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# APPLIANCE & HVAC REPORT

Reaching Design Engineers at the OEM Level

July 2021

VOLUME 3 ➢ NUMBER 3



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## 10 FEATURES COVERING

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# Welcome to our July issue, the third on our quarterly schedule this year



Things are looking up, with COVID diminishing based on all the available metrics. I recently flew to Miami and back. Not a seat to be had on any of my flights…all three completely sold out. Yet we recently passed more than 600,000 deaths in America (including, I regret to say, the passing of my father), and more than 3,000,000 worldwide. We will never forget this past year.

With all of this THE APPLIANCE & HVAC REPORT has been able to "keep on keepin' on". We have now exceeded 100 eblasts for advertisers…no small fete for a start-up during the worst situation in our lifetimes. So we must be doing something right.

What we strive to do is deploy whitepapers and other technical materials to our design engineering audience. And they are responding. How do we know? Because our "open" rates are typically double digits, and we regularly generate 3 figure numbers of unique click-thrus on a regular basis.

For this month, the following nine organizations have generously allowed us to publish their materials:

Align Business Advisory, CASPR Group, CleaverBrooks, Comsol, EpoxySet, Etco, Intertek, JBC Technologies and Renesas.

Also, do you like anniversaries? We do. In recognition of JOHN GUEST's 60th anniversary we have a "Q&A" with Chris Carrier, their Director of Marketing. And no, Chris is not associated with Carrier Corp. despite his well-known surname!

Thank you one and all.

Ladies and gentlemen, these whitepapers are the "guts' of our editorial product. For those of the 21,000 subscribers who read us, if your company wants to contribute technical information we would most appreciate it. While we don't pay for these, we do offer credit in the byline to you and your company. Feel free to contact me to be part of our 4th quarter issue (October) and/or our 2022 editions.

And while advertising pays for what we do, we don't exchange editorial support for the purchase of our paid media.

Have a good summer and connect again after Labor Day.

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APPLIANCE & HVAC REPORT
Reaching Design Engineers at the OEM Level

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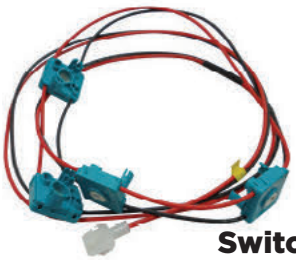
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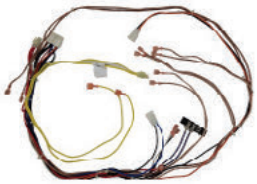
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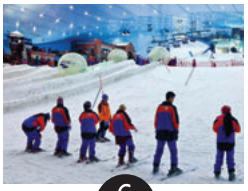



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# July

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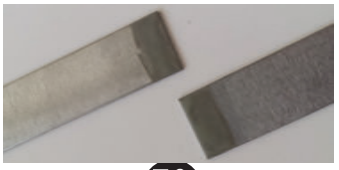
The National Electric Code, (NEC), was recently altered to include special provisions for refurbished electrical equipment.



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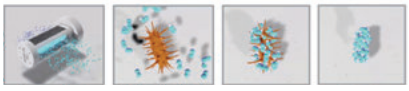
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Cooling an indoor ski slope, providing air conditioning to a prestigious old castle, or chilling and freezing consumer goods — these scenarios all require heat exchanger technology.







# Optimizing Heat Exchanger Designs for Refrigeration and Cooling Technology

**BY RACHEL KEATLEY**

An estimated 103 million tons of food went to waste in the United States alone in 2018 — a number greater than the weight of 600 thousand average-sized blue whales (Ref. 1). A majority of food waste ends up in landfills, where it decomposes and produces methane. The United States Food and Drug Administration (FDA) even reports that food waste accounts for the largest percentage of material in landfills (Ref. 2). Food can be wasted during any stage of its lifecycle, which is why it is important for consumers and the food industry alike to be aware of solutions to help alleviate this problem. One way to help reduce food waste on an industrial level is to ensure that consumer goods are being properly stored before they end up in customers' homes.

Julius Heik, a thermodynamics development engineer at thermofin GmbH, performs simulations to ensure that their heat exchangers are optimized for specific use cases and client needs.

Heik's favorite part about working with simulation? You are able to gain knowledge before actual measurements are carried out.

## Designing Optimized Heat Exchangers

Since its founding in 2002, thermofin GmbH has expanded from 6 employees to more than 500, with production sites on several continents. Their dependable heat exchangers have made them a popular choice in the refrigeration and air conditioning industry.

Heat exchangers sound like a simple concept, but they can actually be quite challenging to design. The essential task in cooling a product is to get rid of unwanted heat so that thermal energy from perishable goods is extracted. This is where the refrigerant of a refrigeration cycle comes into play. By changing the refrigerant phase from a liquid to a vapor state, the heat exchanger is removing heat from its ambient surroundings. This heat then has to be passed over to a second heat exchanger, which emits this energy to the outside environment.

In transcritical CO2 refrigeration cycles, a so-called gas cooler chills the refrigerant inside a heat exchanger. Often, people get confused by the name "gas cooler", as if it uses gas to chill its surroundings. Designing heat exchangers in general, and gas coolers in particular, present a fair amount of difficulties, according to Heik. When striving for better, more energy-conserving refrigeration cycles, well-engineered heat exchanger designs serve as a main contribution.

Like many cooling systems, gas coolers are designed to have a minimal direct impact on the environment, so they use the natural refrigerant CO2. For example, in the supermarket sector, CO2 is now used almost exclusively because it is classified as a nonhazardous gas (safety group A1). Due to its properties, however, it must dissipate its heat at air temperatures above

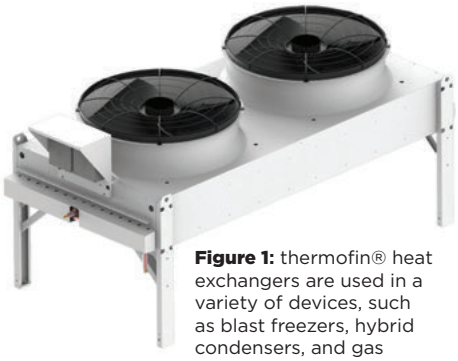


**Figure 1:** thermofin® heat exchangers are used in a variety of devices, such as blast freezers, hybrid condensers, and gas coolers (shown).

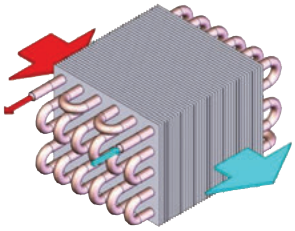
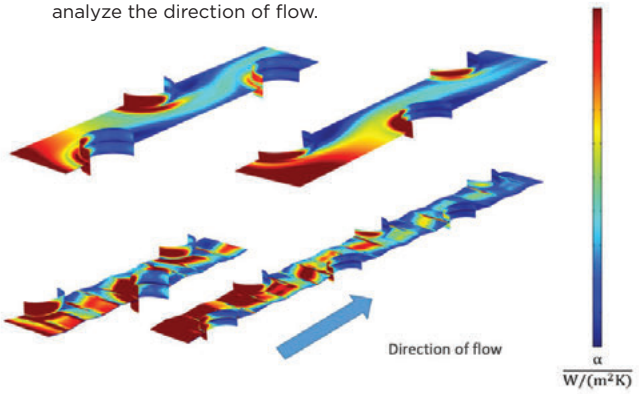


**Figure 2:** Geometry of a thermofin® heat exchanger. The large arrows represent the airflow, while the small arrows represent the refrigerant flow. In addition, the red and blue colors indicate a temperature change. For example, airflow is hot at the inlet (red) and cold at the outlet (blue).

Thermofin® heat exchangers contain slats or fins of varying material properties and spacing requirements. To better understand how these slats work, thermofin GmbH uses simulation to analyze the direction of flow.




20–25°C, in the so-called transcritical range. That is why these systems have a large temperature difference, consist of many different circuits, and are made up of a wide range of materials. Using simulation, Heik is able to efficiently and simultaneously analyze the airflow and material properties of these devices.

Designing the inner finned tubes presents another unique challenge when developing heat exchangers. These tubes are used in heat exchangers to transform a hot fluid into a cold fluid or vice versa. The arrangement, diameter, material (stainless steel is required if using ammonia), and fin spacing of these finned tubes all depend on the type of heat exchanger in which they are being used. ''There is not a lot of measured data available on how these tubes work,'' said Heik. With simulation, he can get a better understanding of how finned tubes affect a heat exchanger design by modeling multiple tube geometries and investigating their inner and outer heat transfer capabilities. The finned tube geometries that offer the best performance are built and tested at an in-house experimental station. ''We look to see if the calculations and results are the same or similar, and then we take the best tube for our industrial line,'' said Heik.

## Cold Storage Room Simulations

In addition to performing simulations of heat exchanger technology, thermofin GmbH also simulates their customers' cold storage warehouses. For one specific project, a customer asked for help designing a meat storage room, which would include several robotic machines that hold the meat. In this storage room, meat enters at room temperature and needs to be cooled before it can be brought into a different cold storage room. ''It was important that the air velocity in the room wasn't too high so that the meat wouldn't fall off the robotic [machines], and on the other hand, it was really important that every area in the room gets the same or similar amount of air,'' said Heik

When performing cold storage simulations like this one, there are several criteria that need to be taken into account, including temperature distribution, airflow distribution, relative humidity, adjacent heat loads, and natural convection. At first, thermofin GmbH believed that their customer would need to use five heat exchangers in order to get an even amount of air distribution within the storage room.

After simulating a room with five devices, Heik noticed a problem. ''The backflow of the air would partly bypass into the intermediate ceiling,'' said Heik. To fix this issue, Heik

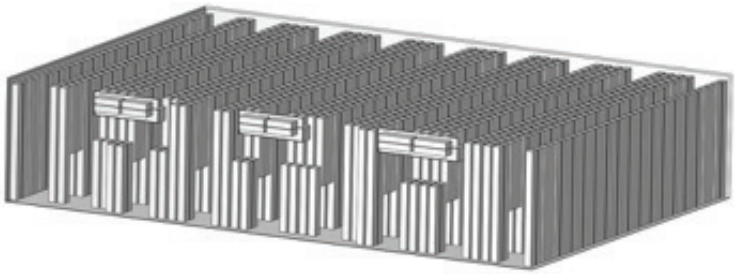


**Figure 3:** Geometry of a cold storage warehouse from another project, where air is distributed via the cold lake principle, in which cold air is introduced toward the floor, spreads out due to density differences there to rise at the other end of the room, and is drawn back in at roof height. The model takes into account the high stacking density of the storage racks with forklift passages.

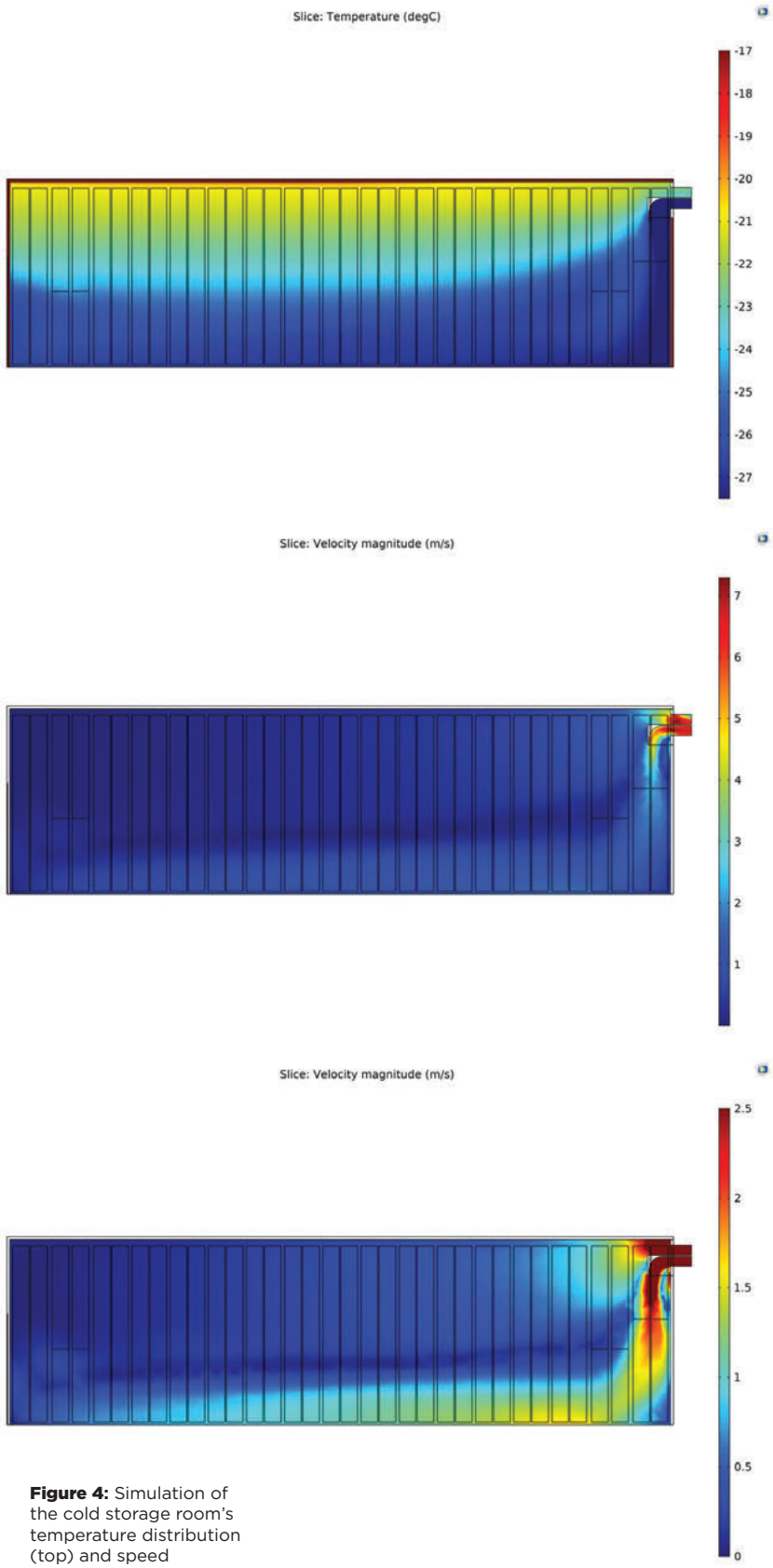



**Figure 4:** Simulation of the cold storage room's temperature distribution (top) and speed distribution of the airflow (middle and bottom).

simulated some air-guiding veins in the room, which would help ensure a smooth backflow, ultimately reducing the amount of vortexes in the room. Following the advice of thermofin GmbH, the customer ended up using five thermofin® units and built their storage room with air-guiding veins. According to Heik, the customer is happy with the results and has thankfully not experienced any occurrences of falling meat.

