatings.

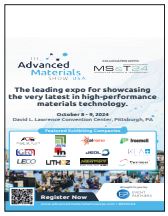
The family of products includes PPG DuraNEXT EB clearcoat, which offers excellent weather resistance, durability and color/gloss retention. The technology is engineered for interior and exterior coil applications and is used over digitally printed inks to maintain their beauty and durability. ■

Authors: Emeline Firmin, Global Technical Manager, Energy Cure Products; Craig Smith, Ph.D., Global Technical Platform Director, Coil Coatings; and Marisol Rodriguez, Ph.D., Global Technical Director, Industrial Product Development

Coating technologies: Ultra-violet (UV) and electron beam (EB)

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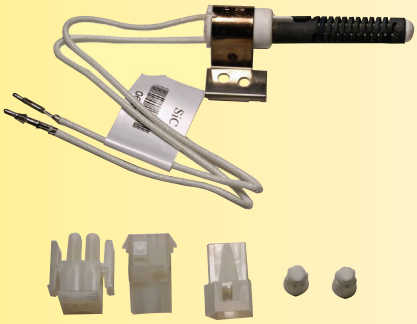
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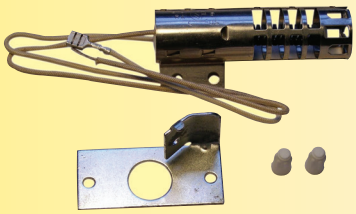
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