## The Future of Heat Exchanger Technology

"In our future research plans, we want to design [heat exchangers with a] new fin shape," said Heik. A change like this requires that the heat exchanger's tubes expand in diameter. To successfully implement this change, thermofin GmbH first needs to find the optimal way to space out these tubes. "For a new fin geometry, we would have to simulate it before we buy the tools to produce it ourselves," said Heik. A modification like this could help enhance the heat transfer capabilities of their heat exchanger designs.

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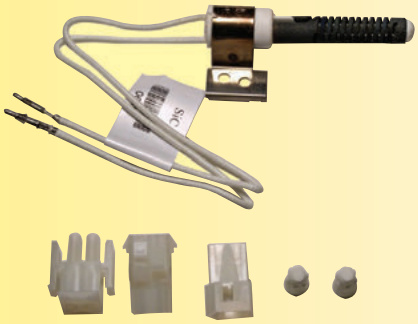
***2.*** *"Food Loss and Waste", United States Food and Drug Administration, 2020, https://www.fda.gov/food/consumers/food-loss-and-waste.*



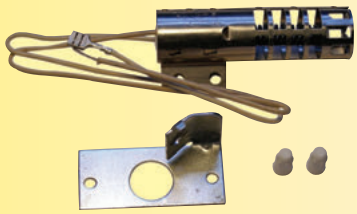
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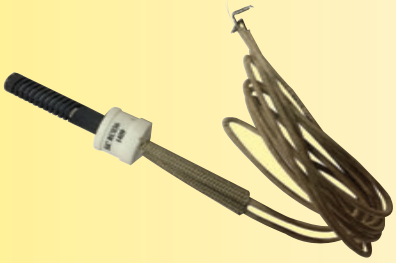


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# Q&A

*By Brad Glazer*


Chris Carrier

**Editor's Note:** We're big on anniversaries here at *Appliance & HVAC Report*. So on the occasion of **John Guest**'s 60th Editor and Publisher Brad Glazer sat down, virtually of course, with Chris Carrier their Director of Marketing for a Q&A. Here is the (lightly) edited transcript of their conversation.

**Q** I know this is an anniversary for **John Guest** as being in existence. Most of our readership is US based. How long have you been in the United States?

**A** **John Guest** has been in existence for 60 years. We were founded by **John Guest** himself. Currently we are traded on the Australian Stock Exchange, in case any of your readers are interested in investing. Maybe you are too Brad? Regarding John Guest's entry into the United States it was in the 1980s.

**Q** Who is your primary target audience?

**A** Primarily our target markets are OEM customers and that's especially so here in North America. In Europe including the UK there is a lot in the plumbing and heating areas too. But again, OEMs are our emphasis. So people that do water treatment systems, like filtration, reverse osmosis, water dispenser icemakers to name a few…in effect we are in many different vertical markets. We started doing a lot in hand sanitation with the onset of Covid-19. Agriculture and car washes are important industries for us too.

Even marine and RV. As part of RWC we have products such as SharkBite. But there are some differences in the products, as one uses primarily metal coils, the other high density plastic material. It's crucial to have both available to our customers.

**Q** How do you sell? Do you have a direct sales team, use independent reps, both?

**A** We have a direct sales team of 11 professionals. Most of our sales are through distributors but we do have some direct relationships with OEMs.

**Q** What is the strongest part of the **John Guest** brand

**A** I'd say the strongest is the easy one to answer. It's the brands itself. Remember its been around for sixty years, a long time. It's one of those brands that people trust. And

if you think about an OEM customer, you know, you're putting this component into your filtration system that you're going to sell out to the market or into your icemaker, or whatever that is, maybe your car wash, you don't want it to go down because then you can't say this brand is has a tremendous amount of trust. With **John Guest** the customers don't have any such worries. When we became part of the RWC family three years ago we weren't really participating in this OEM market. But as we learned about it, we were all really impressed by how much brand equity **John Guest** has, and how much people really think about it for quality. So I think the trust component of our relationship with OEMs… it really does live up to it's reputation.

**Q** Interesting Chris your last name is Carrier. And the name of our brand includes the acronym HVAC. And to add more of a coincidence to the mix, I was born and raised in Syracuse, NY which at one time was the home of Carrier Corp. And air conditioning was invented by Willis Carrier. Have you ever tried to find out if you are related? Do you work with Carrier too?

**A** No, I haven't traced that back. If we do sell to Carrier its probably a minimal amount and through our distributors. But yes, these connections while coincidental are interesting to say the least.

**Q** I know you exhibit at the AHR show in the US. Any others?

**A** Primarily two other shows besides AHR, one for the water treatment industry, the Water Quality Association Convention and Exposition and the other for the car wash market, The NAMA Show. So these are the three major events for us and hopefully they will be coming back stronger than ever. Time will tell.

**Q** We all are affected by COVID-19 of course. How has it effected your company? Are your people working remotely? How have sales been affected, if at all.

**A** Actually we did well during COVID, though its certainly not the way we want to get opportunities. We've seen quite a bit of growth in the last year. Of course there was a lot of uncertainty for us, as for everybody. But as we got further into it we saw opportunities for growth for various verticals from an OEM perspective. Health and Sanitation are two of them. As people started buying hand sanitizers and other soaps and such, that led to us getting requests to help in these areas. Of course we didn't anticipate these events.

**Q** If you can disclose strategic goals and objectives, what are your top ones for the next 5 years?

**A** That's a tough one to get into. We do have strategic goals of course, and a lot of it is centered on growth. So we are looking at where we are most successful and putting continued emphasis on these areas. Quality and Innovation are two of the major pillars of our growth and success and that is what we will continue to be all about.

**Q** Was there a person named **John Guest**? Tell us about him.

**A** Yes our founder was named **John Guest**. He was born in Doncaster, England in 1927. Guest started his working life as a toolmaker, but by 1950 he had developed his first prototype hollow pressure die-casting machine. Under the name of **John Guest** Engineering the newly established company specialized in tool making and precision engineering. It operated out of a small building that was known as Factory 1. The following year, **John Guest** Engineering merged with Guest Castings Ltd - a company specializing in zinc die-casting. This business also operated out of the Factory 1 site and its name remained unchanged until the early 1970s. During the 1960s both companies grew steadily specializing in simple die-cast products and tool making, consolidating their business in the white goods and automotive industries.

Renamed to **John Guest** Ltd in the early 1970s, Guest castings started producing more complex die-cast items and machining for the UK's major pneumatic valve manufacturers. The steady expansion enjoyed by the company was also the result of the investment in the second operation-machining department and painting facilities, including an automatic black elector-phonetic paint plant. In 1978 the company known today was formed, established specifically to market products designed and produced under the group name of **John Guest** Ltd.

**John Guest** Ltd. was recognized as a leading UK export manufacturer with two Queen's Awards for Export Achievement both in 1990 and 1995. **John Guest** died in 2010. He was 83.

**Q** When did RWC acquire **John Guest**?

**A** June, 2018

**Q** How big a component of RWC is John Guest?

**A** This was a very significant acquisition for **John Guest** , probably their biggest ever. I don't have the history of the past 5 years. This acquisition allowed the company to marry our SharkBite brand, which is primarily metal, with us, the leader in same for plastic. We think it's a great combination that is complimentary to each other.

**Q** Where is **John Guest**'s manufacturing done?

**A** Most of our manufacturing is done in the UK, though not all of it. We do have some done here in the US. As far as the bulk of the manufacturing being done outside of America it is then shipped to warehouses here in the US. From there we ship to customers.



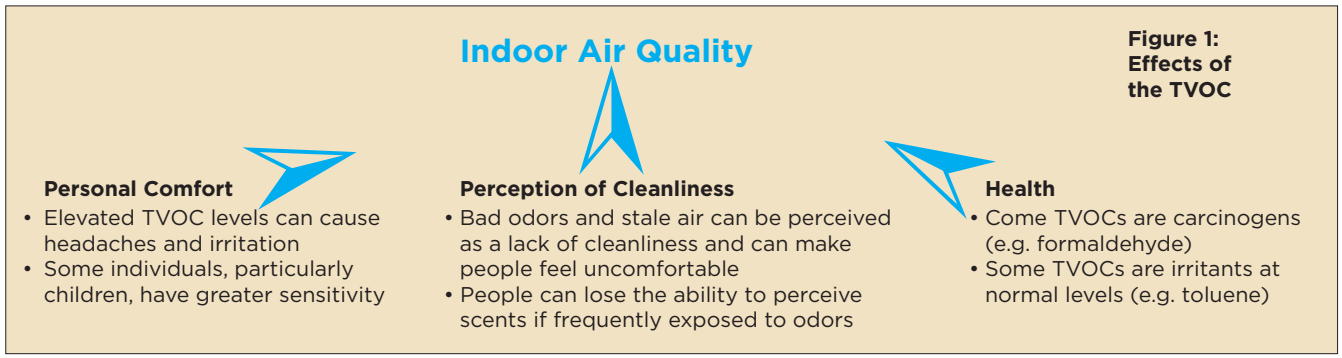



**Figure 1: Effects of the TVOC**

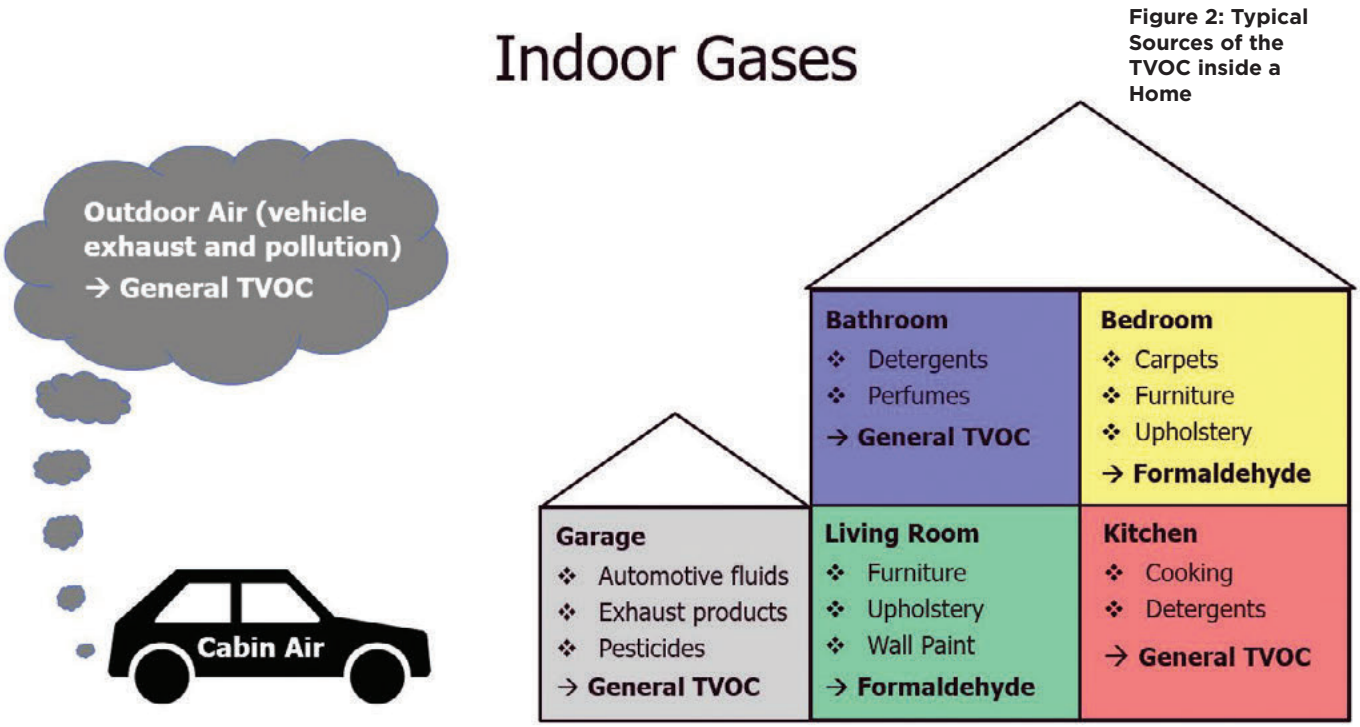



**Figure 2: Typical Sources of the TVOC inside a Home**

# Gases of Interest for Indoor Air Quality

**BY DR. CHRISTIAN MEYER**

## Definition of TVOC

There are different classifications of Total Volatile Organic Compounds (TVOC). Most commonly used is the World Health Organization (WHO) definition , which differentiates the volatility (or boiling point) of organic compounds to define Very Volatile Organic Compounds (VVOCs), Volatile Organic Compounds (VOC) and Semi-volatile Organic Compounds (SVOCs) as defined in Table 1. This usually involves the molecular length of the carbon structure; i.e., the number of carbon atoms in the chemical formula. The summation of all VOCs is called the Total Volatile Organic Compounds (TVOC). The volume of gas per classification and the sum of all gases (TVOC) are important reflections of the relevant organic compounds found in indoor air.

**Table 1: Classifications of Volatile Organic Compounds**

| Class | Name | Typical Number of Typical Boiling Point [°C] | Carbon Molecules | Example |
|---|---|---|---|---|
| VVOC | Very Volatile Organic Compound | < 0 to (50 – 100) | < C6 | Formaldehyde |
| VOC | Volatile Organic Compound | (50 – 100) to (240 – 260) | C6 to C16 | Benzene |
| SVOC | Semi Volatile Organic Compound | (240 – 260) to (380 – 400) | > C16 | Diisononyl phthalate |
| TVOC | Total Volatile Organic Compounds | Sum of all compounds listed above | | |

**Table 2: VOCs That Contribute to Poor Air Quality and Their Sources**

| Chemical TVOC Class | Chemical Examples | Source Examples |
|---|---|---|
| Alkanes | n-Butane, n-Pentane, n-Hexane, n-Heptane, n Octane, Cyclohexane | Aerosol spray products for some paints, cosmetics, automotive exhaust products, leather treatments, paint thinner, oil based paints, spot removers, aerosol/liquid insect pest products, mineral spirits, furniture polishes |
| Alkenes | Isobutylene, Ethylene | Solvents, fruit ripening, pest control, rubber production |
| Aromatics | BTEX (Benzene, Toluene, Ethylbenzene, Xylene), Dichlorobenzene, Naphthalene, Styrene | Tobacco smoke, moth balls, moth flakes, deodorizers, air fresheners, automotive exhaust products, paint thinner, oil based paints, aerosol/liquid insect pest products, mineral spirits, furniture polishes, rigid foam products, contact cement, model cement, tar board, plasticizer |
| Halocarbons | Methylene Chloride, PERC, TCE, 1,1,1-Trichloroethane, Carbon Tetrachloride, Dichlorodifluoromethane (R12), Difluoromethane (R32), Pentafluorethane (R125), R-410A | Dry cleaned clothes, spot removers, fabric/leather cleaners, degreasers, aerosol penetrating oils, brake cleaner, carburetor, cleaner, commercial solvents electronics cleaners, spray lubricants, refrigerant from air conditioners, freezers, refrigerators, dehumidifiers, urinal deodorizer block |
| Alcohols | Ethyl Alcohol (Ethanol), Methyl Alcohol (Methanol), 2-Propanol (Isopropyl Alcohol) | Cleaning agent, personal care products: nail polish, remover, colognes, perfumes, rubbing alcohol, hair spray |
| Terpene | α-Pinene (pine odor), D-Limonene (citrus odor) | Cosmetics, citrus (orange) oil, pine oil cleaners, fragrance additive, wood |
| Aldehyde | Formaldehyde, Hexanal | Disinfectants, upholstered furniture, carpets, plywood, pressed wood products, linoleum decomposition, oil-based paint |
| Ketones | Acetone, Methyl Ethyl Ketone (MEK), Methyl Isobutyl Ketone (MIBK) | PVC cement and primer, various adhesives, contact cement, model cement, UV processed varnishes |
| Ether | Methyl Tert-Butyl Ether (MTBE) | Automotive additive, medical solvent, plasticizer |
| Siloxane | Octamethylcyclotetrasiloxane (D4), Decamethylcyclopentasiloxane (D5) | Cosmetics, soaps, defoamer, silicone oil, , detergent antiperspirants |

## TVOC as an Indicator for Indoor Air Quality

Figure 1 shows some of the reasons for concern about the TVOC inside buildings. The TVOC is considered an important indicator for indoor hygiene and indoor air quality (IAQ). In addition to serious health concerns, there is the psychological aspect: homes, offices, and other environments that smell clean typically seem more welcoming than areas with foul odors caused by organic compounds.

### Common Volatile Organic Compounds in Indoor Spaces and their Sources

Volatile organic compounds are pervasive both outdoors and indoors. Depending on the interior decoration and usage, a room might be polluted with different organic compounds at the same time. Figure 2 shows typical sources of volatile organic compounds inside a home, and Table 2 gives potential examples and sources for the TVOC. Many volatile organic compounds have a chemical similar structure, which makes it difficult or sometimes impossible to distinguish between these in a VOC gas mixture. More information on detection of the TVOC can be found in Renesas' *Application Note – TVOC Sensing*.

### Implications of TVOC Exposure

There are significant health hazards associated with exposure to indoor air contaminants in residential and office spaces. The US Environmental Protection Agency (EPA) estimates that poor indoor air quality (IAQ) affects 33% to 50% of commercial buildings in the USA and is responsible for over 125 million lost school days and 10 million lost work days each year. Problems with indoor air quality, such as the so-called sick building syndrome, have significant health and financial impacts on the community. For example, recent studies have found that increased indoor pollutant concentrations and lower ventilation rates are associated with a statistically significant reduction in perceived mental performance among students and that controlling pollutant concentrations improved the measured performance of office workers . Reports also show that building and indoor air quality significantly affects the prevalence of respiratory disease, allergies, asthma symptoms, and poor worker performance. The financial impact of improvements in IAQ are estimated at 6 to 14 billion US dollars in savings from reduced respiratory disease, 2 to 4 billion in savings from reduced allergies and asthma, 15 to 38 billion in savings from reduced symptoms of sick building syndrome, and 20 to 200 billion in savings from improvements in productivity unrelated to health . The effect of indoor air quality on health is dramatic. It has been reported that the median level of the TVOC in office buildings might increase to 5 times greater than outdoor levels. Taking into consideration the greater amount of time most people spend indoors, indoor exposures are 10 to 50 times greater than outdoor exposures.

### Hazardous Condition Limits and Standards for TVOC

There are several sources of recommendations regarding the TVOC levels that are hazardous to human health. Table 3 presents a summary that compares levels from the varying sources for a range of chemicals. All levels are expressed in milligrams per cubic meter (mg/m3) with a usual exposure time of 8 hours daily, except where a different period is mentioned. Although the concentrations vary from agency to agency there is a general agreement to keep the TVOC concentrations to a minimum.

### US Environmental Protection Agency (EPA)[4]

Acute Exposure Guideline Levels (AEGLs) provided by the Environmental Protection Agency of the United States of America describe the human health effects from exposures to airborne chemicals. AEGLs, which are used by emergency responders when dealing with chemical spills or other catastrophic exposures, are set through a collaborative effort of the public and private sectors. AEGLs are classified into levels by the toxic effects caused by the exposure, with Level 1 being the least and Level 3 being the most severe, and these are divided into sublevels for the time of exposure. A Level 1 effect means a notable discomfort and irritation occurs but these effects are not disabling, are

**Table 3: TVOC Values Reported as "Actionable" by Different Agencies**

| CHEMICAL SUBSTANCE | EPA, USA (8 HOURS DAILY) | DFG, GERMANY (8 HOURS DAILY) | WHO (EXPOSURE TIME) |
|---|---|---|---|
| Benzene | 29 mg/m$^3$ | 0.2 mg/m$^3$ | No safe level |
| Formaldehyde | 1.12 mg/m$^3$ | 0.37 mg/m$^3$ | 0.1 mg/m$^3$ (30 min) |
| Napthalene | | 0.5 mg/m$^3$ | 0.01 mg/m$^3$ (1 year) |
| Styrene | 86 mg/m$^3$ | 86 mg/m$^3$ | 0.26 mg/m$^3$ (1week) |
| Trichloroethylene | 420 mg/m$^3$ | 33 mg/m$^3$ | 230 mg/m$^3$ (lifetime risk of 1/10.000) |
| Tetrachloroethylene | 241 mg/m$^3$ | 138 mg/m$^3$ | 0.25 mg/m$^3$ (1 year) |
| Toluene | 257 mg/m$^3$ | 190 mg/m$^3$ | 0.26 mg/m$^3$ (1 week) |

transient, and are reversible after exposure. Table 3 gives the AEGLs for a Level 1 exposure period of 8 hours.

### Commission for the Investigation of Health Hazards of Chemical Compounds (Germany)[5 6]

Maximum Workplace Concentrations (MAK and AGW values) are derived by the DFG Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, which is part of the German Research Foundation (DFG). The commission aims to determine the latest state of research related to health risks caused by materials and chemical substances in workplaces and to advise public authorities accordingly. MAK and AGW values for Time Weighted Average (TWA) are usually given for an 8-hour working day and are based on an average 40-hour working week. The values are published every year by the commission itself and are provided by other institutions; e.g., the statutory accident insurance.

**Table 4: Gases to be Evaluated for IAQ by The German Federal Environmental Agency**

| Chemical Substance | GV I | GV II |
|---|---|---|
| Aliphatic Hydrocarbons | 0.2 mg/m3 | 2 mg/m3 |
| Bicyclic Terpenes | 0.2 mg/m3 | 2 mg/m3 |
| Carbon Monoxide | 6 mg/m3 | 60 mg/m3 |
| Dichloromethane | 0.2 mg/m3 | 2 mg/m3 |
| Mercury | 0.035 Qg/m3 | 0.35 Qg/m3 |
| Naphthalene | 2 Qg/m3 | 20 Qg/m3 |
| Nitrogen Dioxide | – | 0.35 mg/m3 |
| Pentachlorophenol | 0.1 Qg/m3 | 1 Qg/m3 |
| Styrene | 0.03 mg/m3 | 0.3 mg/m3 |
| Toluene | 0.3 mg/m3 | 3 mg/m3 |
| Tris(2-Chloroethyl) Phosphate | 5 Qg/m3 | 50 Qg/m3 |

**Table 5: Parameters for IAQ as Reported by the IAQ Management Group in Hong Kong**

| | | 8-Hour Average | |
|---|---|---|---|
| Parameter | Unit | Good Class | Excellent Class |
| Room Temperature | °C | < 25.5 | 20 to < 25.5 |
| Relative Humidity | % | < 70 | 40 to < 70 |
| Air Movement | m/s | < 0.3 | < 0.2 |
| Carbon Dioxide (CO2) | ppm | < 1000 | < 800 |
| Carbon Monoxide (CO) | $Qg/m^3$ | < 10000 | < 2000 |
| Particulates (PM10) | $Qg/m^3$ | < 180 | < 20 |
| Nitrogen Dioxide (NO2) | $Qg/m^3$ | < 150 | < 40 |
| Ozone (O3) | $Qg/m^3$ | < 120 | < 50 |
| Formaldehyde (HCHO) | $Qg/m^3$ | < 100 | < 30 |
| Total Volatile Organic Compounds (TVOC) | $Qg/m^3$ | < 600 | < 200 |
| Radon (Rn) | $Bq/m^3$ | < 200 | < 150 |
| Airborne Bacteria | $cfu/m^3$ | < 1000 | < 500 |

### World Health Organization (WHO)[7 8]

The World Health Organization (WHO) presents guidelines for the protection of public health from risks due to a number of chemicals commonly present in indoor air. The substances under consideration have indoor sources; their hazardousness to health is known; and they are often found indoors in concentrations of health concern. The guidelines target public health professionals who are involved in preventing health risks due to environmental exposures, as well as specialists and authorities involved in the design and use of buildings, indoor materials, and products. They provide a scientific basis for legally enforceable standards.

### Study by the German Federal Environmental Agency[9]

The "Umweltbundesamt" (UBA) is the Federal Environmental Agency in Germany, which carried out investigations and studies on indoor air and the TVOC for several years. A study from the year 2007 became very well-known. It is a compendium of 48 other research papers and reports that seeks to understand and summarize the best knowledge on indoor air quality. In particular, the TVOC references for indoor air quality are useful because not only does it identify levels of potential hazards, but it also provides guidance on which actions are recommended based on these TVOC levels. This 5-step TVOC indication for IAQ is used by Renesas' gas sensor ZMOD4410 and is described in more detail in the "IAQ Classification" section.

IAQ itself is defined by 11 gases, of which 8 belong to the TVOC classification (see Table 4). The Guideline Values GV I describe concentrations below which no

**Table 6: Maximum VOC Levels for Compliance With The Good Class**
Per The IAQ Management Group

| Volatile Organic Compound | Good Class [Qg/m3] |
|---|---|
| Benzene | 16.1 |
| Carbon Tetrachloride | 103 |
| Chloroform | 163 |
| 1,2-Dichlorobenzene | 500 |
| 1,4-Dichlorobenzene | 200 |
| Ethylbenzene | 1447 |
| Tetrachloroethylene | 250 |
| Toluene | 1092 |
| Trichloroethylene | 770 |
| Xylene | 1447 |

**Table 7: Gases Evaluated for The WELL Building Standard**

| Chemical Substance | Limit for Passing Test |
|---|---|
| Formaldehyde | < 27 ppb |
| Total Volatile Organic Compounds | < 500 Q/m3 |
| Carbon Monoxide | < 9 ppm |
| PM2.5 | < 15 Q/m3 |
| PM10 | < 50 Q/m3 |
| Ozone | < 51 ppb |
| Radon | < 50.148 Bq/L |

adverse health effects are to be expected at life-long exposure. Guideline Values GV II concentrations are likely to present a threat to health, especially for sensitive people, when exceeded and immediate action should take place, e.g. restriction of the time spent in the room.

### Guide by the Indoor Air Quality Management Group of Hong Kong[10]

The document A Guide on Indoor Air Quality Certification Scheme for Offices and Public Places (the Guide) sets out the procedures for participating in the Indoor Air Quality Certification. It was published by the Indoor Air Quality Management Group of the Hong Kong Special Administrative Region Government. It gives details for a voluntary IAQ certification scheme with a differentiation into two classes (good and excellent) for offices and public places, such as theaters, cinemas, hotels, shopping malls, hotels, etc.

A competent examiner, such as a registered professional engineer or appointed public officer, will execute the certification scheme and conduct a walkthrough inspection, identify any IAQ problems, and conduct an IAQ measurement. This IAQ measurement consists of 12 parameters, which are recorded over a period of 8 hours and include 3 physical parameters; 8 chemical parameters and 1 biological parameter (see Table 5). As an alternative, the measurements of 10

**Table 8: IAQ Rating by Renesas**

| RENESAS IAQ RATING | REFERENCE LEVEL[12] | AIR INFORMATION | ACTION | TVOC (MG/M³)[13] | AIR QUALITY |
|---|---|---|---|---|---|
| ≤ 1.99 | Level 1 | Clean Hygienic Air (Target value) | No action required | < 0.3 | Very Good |
| 2.00 – 2.99 | Level 2 | Good Air Quality (If no threshold value is exceeded) | Ventilation recommended | 0.3 – 1.0 | Good |
| 3.00 – 3.99 | Level 3 | Noticeable Comfort Concerns (Not recommended for exposure > 12 months) | Ventilation required Identify sources | 1.0 – 3.0 | Medium |
| 4.00 – 4.99 | Level 4 | Significant Comfort Issues (Not recommended for exposure > 1 month) | Refresh air when possible. Increase ventilation. A search for sources is required | 3.0 – 10.0 | Poor |
| ≥ 5.00 | Level 5 | Unacceptable Conditions (Not recommended) | Use only if unavoidable and only for short periods | > 10.0 | Bad |

more commonly found individual volatile organic compounds can determine compliance with a Good Class TVOC objective (see Table 6).

The guide describes in detail the procedure for sample collection. After completion, if the environment is in compliance with the certification scheme, the certificate is issued and is valid for 12 months.

### WELL Building Standard[11]

The WELL Building Standard was first launched in 2014 with an addendum in 2017 by the International WELL Building Institute (IWBI), which is a public benefit corporation. It promotes health and well-being in buildings, focusing on the people's needs because of the increasing staff incapacities due to unsatisfactory working conditions. The IWBI also cooperates with the Green Business Certification Institute, which is a commonly used green building rating system, and certifies the LEED (Leadership in Energy and Environmental Design). The goal of the WELL Building Standard certification is to raise awareness of human health and comfort needs in the planning and design of buildings and in the development of best building practices. Parameters such as air, water, nourishment, light, fitness, comfort, and mind are measured by an assessor, rated, and classified in the categories "Applicable" and "Achieved." The result is a total score value in the range of 1 to 10, and it is listed in the WELL Scorecard for the individual parameters. Depending on the total score, IWBI grants a Silver, Gold, or Platinum Certificate, which in most cases is valid for 3 years.

To identify relevant air contaminants, the WELL Building Standard adopts the National Ambient Air Quality Standards (NAAQS) by the Environmental Protection Agency (EPA) and expands these requirements by taking additional standards, such as the World Health Organization (WHO), and best practices from industry, such as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), into consideration. Also, the LEED program sets standards for air filtration and building material selection to improve air quality. The parameter "Air" considers 29 criteria, such as air quality standards, smoking prohibition, ventilation effectiveness, VOC reduction, air filtration, and others. The Air Quality Standards criteria itself gives detailed information regarding single gases (see Table 7).

### IAQ Classification

The TVOC covers a large range of different organic gases that may be chemically similar and difficult to distinguish. Therefore, a single gas is not representative for an IAQ rating. Hence, Renesas has investigated different TVOC and IAQ standards as discussed above. To cover a wide range of standards and gases, two internationally well accepted TVOC representatives were used: a combination of the Environmental Protection Agency (see the "US Environmental Protection Agency (EPA) " section) standards and the volatile organic components of the study by the German Federal Environmental Agency (UBA; see the "Study by the German Federal Environmental Agency " section).

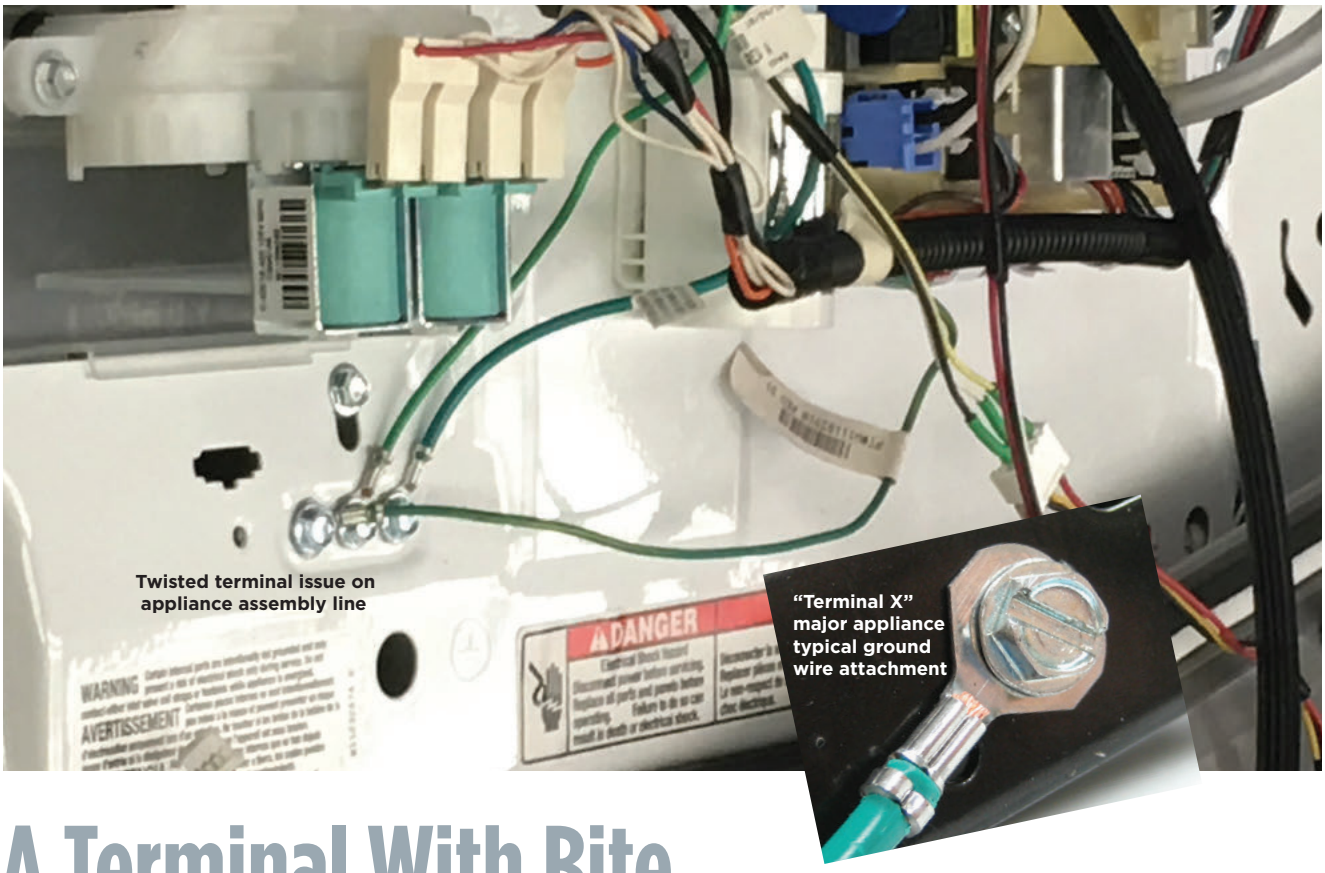
The TVOC representative mixture EPA TO-15/17 Calibration Mix by the Environmental Protection Agency consists of 25 individual volatile organic compounds and complies with all US EPA and state-mandated methods. The VOC representative mixture of the UBA study gives the 8 listed volatile organic compound gases (see Table 4). Tested with both blends, Renesas' gas sensors were tested with the most relevant volatile organic compounds in a large concentration range.

As a result, the UBA levels for the TVOC are applied as a reference for all of Renesas' IAQ ratings (see Table 8). Integrating a gas sensor in home applications not only provides information about the current TVOC level to an end-user, but also allows the user to determine which actions should be taken and over what time period. Given the UBA levels as a reference, for an end-user who has conditions with temporarily elevated TVOC levels (cooking, cleaning, painting, new carpet), gas sensing helps to reduce concerns about air quality and to monitor the levels as they decrease over time. ●



***Dr. Christian Meyer*** *is a Product Marketing Manager at Renesas. His past roles in the last 15 years included responsibilities in analyzing different gas technologies, as well as sensor development. His background is in Applied Physics and Engineering for Atmospheric Measurements.*

***For more information*** on TVOC detection in general and Renesas' gas sensors, the Application Note – TVOC Sensing is recommended.
A certificate by the research institute KSI for an independent investigation of Renesas gas sensors confirms their functionality, and it is available on the Renesas website at ***https://www.renesas.com/us/en/products/sensor-products/environmental-sensors.***



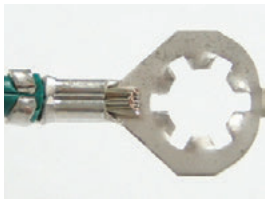

# A Terminal With Bite

**BY EDWARD JACQUES**

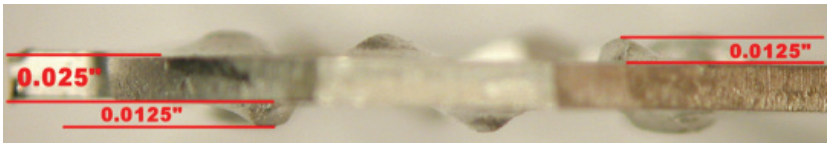
## Introduction

This report will detail the efforts, processes and results of ETCO's Engineering, Research and Development Team's endeavor to resolve a known wire harness issue of the appliance industry. The R&D team had become informed of problems where the locking ring terminals on ground wire attachments of appliances were frequently twisting during the assembly process or became loose in the field while being used by the consumer. When a locking ring terminal slips, twists or fails to lock in position during assembly on the production floor, time is squandered especially if the screw needs to be removed and re-fastened. Then there is the potential of damage to the harness or the possibility

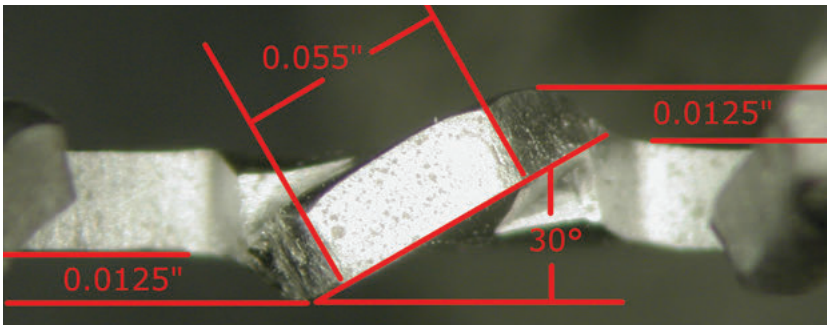

**TERMINAL X terminal, ISO view**


**TERMINAL X crimped, top view**


**TERMINAL X crimped, bottom view**



**TERMINAL X side view from outside showing metal thickness and tang heights**



**TERMINAL X close-up view of tang with dimensions labeled**



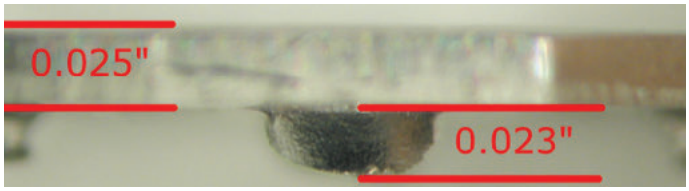
59332 terminal, ISO view



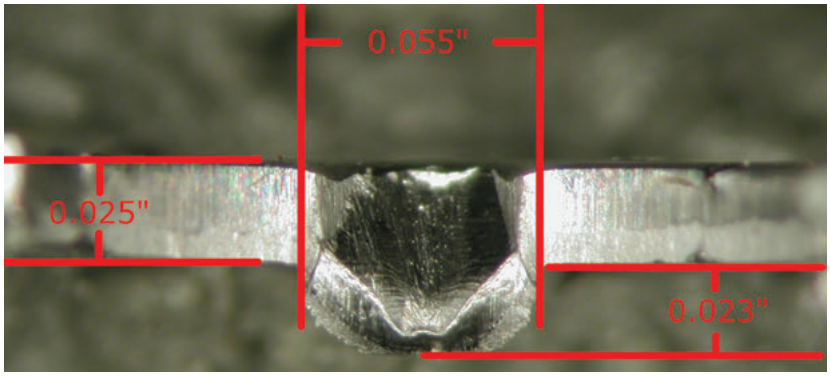
59332 crimped, top view



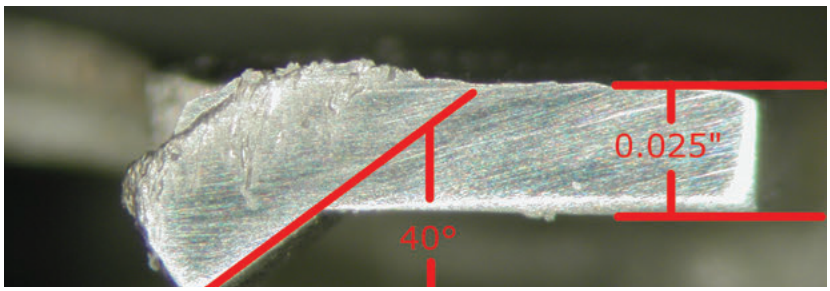
59332 crimped, bottom view




59332 side view from outside showing metal thickness and tang heights




59332 close-up view of tang with dimensions labeled




59332 close-up side view cross-section of tang with dimensions labeled

of arcing and electrical shorts with adjacent terminals. A robust connection is absolutely critical not only to production efficiency but the integrity of the circuit. Once secure it is imperative that the terminal remain mechanically tight throughout the appliance's life cycle with all the vibrations it may encounter.

Our team set out to analyze and test locking ring terminals used for locking ground connections on appliances. The project's hope was to develop and ultimately offer an improved terminal with features and characteristics giving it the ability to meet the industry's performance requirements.

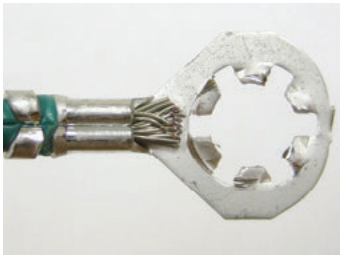
To start, the team procured an assortment of OEM wire harnesses used on various, current models of major kitchen appliances. These harnesses were examined for their ground wire terminal types and attaching methods. It was determined that manufacturers predominately use a 6 fluted / tanged, tin plated brass locking ring terminal for the ground wire connections on their appliances. Based on its common usage, a terminal of this design and material was chosen for base line assessment in this experiment. For this report and evaluation this commonly used terminal will be identified as Terminal X . It will be compared with a terminal incorporating a different locking feature design, ETCO's Locking Ring terminal # 52339. All terminals were measured, photographed and subjected to several test procedures including, cross sections of terminal assembly's surface penetration, corrosion/salt fog chamber exposure and electrical testing.

## Salt Fog Corrosion Testing

The "salt fog" testing was conducted as per ASTM B117 specifications, using procedures developed at our R&D team. Our "salt fog" chamber is prepared to ASTM B117 standard requirements prior to sample distribution. The chamber is cleaned and rinsed. Our water treatment system provides 55 gallons of de-ionized and filtered water to a solution tank where salt is added to attain 6% on a salometer. The "bubble tower" conditions compressed air at 15 PSI through water provided by the filters and



ETCO Atlas SF500 corrosive fog/ humidity cabinet



TERMINAL X pre-test, top view



TERMINAL X pre-test, locking ring close-up



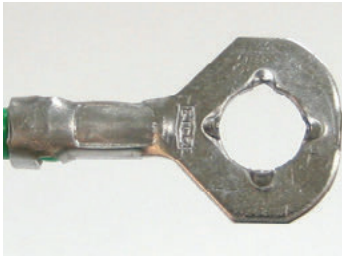
TERMINAL X after 384 hours, top view



TERMINAL X after 384 hours, locking ring close-up



59332 pre-test, top view



59332 pre-test, bottom view



59332 after 384 hours, top view

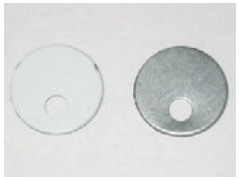


59332 after 384 hours, bottom view

heated to 48°C before sending it to the specimen chamber. The solution is contained in a reservoir at the bottom of the specimen chamber where the compressed air from the "bubble tower" is utilized in atomizing it into a mist, which creates a salt fog atmosphere in the 34°C heated specimen chamber. The mist generated fills the specimen chamber and covers the test specimens. Results of an ASTM B117 test cannot be correlated to any earthly timed event and it's a process used strictly as a comparative corrosion test where a standardized environment is applied to specimens.

Terminals were prepared by crimping to 4 inch sections of 16 AWG wire, then fastening to ground points found on "Brand X" appliances with the same screws that are being used in their ring terminal ground connections. After securing the terminal to a ground point connection, the terminals were removed, and placed inside the salt fog chamber for corrosion testing. This additional procedure is meant to simulate real world attachment scenarios involving these terminals. As a result of the attachment and detachment process, the terminals showed score marks and other signs of mechanical manipulation.

After 384 hours of salt fog exposure both terminal types faired very well. No evidence of corrosion on either terminal type.



Enameled steel (left) and galvanized steel (right) testing discs



Ground screws used in securing terminals for testing



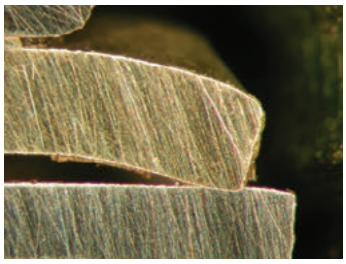
Torque screwdriver used to secure terminals and readout of torque screwdriver showing 7 inch-pounds securing force



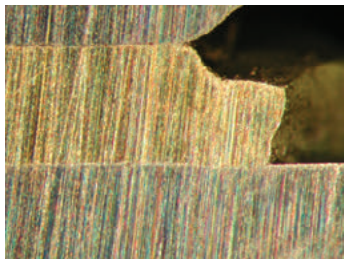

## Surface Penetration

The Team observed there were two different surface types utilized in ground wire connections on standard appliances those being enameled steel and galvanized steel. Samples were prepared from actual OEM appliance parts of each material / surface type, Specimen discs measuring

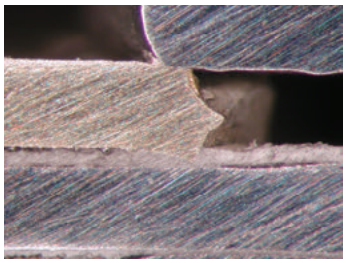
3/4'' in diameter were cut from appliance panels. These discs were then punched with a 3/16'' hole to accomodate a terminal and ground screw assembly. After cleaning, discs were secured with terminals and ground screws creating an assembly for testing retention to surface. The goal of this experiment was to gauge the effectiveness of locking ring terminal's penetration features that could improve it's ability to withstanding dislodging forces. A torque screwdriver was used to secure the terminals to the discs to standardize the process. Once assembled cross-sections of the specimens were processed to allow a magnified look and analayis of each samples tang penetration into the disc's surface.



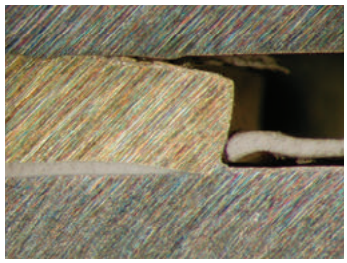
**TERMINAL X on galvanized steel, 7 inch pounds of tightening force**



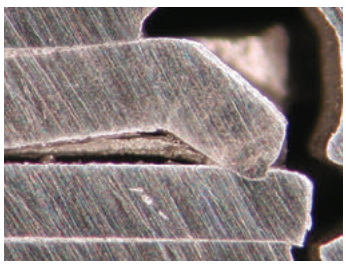
**TERMINAL X on galvanized steel, 26 inch pounds of tightening force**



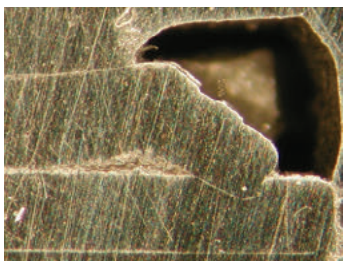
**TERMINAL X on enameled steel, 7 inch pounds of tightening force**



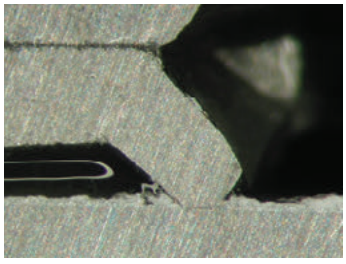
**TERMINAL X on enameled steel, 26 inch pounds of tightening force**



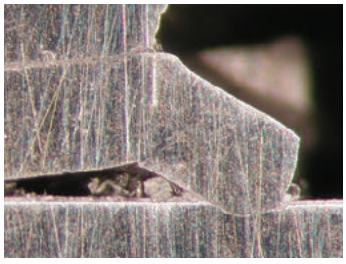
**59332 on galvanized steel, 7 inch pounds of tightening force**



**59332 on galvanized steel, 26 inch pounds of tightening force**



**59332 on enameled steel, 7 inch pounds of tightening force**



**59332 on enameled steel, 26 inch pounds of tightening force**

## Surface Penetration Cross-Sections

A review of the assembly cross-sections clearly showed the 59332 Stainless Steel terminal with deeper penetration than the Tinned Brass Terminal X into both types of surface materials, Enamel Coated Steel and Galvanized Steel, at both torque settings. It could be that the 59332's harder material and sharper (40º) edge gave it the ability to plow deeper into the disc utilizing the same torque settings as Terminal X.

## Electrical Testing and Results

Terminals were secured to enameled surfaced discs cut from actual appliance framing to measure effectiveness of the connection. Isolating every variable and measuring directly across the energized terminal connection to the mated surface.

**FIGURE 1:**
**Test Assembly**

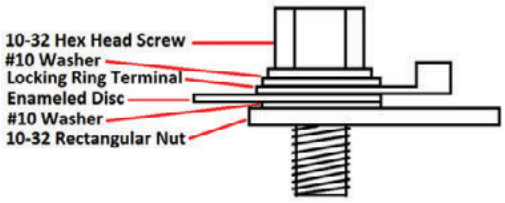
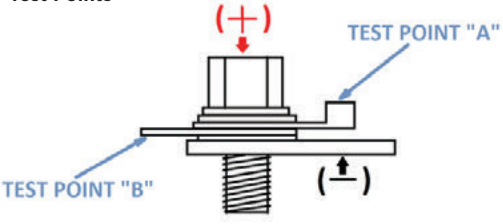



**FIGURE 2:**
**Electrical Lead Locations and Test Points**



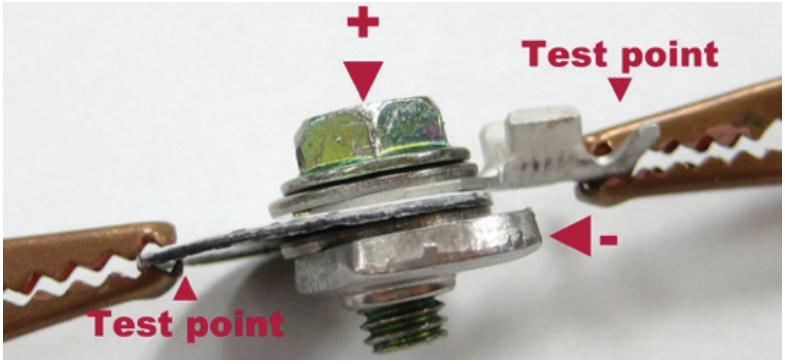
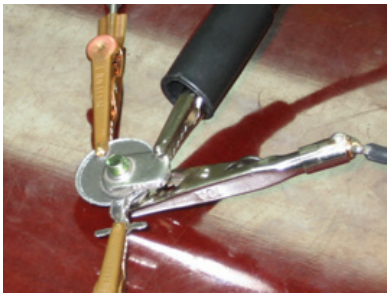


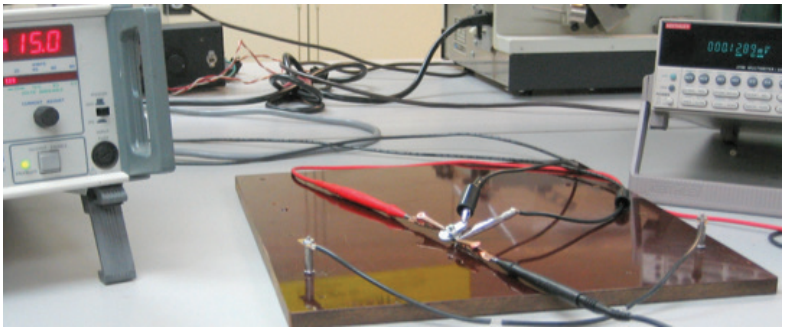

**Photo of Test Assembly**



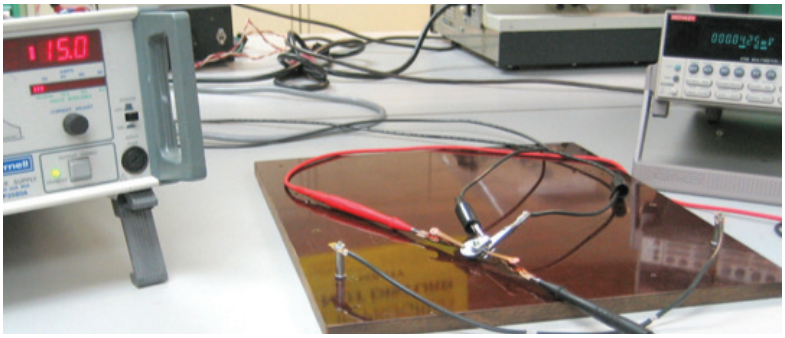
**59332 experiment setup**



**TERMINAL X experiment setup**



**TERMINAL X showing 0.1289 mV dropped across the terminal connection**



**59332 showing 0.0425 mV dropped across the terminal connection**

## Measurements

Results of this experiment showed the TERMINAL X was dropping more than 3x (three times) as much voltage across the connection as the ETCO 59332 at 15 amperes of current. An increase in voltage measured is indication of higher resistance or a less secure connection. All terminals were secured at 26 in/lbs. of torque to the mated surfaces to insure uniformity. This test was a direct comparison of terminal mating features between the 59332 and the TERMINAL X.

| ETCO 59332 | TERMINAL X |
|---|---|
| @ 15 amp current | @ 15 amp current |
| 0.0425 mV | 0.1289 mV |

## Observations and Conclusions

1) All locking ring terminal types surpassed UL expectations for retention to wire by more than doubling UL's minimum requirement forces.

2) Evidence of tang penetration illustrated in the cross sections clearly showed the 59332 SS terminal as best in class.

3) Salt fog testing showed both the TERMINAL X and the 59223-SS with salt buildup and no visible corrosion after 384 hours of exposure. Both impressive.

4) Electrical Testing. Although minuscule at less than 9/100's of a volt, the 59332 yielded a lower measured voltage loss over its energized assembly than the TERMINAL X did with its assembly.



***Edward Jacques*** *is the Director of Research & Development at ETCO Incorporated. His work centers on researching industry practices and making improvements to existing electrical connections along with the design and development of new electric terminals. With over 50 years in the in the electric terminal business, his efforts have resulted in many patents in the appliance and automotive industries including several white papers. He is a longtime member of the Society of Automotive Engineers (SAE), and has sponsored Standard Documents as part of SAE's Ignition Standards Committee.*

*Much credit should be given to* ***Scott Wasik*** *for his work on this project excelling in the lab as ETCO's Lab Tech.*

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**Redwood Services** a home services firm focused on investing in leading residential HVAC, plumbing and electrical services companies in growing U.S. markets, announced today that John Conway, a recognized leader in the industry, has joined Redwood as its Chief Operating Officer to help guide and direct Redwood's strategy of identifying, acquiring and growing partner companies.

Mr. Conway was most recently a part of the member-owned Nexstar Network, one of the industry's most successful best-practices-sharing groups, where he spent the past six years as a recognized HVAC coach and resource. At Nexstar, John dedicated his time to coaching the best HVAC service providers across the country while developing a network of HVAC owners and operators who are committed to providing efficient, customer-focused service to their customers in their respective markets.



**Coto Technology** has produced and posted a new Quick Reference Guide for its complete line of RedRock® TMR Magnetic Sensor products. To aid in product selection, the guide lists the essential specifications of nearly 40 RedRock® part numbers. Additionally, the guide offers quick reference information on where, why and how the products are used within typical applications. The guide also provides valuable insight into end product requirements, as well as the ways in which TMR technology addresses common application issues and resolves problems that other technologies do not.

Specific part number recommendations are provided as a starting point for device designs. For in-depth product information, detailed datasheets for all RedRock® TMR magnetic sensor products are available for download on Coto's website.



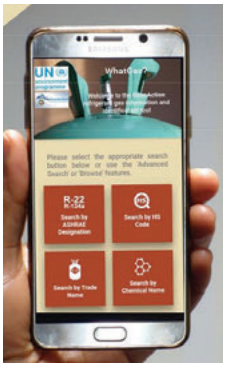
**John Guest**, part of the **RWC** family of brands, turns 60 in 2021, celebrating a long history of delivering advanced plumbing technology, quality products and innovative solutions to a diverse range of industries. Over the years, John Guest's push-fit plumbing products have paved the way for better drink dispense, water filtration, air and pneumatics, telecoms, automotive and OEM solutions.

''With more than 1 billion fittings installed and in use worldwide, John Guest is a leader in the plastic push-to-connect category,'' said Ted Antony, fluid tech marketing specialist at RWC. ''OEMs choose us because we're known for providing reliable products, offering strong process controls, meticulous testing and adherence to required approvals.''




**Honeywell** announced that global natural and organic foods retailer **Whole Foods Market** has adopted its Solstice® N40 (R-448A) lower global-warming-potential (GWP) refrigerant in its stores across the United States as it seeks to reduce refrigerant emissions under the U.S. Environmental Protection Agency's GreenChill program.

Whole Foods Market will retrofit their commercial refrigeration systems at more than 100 stores with Honeywell's reduced-GWP alternative, replacing high-global-warming-potential refrigerants R-404A and R-22.



**The WhatGas? UN Environment Program OzonAction application** is an information and identification tool for refrigerant gases: ozone depleting substances (ODS), hydrofluorocarbons and other alternatives. It is intended to provide stakeholders, including Montreal Protocol National Ozone Officers, customs officers, and refrigeration and air conditioning technicians with a user-friendly tool that can be accessed via mobile devices or the OzonAction website. The app facilitates work in the field, when dealing with or inspecting ODS and alternatives, and as a useful reference tool. If the user requires additional information or assistance in identifying a refrigerant gas under inspection or described in relevant paperwork, the app can be consulted for the requisite data.

The WhatGas? app, available in English, French and Spanish, provides a wealth of useful information about refrigerants through a variety of search methods. By entering partial information or browsing the database, the application provides quick reference information on many aspects of the chemical in question, including the chemical name and formula, type of chemical, common trade names, various chemical and commodity identifiers, flammability and other hazards, and ozone depleting and global warming potentials.




**Reliance Worldwide Corporation** has been honored with a **Metro Atlanta Top Workplaces 2021 Award** by *The Atlanta Journal-Constitution*. This was the company's first time applying for a spot on the Top Workplaces list, which is solely based on employee feedback gathered through a third-party survey, and is the first time the company is being honored.

The anonymous survey uniquely measures 15 culture drivers critical to the success of any organization, including alignment, execution and connection. RWC received top scores in three areas: execution, open-mindedness and innovation.

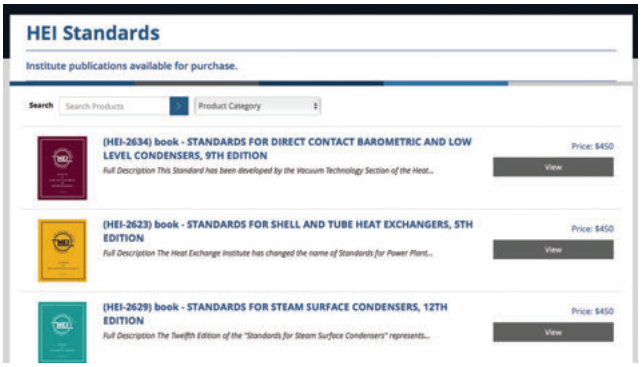


**Script to Screen**, a performance-driven marketing agency with 30 years of experience as the market leader assisting some of the most well-known products and brands, such as Amazon, SharkNinja, Keurig, and Nutrisystem, in building and optimizing their direct-to-consumer channel, has launched several spots of varied lengths for **Cleva's new Kenmore Intuition**, an upright vacuum with a patented allergen seal bag and no-touch, push and release dirt-and dust-free disposal.

Cleva engaged Script to Screen due to their creative storytelling approach and track record of incomparable performance in the category. The new ads demonstrate the powerful suction and triple filtration technology that pulls dirt into the allergen seal bag. Cleva is successfully running both Full Break three-minute and Long-Form infomercial length versions. M2 Management and Marketing Services is overseeing and providing analytics for the television campaign rollout.

The commercials highlight the exclusive powerful technology of the vacuum that pulls dirt and dust quickly and without mess into the vacuum. They demonstrate the ease at which users dispose of the full bags without ever having to get their hands dirty or being exposed to any dust plumes.

The new ads feature happy Kenmore Intuition users touting the benefits of the vacuum including its power and lightness. They also demonstrate the ease at which the bag jettisons from the body of the vacuum when it's time to dispose of the debris. The ads also feature the model's HEPA filtration action and the fact that the vacuum allows for everything inside the disposal bag to stay inside until it's time to be tossed away.




**The Heat Exchange Institute** offers the sale of all nine HEI standards on their own updated (2020) website. Each standard is available for purchase at https://www.heatexchange.org/products/hei-standards.

No login or membership is required to purchase materials. Users from anywhere in the world can simply add the desired standard(s) to the cart and purchase securely and conveniently by credit card. Materials will be shipped in 1 to 2 business days via UPS ground or UPS worldwide.

HEI tech sheets are also available on the site for download at no charge.

HEI, a trade association committed to the technical advancement, promotion, and understanding of a broad range of utility and industrial-scale heat exchange and vacuum apparatus, produces nine standards in all. Each standard is reaffirmed or revised on a five-year cycle.

Heat Exchange Institute spokesperson Craig Addington said, "HEI standards are used throughout the world. We are pleased to offer our members and customers a quick and easy way to obtain the standards they need directly from HEI on our own website. On the home page, simply click Standards to access the list, descriptions, and pricing."

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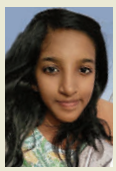
# Congratulations to Our 2021 Mercury Plastics Scholarship Recipients!


Abram Brown


Sarah Conard


Eric Richards-Diaz


Erica Ferguson


Natasha Ninan


Megan Stanfield


Dennis Williams

**Mercury Plastics LLC**, a manufacturing company based in Middlefield, Ohio, recently awarded eight *University of Akron* engineering students scholarships totaling $17,000. Mercury Plastics is a supporter of the College's diversity and inclusion efforts.

**Abram Brown**, mechanical engineering major

"During my freshman year, I was an active participant in the Emerging Leaders Program and had the opportunity to help not only at school events, but also in Akron at places like ACCESS, a homeless shelter for women and children.

Because I live in Washington D.C., my need for financial assistance is high since I travel so far to go to school. With a scholarship, I will be able to continue my education in Akron and take advantage of opportunities such as the co-op program, where I can get experience while earning my degree, making me more competitive when I graduate."

**Sarah Conard**, mechanical engineering major

"My background and dedication sets me apart from my peers. I went from being a Russian orphan to coming to America with my adoptive parents, struggling in school, to eventually succeeding as an engineering student. I have a perspective that many others may not be able to provide. I worked hard to get where I am today.

Receiving this scholarship will help me continue my education and to focus on my studies rather than having the stress of more loans and working constantly. I have five siblings and my parents cannot afford to pay my college expenses because they are supporting my brothers and sisters. I have always worked hard for what I wanted and school was no different. I am investing in my future."

**Eric Richards-Diaz**, mechanical engineering major

"Although I am close to completing my third semester of college, I am still unsure of exactly where I would like to work but I plan to have a co-op to find the right fit. I would like to work for a larger company and preferably something that relates to the automotive field. I have always had an interest in cars and trucks.

I am motivated to be the first person in my family to attend college. I have help from my parents when it comes to food and books, but I work and pay my tuition and housing. Receiving a scholarship means that all my hard work is being recognized."

**Erica Ferguson**, mechanical engineering major

"People have nicknamed me 'smiley' my entire life. It does not take long for teachers, coaches, bosses, and friends to notice my positivity. Team members have relied on me to keep them optimistic and motivated.

My involvement in The University of Akron's Institute for Leadership Advancement and the Engineering Service Design Team has given me outstanding leadership, teamwork, and interpersonal skills that are unmatched by anything learned in the classroom. I am excited to be a part of an endless, growing field, so I can let my curiosity roam free, while making people's lives better as their coworker or their engineer.

When I graduate, I want to be a consulting engineer in the HVAC industry. I cannot imagine how rewarding it would be to look up at a building that I helped design. The architects design the layout and make it aesthetically pleasing, but the engineers breathe life into it."

**Keji Laki**, mechanical engineering major

"My love for mechanical engineering started during my freshman year of high school in a class called Tech Action Lab which granted me full exposure to the scope, rigor, and discipline of engineering. Through the course, I researched new bridge concepts and designed prototypes. Then I took classes in robotics and civil engineering and learned how to conduct research and build robots designed to accomplish specific tasks.

I plan to help my native country with what I learn here in Akron, and to also bring in diversity and culture to wherever my education takes me. I hope to bring in my ideas as not only a woman but as a woman of color into STEM programs. My contributions will stimulate new ideas. We are not only learning from each other but growing as a society to help future generations."

**Natasha Ninan**, mechanical engineering major

"Growing up in India and Dubai has given me a very unique and broad worldview. From an academic perspective, having been schooled in an Asian curriculum which tends to have a very rigorous STEM focused course load with advanced mathematics, has given me the ability to cope with high pressure academics. I believe this gives me an edge.

While graduation is a long way ahead, I would like to get involved with asteroid mining as well as the NASA New Frontiers Program called 16 Psyche. This is the asteroid that was discovered recently and was found to contain metals worth more than the global economy."

**Megan Stanfield**, mechanical engineering major

"I am passionate about keeping up with innovation to help people, animals, and the environment. I am driven to work towards solutions for climate change and pollution to better the environment and the quality of life. I chose mechanical engineering with the co-op program in order to gain valuable hands-on experience, as well as to have a broad education in the engineering field.

This semester I created and currently lead the education team as a member of Engineers for a Sustainable World. We are creating K-12 presentations to replace field trips that have been cancelled due to COVID-19. We will also be hosting events to educate the UA community about sustainability and the environment."

**Dennis Williams**, mechanical engineering major

"I have a passion for helping, supporting, and mentoring not only my peers but the younger generation. I make myself available for others so they can obtain the help and support they desire to keep moving forward. I have years of experience in leadership roles of various student organizations and programs which has helped mold my character of integrity, honesty, excellency, and leadership. Pursuing my induction status in the National Society of Leadership and Success, I found my purpose of seeking to help students academically and professionally. Mentoring students and youth means a safer and more unified tomorrow!

After graduation, I want to start my career in construction management so I can be responsible for a team that delivers quality results in a safe, timely, and beneficial manner to the customer."



**ETCO Incorporated** has introduced a line of battery terminals, ignition terminals, and various other connector types that are manufactured in the USA and offered as a single SKU for OEMs to simplify purchasing and inspection.

**ETCO Standby and Portable Generator Terminal Products** include top post battery terminals which are lead-free and RoHS compliant, locking ring terminals and serrated rings, ignition and spark plug terminals with high retention clips, and insulated terminals. American made to eliminate supply chain woes, they can be packaged and delivered as a single SKU.

Supplied loose or in strip form for automated processing equipment, most ETCO Standby and Portable Generator Terminal Products have an F-Crimp for a more secure connection than conventional rollover style flag ears and permit faster automated wire processing speeds with less fracturing, better wire deformation and a more distinct bellmouth. ETCO has 74 years of experience.

ETCO Standby and Portable Generator Terminal Products conform to critical specifications: ISO 9001:2015, IATF 16949:2016, ISO/TS 1649:2002, and more.



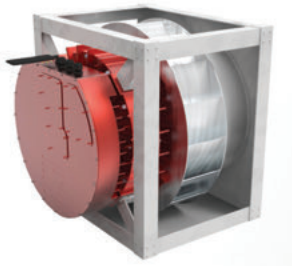
**Littelfuse, Inc.**, an industrial technology manufacturing company empowering a sustainable, connected, and safer world, recently launched a new building automation microsite, **Littelfuse.com/Building-Automation**. Developed to simplify the product selection process, this microsite makes it easier for customers to find technical information and specifications on solutions for their building automation system.

"Building automation systems are at the heart of a smart building, encompassing everything from security cameras to HVAC systems," said Debra Jayson, Senior Marketing Manager, Littelfuse Industrial Business Unit. "Our new microsite helps customers quickly access resources to help design a safer, more convenient and energy-efficient infrastructure."

The Littelfuse.com/Building-Automation site includes:

- Product information, data sheets and technical specifications
- Building Automation Application Guide
- Customer success story
- System applications overview



**Infinitum Electric's IEs Series** product line is now available in the 5-15 horsepower (HP) range. By broadening the range of power beyond 7.5 and 10 HP, Infinitum Electric is delivering the market's most comprehensive line of electric motors with class-leading efficiency and IoT capabilities in a package that is 50 percent lighter, smaller and significantly quieter than conventional motors.

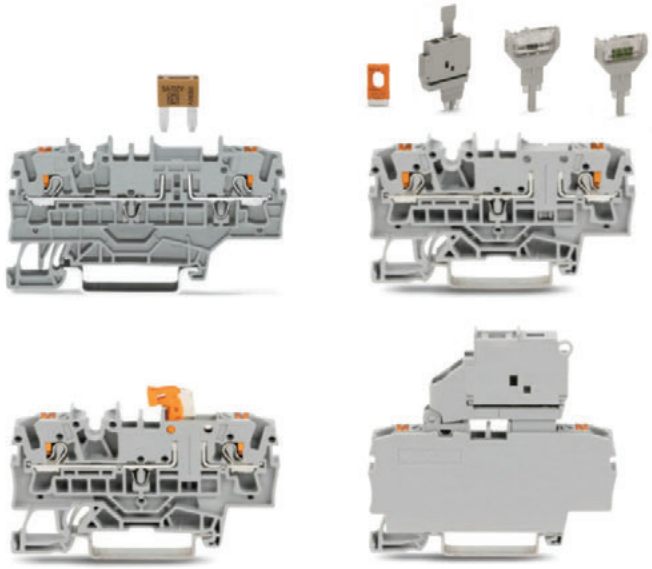
The IEs Series offers a fully integrated system: motor, variable frequency drive (VFD) and embedded IoT in a single compact package. Customers currently using Infinitum Electric's debut model, the IEs205, with plans to take advantage of the expanded power range include Comefri USA, Twin City Fan and Acme Fan.



**Solenoid Solutions'** high-performance **Wattimizer series solenoid valves** are now available with a plastic body ideal for air, gas, and corrosive media. For many applications, plastic valve bodies offer significant value over metal-based bodies as they're lightweight, corrosion resistant, offer a lower profile and use convenient push-to-connect fittings... all at a lower cost. These plastic bodies are CUL recognized..

The plastic valve body is approximately 1-inch diameter, comes with integral 1/4-inch OD tube "push-to-connect" port fittings and has a maximum pressure rating of 125 psig at room temperature. Plastic bodies and manifolds are designed for medical, beverage, appliance, fluid power, automotive, gas, and more; and can be used in direct acting and pilot applications.

The Wattmizer is a highly efficient, miniature electric 12v solenoid valve designed for use in compact areas requiring low power draw. These 2-way and 3-way solenoid valves are offered in a range of .65 to 9 watts of continuous power, with operating pressure capacities of up to 1200 psi (85 bar) with machined metal bodies. Note, plastic valve bodies are limited to low pressure applications up to 125 psi.



**WAGO** added a complete line of function terminal blocks to its **TOPJOB® S push-button terminal block family.** This expansion includes automotive and pivoting fuse holders, blade disconnects and base carrier terminal blocks for pluggable modules.

All variants feature industry-proven Push-In CAGE CLAMP® connection technology and the intuitive, easy-to-identify, orange push-button, which can be actuated using a standard tool. Using the same profile as other terminal blocks in the TOPJOB® S family, accessories such as jumpers and universal marking strips may be interchanged throughout the entire line.

These new Function Terminal Blocks come in four basic styles and in 2, 3 and 4 conductor variants:

1. Mini automotive blade fuses or mini-circuit breakers (multiple LED blown fuse indication options).
2. Pivot-style glass fuse holder (5 x 20 mm mini metric fuses)
3. Blade disconnect
4. Base carrier style for pluggable glass fuse holders, orange disconnect plugs or electronic component modules (offering various plugs, including custom and empty, allowing users to design their own)

''Function terminal blocks add tremendous value with their ability to protect circuits, support troubleshooting and integrate electronic components - diodes, resistors and more.




**The Industrial Gas Filtration and Generation Division of Parker Hannifin Corporation**, the global leader in motion and control technologies, announced a portable system that uses advanced filtration and irradiation technology to purify the air for indoor spaces. The combination of ultraviolet energy and True-HEPA filtration captures, irradiates, and filters bacteria, dust, mold spores, odors, and virus particles as small as 0.3 microns which is about 250 times smaller than a human hair.

**CRYSTAL-AIRE®UV** is a mobile, wall, or ceiling mount system that includes up to four stages of air purification. In the first stage, large particles are filtered out of the airstream by the MERV 8 pre-filter. The air then passes into a second stage, where particles are dosed with high-intensity UVGI energy. In the third stage, the high-efficiency True-HEPA filter captures particles as small as 0.3 microns, and the UVGI high-intensity energy irradiates them. Third-party lab tests show CRYSTAL-AIRE®UV deactivates >94% of micro-organisms in 10 minutes and >99% in 15 minutes.

The cleaned and purified air is then returned into the indoor space. Before the air exits the unit, there is also an optional fourth stage where the air can pass through a carbon filter to help with odors in difficult environments.

"Now more than ever, we know the air we breathe is critical to our health. You want your employees, customers, and friends to be safe and to trust they are in a clean air environment," said Tim Rosiek, product manager, Industrial Gas Filtration and Generation Division. "CRYSTAL-AIRE®uv combines ultraviolet germicidal irradiation with high-efficiency filtration to continuously purify indoor air from pollutants such as allergens, dust, viruses, mold, and bacteria that may be airborne and we are excited to share this proven solution."

The applications for this equipment are endless, administrative offices, worship centers, retirement/assisted living centers municipal centers, police stations, residential halls, courtrooms, reception areas, hotel lobbies, passenger terminals, offices, conference and meeting spaces, physical fitness centers, gymnasiums, classrooms, breakrooms, restrooms, lunchrooms, restaurants, bars/nightclubs, and weight rooms.




# Why Timing is Everything

## When it Comes to M&A in HVAC

**BY DENA JALBERT**

When it comes to mergers and acquisitions of small-to-middle market HVAC businesses, several items factor into the deal-making process. However, one key consideration should be at the forefront of a business owner's mind – timing. According to the ***Harvard Business Review***, 70 percent of M&A deals fail for various reasons, but timing can play the major factor in the success of your potential deal. It could also result in getting the highest valuation for your HVAC business.

Is this the right time to sell your HVAC business? The answer at the moment is yes, primarily due to favorable market conditions and increasing competition from private equity firms for strong HVAC businesses. Here is what you should be considering when it comes to timing.

•Retirement Planning: Retirement planning can play a major role in determining the timing of a potential transaction. Most business owners have a significant portion of their personal wealth tied up in their business. Selling your business unlocks that value and allows owners access to liquidity. Working with a financial advisor to determine the amount of money you need for retirement will allow you to evaluate when market conditions are best to deliver the needed exit transaction outcome to meet your financial goals. If you know what number you need, it makes evaluating offers to purchase your business much easier.

• Market Conditions: Deal activity in HVAC is on the rise, driven predominantly by increased investment from Private Equity. In 2011, only approximately 20 M&A transactions were completed. Fast forward to 2019, and there are more than 120 being done each year according to Pitchbook. The HVAC industry is very fragmented and has more than 75,000 companies in the U.S. alone, which means there are plenty of other businesses available for additional consolidation. This large supply of prospective acquisition targets has driven investor demand, with investors competing aggressively for good HVAC companies to acquire. Owners considering an exit should take advantage of strong demand conditions in timing their potential exit. An experienced M&A advisor can give you insight into these investment trends and help you evaluate market demand so that you can time your exit when demand is high.

• Stage of the Business: Most HVAC businesses are smaller businesses, but they have the potential to grow and scale into larger businesses with additional capital. This is why so many Private Equity investors are interested in the space – they can bring capital and experience in growing businesses to help these entities become much larger enterprises. Their intention is to consolidate smaller businesses into one larger entity, and then sell the larger company to another financial investor in the future, giving HVAC business owners an opportunity to receive additional sale proceeds in that second transaction. This is known as the "Second Bite of the Apple" and can be quite lucrative – owners earn well for the initial sale of their business, but then earn even more on the second transaction in the future. If you are not quite ready for retirement yet but are considering a transaction in the next 5-10 years, a transaction with Private Equity could be the best fit for you. You can achieve financial security today but also earn on the rapid growth of the business in the future.

Timing is everything and the time for HVAC M&A is now. Competition for strong assets is high and the next cycle may not come for another decade. Multiples are strong and the highest they'll be until the next cycle. It's a seller's market, so you are more likely to get agreeable terms that meet your needs. You can be proactive versus reactive and design the outcome you want versus reacting to a future triggering event. Lastly, your direct competitors are receiving funding from investors at a rapid pace. Per Pitchbook, 819 HVAC companies have received over $10B in M&A investment. You'll now have to compete with the deep pockets of their partners to retain your market share. Taking advantage of the right timing can result in a very profitable and smooth transaction.



***Dena Jalbert**, Founder & CEO, Align Business Advisory, in Orlando, Florida.*
*She can be reached at* ***djalbert@alignba.com***

# DEBUNKING Myths ABOUT CONDENSING BOILERS

BY DAVID GRASSL, PE AND CATIE VANWORMER, PE, LEED AP

There are many reasons why engineers believe that condensing boilers do not fit a design application, but most of these reasons are inaccurate due to outdated information.

Condensing boilers have the latest technology to replace standard, non-condensing boilers for most applications. Within the condensing boiler segment, a variety of technologies are available. High-mass firetube condensing boilers have been developed to overcome many of these obstacles and can be piped in a variety of systems with success. Therefore, it is important to understand each boilers' operating requirements as well as total cost of ownership when making a boiler selection.

### Myth #1 – We need to maintain 180°F hot water supply for the system to work

Prior to condensing boilers, it was common for systems to be designed with high hot water supply temperatures in the range of 180°F to 200°F. One of the main purposes of the high hot water temperature was to satisfy the hot water return temperature back to the boilers since a higher hot water supply temperature results in a higher hot water return temperature delivered back to the boiler. In noncondensing boilers, the hot water return temperature is critical as the water temperature must always be maintained above the condensing temperature of the flue gases to protect the heat exchanger.

Similar to non-condensing boiler systems, in condensing boiler systems a lower hot water supply temperature results in a lower hot water return temperature delivered back to the boiler. The difference with a condensing boiler is that hot water return temperature is the driving force behind condensing boiler efficiency. In condensing boilers, the goal is to generate as much condensation as possible because the heat exchanger is constructed of a corrosion-resistant material such as stainless steel or aluminum specific to this application. In addition to the hot water return temperatures, coils can also be designed to satisfy the load based on varying hot water temperatures.

### Myth #2 – We need to maintain a 20°F system ΔT

Myth #2 is similar to myth #1 in that older systems typically maintain a low ΔT in order to keep the hot water return temperature above condensing conditions. In condensing systems, temperature differentials of 30°F or higher can be designed to increase boiler efficiency by lowering the hot water return temperature back to the boiler. Increasing the temperature differential between the supply and return water has the added benefit of reducing the flow rate since the flow rate is related to the overall heat output of the coil. Therefore, the higher the ΔT, the lower the flow rate, which results in smaller pumps, less horsepower required to move the fluid, smaller piping, and other system benefits.

### Myth #3 – Hot water reset doesn't work

Hot water reset involves resetting the hot water supply temperature based on outside air conditions. The theory behind resetting the hot water supply temperature is that as the outside air temperature increases from the design condition, the amount of heat required to satisfy the space load decreases. Similarly, as the space load decreases, it is also possible to heat the space with a hot water supply temperature less than the design condition, which uses less energy to heat the water to a lower set point.

Hot water reset is a simple control strategy that has been used for many years on hot water systems with a lot of success. With condensing boilers, the

**Figure 1: Hot water temperature versus outdoor air temperature.**

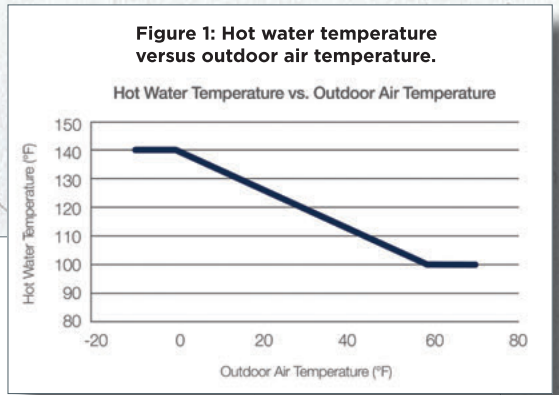
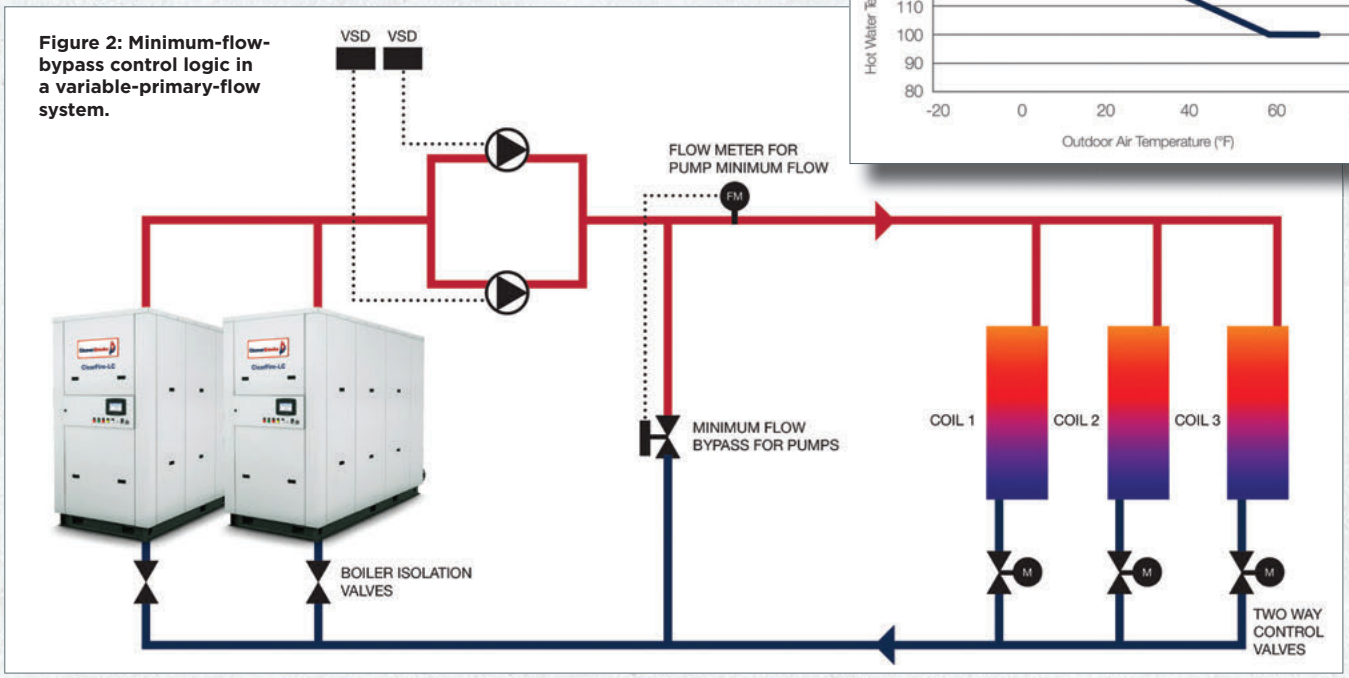



**Figure 2: Minimum-flow-bypass control logic in a variable-primary-flow system.**



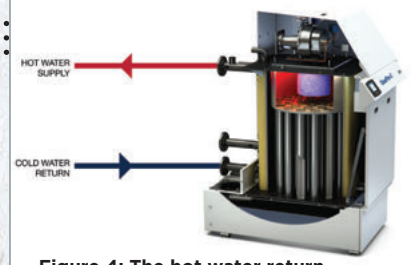



**Figure 4: The hot water return temperature to a condensing boiler dictates boiler efficiency as the water is the first contact point with the flue gases and more condensation occurs with lower water temperatures.**

hot water reset functionality based on outside air is generally built-in, making this a relatively low- or no-cost item to implement within the system. Reset strategies have also been used on supply air and chilled water systems for years so designers, operators, and contractors are aware of the design intent and goal of resetting system temperatures. The one item that should be understood regarding hot water reset is that there are conditions where resetting the hot water supply temperature will require additional flow to satisfy the load. In this scenario, hot water reset is less efficient as the additional pump energy required to move the fluid costs more than the energy benefits received from resetting the water temperature, so this condition should be avoided.

### Myth #4 – Variable-flow-primary systems are more complex

Hot water systems are generally known for using primary-secondary systems, which became the norm as non-condensing boilers cannot handle variable flow to maintain hot water return temperatures above condensing conditions.

Variable-flow-primary systems are simpler than primary-secondary systems because variable-flow-primary systems only require one set of pumps to handle everything in the system. Also, there is no mixing due to two hydraulically separate pumping loops and less equipment is required so there are fewer devices to control. In variable-flow-primary systems, there are three items that must be addressed for proper system operation, all of which are standard and limit the need to learn new control algorithms or special sequences.

1. Flow meter that can measure the water flow rate to the distribution system. In many designs, this is common practice for measurement and verification or for owners who are interested in tracking the energy consumption, so it may already be part of the design.

2. A minimum-flow bypass with a modulating two-way temperature control valve, which is the same control valve at all the heating coils in the system. These two items work in parallel with one another as the flow meter ensures minimum flow to the boilers and/or pumps is always maintained thus protecting the equipment.

3. Another two-way temperature control valve is required for each boiler when there are multiple boilers operating in parallel. This control valve is a two-position isolation control valve that remains closed when the boiler is off and opens when the boiler is on. This is also typically a function that the boiler controls can perform. The purpose of the control valve is to prevent flow through the boiler when the boiler is off, which results in bypassing and mixing with reduced hot water supply temperatures.

### Myth #5 – Reverse return helps balancing

Piping distribution systems that deliver water to the system heating coils are designed using one of two strategies, either direct return or reverse return.

Reverse return is a concept that evolved to solve the problem with direct-return systems. In a reverse-return configuration, the first coil to receive water from the central plant is designed to be the last coil to return water to the central plant. In theory, this equalizes the distance the water is pumped when distributed in the piping network and attempts to create a relatively equal pressure drop for each coil circuit.

### Myth #6 – Hot water supply temperature is important for efficiency in condensing boilers

Hot water supply temperature is part of the equation in defining heating

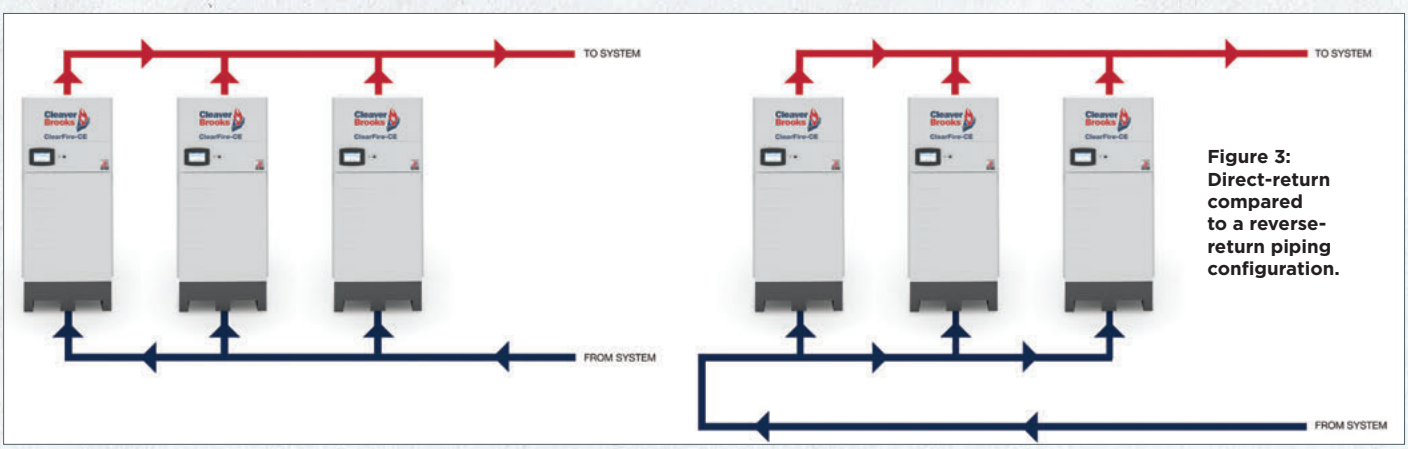



**Figure 3: Direct-return compared to a reverse-return piping configuration.**

coil sizing, but it is not the defining point of determining a boiler's efficiency. As referenced previously, boiler efficiency is dictated by the hot water return temperature since the amount of condensation that occurs in the heat exchanger depends on the temperature of the water compared to the flue gas temperature. Hot water supply temperature will almost always be above the condensing point of the flue gases, whereas the return water is the fluid that comes in first contact with the flue gases, cooling them to below the flue gas dew point, causing condensing and recovery of the latent heat from the moisture in the flue gas, which creates the efficiency gains.

**Myth #7 – Condensing boilers are more difficult to service and require more frequent service**

Condensing boilers do not require any more service or maintenance compared to a standard boiler and heat exchanger. A condensing boiler consists of a stainless steel or aluminum heat exchanger that provides more resistance to changing water temperatures as compared to a standard, noncondensing boiler where the operating temperatures are extremely important, especially the return water temperature. In theory, although it is not recommended, less care could be provided to a condensing boiler due to its overall robustness. Due to its construction, a condensing boiler will last longer than a non-condensing boiler. If proper water chemistry and maintenance is performed, some condensing boilers are built to last longer than a non-condensing boiler. ●

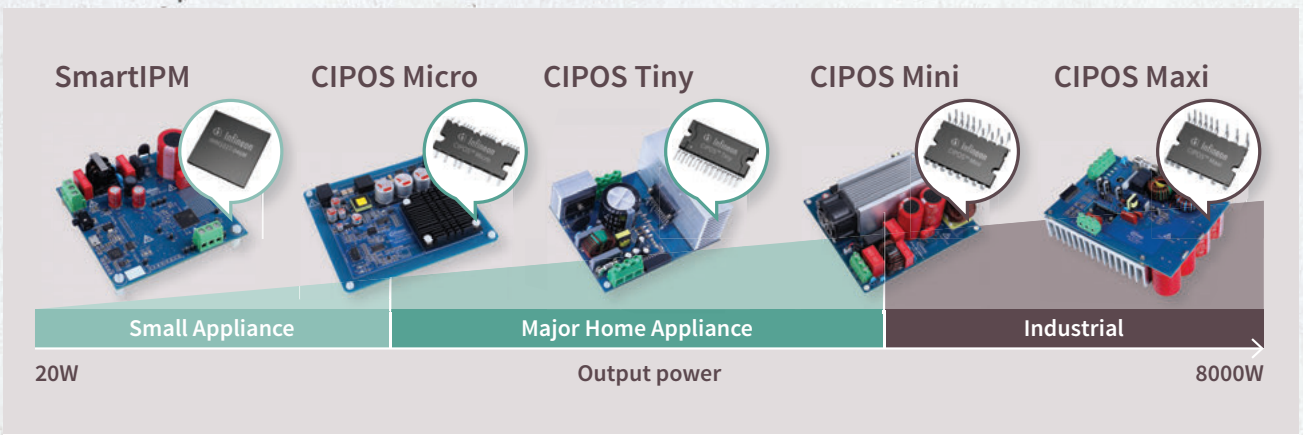
Read the full version at https://info.cleaverbrooks.com/debunkingmyths.



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***Catie VanWormer*** *is engineering manager, Packaged Boiler Systems for Cleaver-Brooks and a certified Hydronic Solutions Specialist who helps engineers and customers design hydronic and steam boiler systems to achieve maximum efficiency. Catie formerly worked as project leader in the mechanical engineering division of Peter Basso Associates and as a representative for a boiler manufacturer. Catie holds PE licenses in both Michigan and Wisconsin.*




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# Certification Process for Refurbished Electrical Equipment

**BY L. MATTHEW SNYDER**

With both the HVAC and appliance industries expected to see growth in the coming years, less expensive options will become more attractive to fill demand. Refurbished, or reconditioned, equipment and systems can fill this need. However, these altered products may no longer adhere to safety standards or applicable codes, for several reasons. To address this, the National Electric Code, (NEC), was recently altered to include special provisions for this type of electrical equipment.

Reconditioning differs from repair or servicing, which restores equipment to working condition using components from the original testing and certification process. Because it uses the same components as those used in the original certification process, the overall composition of the certified product is not changed during the process. Thus, it still meets applicable safety standards and regulatory requirements. A repair is also usually done by an authorized facility for the owner and the product is returned to that owner when the repairs are completed. Repaired or serviced products are not intended to be resold.

Reconditioned products may be modified using alternate components not included in the original evaluation and certification, with the intention of reselling it to someone else. While the alternate components may be recognized or certified themselves, they were not included in the equipment's original evaluation, certification, and listing. Using these alternative components essentially alters the general composition of the product, invalidating the original certification. Refurbished products may also no longer adhere to necessary safety standards, so they should be evaluated.

The NEC historically did not mention reconditioned products specifically; however, to address safety concerns around these products, the 2020 edition of the Code, which came out last August now does. Section 110.21(A)(2) outlines requirements for reconditioned/refurbished equipment, which it defines as ''electromechanical systems, equipment, apparatus, or components'' that have been reworked and/or restored. The NEC requirements for these products, based upon the National Electrical Manufacturer's Association's (NEMA) Policy on Reconditioned Equipment, helps to ensure their overall safety and performance.

In addition to obligations for the equipment, the updated NEC also outlines which types of equipment can be refurbished, such as certain types of circuit breakers, electromechanical protective relays, current transformers, switchboards, and switchgears (or sections of switchboards/switchgears). The NEC also defines equipment that cannot be refurbished. This includes (but is not limited to): molded-case circuit breakers, receptacles, panel boards, transfer switches, luminaires/lamp holders and retrofit kits, low- and medium-voltage fuse holders, and non-renewable fuses.

Because they can no longer be considered the same as the original

certified products, the new provisions of the NEC require that equipment eligible to be reconditioned or refurbished must be stripped of their original certification marks (though not the entire equipment label). Then, reconditioned products and equipment must be re-evaluated and certified to applicable standards, being listed as reconditioned or refurbished, if it is desired to sell refurbished equipment with a mark of conformity. They are then released with new model and serial numbers.

National Recognized Testing Laboratories (NRTLs) can evaluate and certify reconditioned electrical equipment. Because process is no different than the one used for new products, it can be done easily. The lab begins by identifying applicable regulations and/or standards – including amendments and notices – for a product. These requirements will vary depending upon the product type, its industry and its intended use. Regulations and standards may come from such sources as the IEC, ANSI, UL, AHRI, AHAM or other organizations. They include guidance such as testing requirements, acceptable results, set-ups and specifications, guidelines, and/or desired qualities. The identified applicable standards, as well as the known conditions of the refurbishment, will form the basis of the equipment's testing plan, which the lab will develop.

Once they have a test plan, the lab evaluates the product to the current version of the identified standard(s). Evaluations may include component assessments, reviewing staff training records, examining instruction manuals and evaluation of the disassembly/assembly process. It may also be necessary to conduct testing for considerations such as electrical safety (i.e. shock, fire, temperature control, etc.), performance obligations, electromagnetic compatibility (EMC), battery safety, and overall construction.

Once testing is complete, data is compiled into a test report, which includes information such as pass/fail findings, specific values, and outcomes. All test reports should clearly state what product was tested, the method followed and the results. Test reports are submitted for review along with the original certification report and nameplate, new nameplate, identification of alternative components used in the refurbishment, remanufacturing instructions, information from a staff training and qualification review, and required environmental conditions.

The information in the test report is examined during a technical review. A satisfactory technical review is followed by certification and mark/label reviews. If all needs are met and the product is shown to comply with applicable standards, certification is issued, and the product is listed in the relevant directory. Following certification, factory surveillance and maintenance activities will occur, just as they do with new, original equipment.

With certification, it is possible that reconditioned electrical equipment may need to be given a new nameplate and unique model name. These should be applied before the equipment is sold or placed in the field, along with an applicable refurbished certification mark. Depending on the NRTL, the language for the certification mark will differ. Typically, the marks are the NRTL's customary certification mark accompanied by language to reflect its reconditioned state, such as "refurbished," "reconditioned," or a similar term.

Many industries are recognizing the potential in refurbishing electrical equipment to meet supply and demand concerns. While appealing for many manufacturers, customers, and projects across multiple industries, it is important to ensure their safety and performance and make sure that these products adhere to codes like the NEC.

Recertifying these products may seem overwhelming or confusing, but it does not have to be. First, it is important to stay up to date on applicable standards for your products. This will help prepare you for the refurbishing process to ensure the final products is compliant and ensure a smoother assessment and certification process.

It is also helpful to compile information on components and parts used during the reconditioning phase along with a guidance document explaining exactly what is done for the refurbishment being performed. This information will help with the process, getting products to market more quickly. Additionally, working with a trusted third part to efficiently evaluate and recertify products is important. These partners will know the applicable standards and testing requirements. They will know how to assess a product, compile information, and work with you to ensure compliance and issue certification.

The changes to the NEC were made to ensure that altered products could perform well and offer a degree of safety to the end-user. Fulfilling these requirements need not be a burden or obstacle. In fact, assessing and certifying these products can fill a need, meet industry demands, and help ensure success. ●



***L. Matthew Snyder*** *is the Director of Electrical Certification at Intertek. He has more than two decades of experience in testing and certifying electrical products and oversees the certification process for Intertek customers. He attended SUNY Institute of Technology.*



# Solutions for Minimizing EMI/RFI Interference in Connected Appliances

**BY KATE GLUCK**

Nowadays, appliances do it all. They've become centerpieces for kitchens, function as entertainment centers and even connect to virtual assistants. Yet, the sensitive electronic components that power the interconnected and improved user experience of these devices are also increasingly susceptible to the challenges associated with Electromagnetic interference (EMI) and radio frequency interference (RFI).

Without proper shielding and grounding, EMI and RFI can compromise performance by distorting and delaying data. Left unchecked, the interference will cause EMI noise and crosstalk, leading to a low signal-to-noise ratio, poor signals, higher error rates, and slower communication speeds. Higher frequencies, electronic components in closer proximity, and increasingly complex products compound the challenge. The good news is that in many cases all of this can be addressed with a piece of custom die-cut specialty tape.

## Trends Driving EMI/RFI

Before diving into the solutions, it is important to highlight why they are needed in the first place.

Key among the trends driving the need for increased shielding and grounding is the proliferation of 4G and 5G networks and Human Machine Interface (HMI). Data speeds are increasing and components must be able operate at higher frequencies and with lower operating voltages. Also, as Internet of Things (IoT) technology is being integrated into new energy-consuming devices, more devices are creating interference and affecting nearby electronics.

All of this has created a myriad of benefits for consumers and a wealth of design challenges for engineers. EMI/RFI applications often have unknown issues that come up in the prototyping phase that can derail product launch timelines if a full electrical redesign is needed. Electrical designs have to meet Electromagnetic Compatibility (EMC) to ensure they don't interfere with nearby electronics.

## Solutions to Minimize Interference

Rather than embark on a full electrical system overhaul, many engineers are turning to die-cut 3M tapes. A far cry from the average tape,

3M electrically conductive tapes, films, and adhesives are formulated to minimize EMI noise and crosstalk and help provide EMI protection from a wide range of frequencies. JBC Technologies can convert these tapes to the specific size, shape, and configuration that you need to solve your unique challenge.

Technical applications for die-cut 3M Electrically Conductive Tapes & Films include:

- Electrostatic discharge (ESD)
- Shield-can lid
- Bond line gap shielding
- PCB/flex/chassis grounding
- EMI shield and gasket attachment
- Electrical connectivity to medium pitch flexible circuits and PCBs
- Flex circuit to flex circuit interconnection
- Passive intermodulation (PIM) management

## Factors to Consider

All EMI/RFI problems have a source, a path and a receiver. The culprits (sources) are the high frequency digital electronics that appliance consumers know and love. The victims (receivers) are the sensitive analog circuits and sensors. The path is all the space in between.

The job of the tape is to block the path, so that both source and receiver can function as intended. This starts at the bond line. Even if it's microscopic, if there is a gap between the two materials at the bond line, EMI energy can escape. This is where the conductive filler type comes into play.

Particle density is also of significant importance. Because electromagnetic interference can be attributed to radio waves and microwaves, not all devices function at the same frequency, nor do they need to shield from the same frequency. 3M™ Electrically Conductive Tapes are available with varying levels of conductive particle density to accommodate different frequency requirements. A helpful rule of thumb is that the higher the density of conductive particles the harder it is for high frequencies (shorter wavelengths) to get through the spaces between particles.

## Selecting The Right 3M EMI Tape

Due to the complexities involved, selecting the right tape usually requires the help of an expert. Below, we list 10 basic questions to help you narrow down which die-cut 3M Electrically Conductive Tapes & Films will work best for your application

1. Are you trying to provide EMI shielding, grounding, or both?
2. What is your contact/ electrical resistance (R) target?
3. What are the substrates you'll be applying the tape to?
4. What is the bond line gap thickness?
5. What is the primary frequency of interest? / What level of shielding performance (db) do you need?
6. Does your application require a Z or XYZ conductivity path?
7. What operating temperature range, environmental conditions, and chemicals will your product be subject to?
8. What is the grounding area size?
9. What is your desired adhesion level?
10. Where and how will the tape be applied?

## Converting Rolls of Tape Into Finished Parts

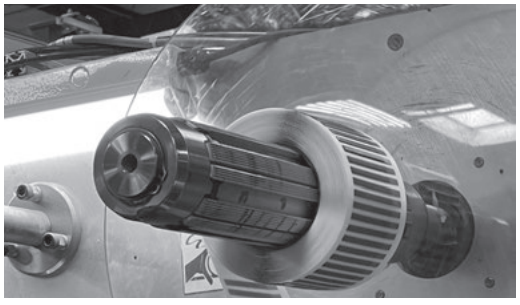
As effective as the 3M tapes and films are, they are even more effective when cut to the size and shape needed for your particular application. A 3M Preferred Converter, JBC Technologies has over 30 years of experience converting flexible materials. We use techniques like high-speed slitting, laminating, and rotary and flat-bed die-cutting to transform electrically conductive tapes and other materials into custom parts that solve our customers' unique challenges. We strive to add value at every stage, from materials selection and product design support to value analysis/ value engineering.

Examples of part presentations we can provide for EMI/RFI shielding tapes include: Slit to custom widths, kiss cut to a liner, island placed on a liner, pull tabs for ease of assembly through cut, and even adhered to customer supplied parts.

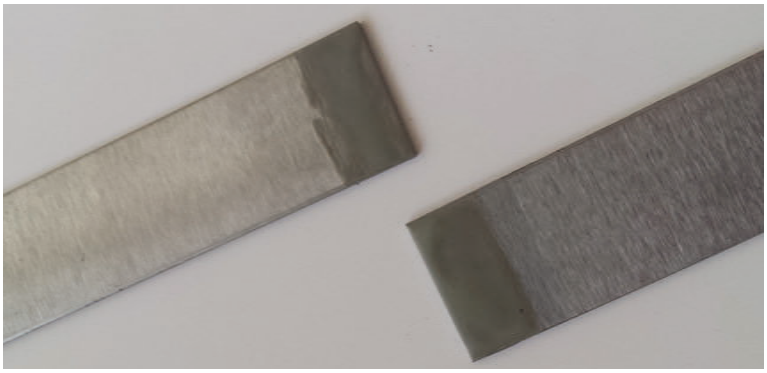


***Kate Gluck*** *is the Vice President of Business Development for JBC Technologies. Prior to this Kate was JBC's Director of Sales and Marketing and was responsible for all of the company's sales and marketing operations, including end-to-end management of JBC's online presence and advertising, estimating and sales activities, and service and support in all markets. Kate's current mission is to partner with industry experts and leading suppliers to uncover new opportunities for profitable, sustainable growth for JBC's custom and branded products.*

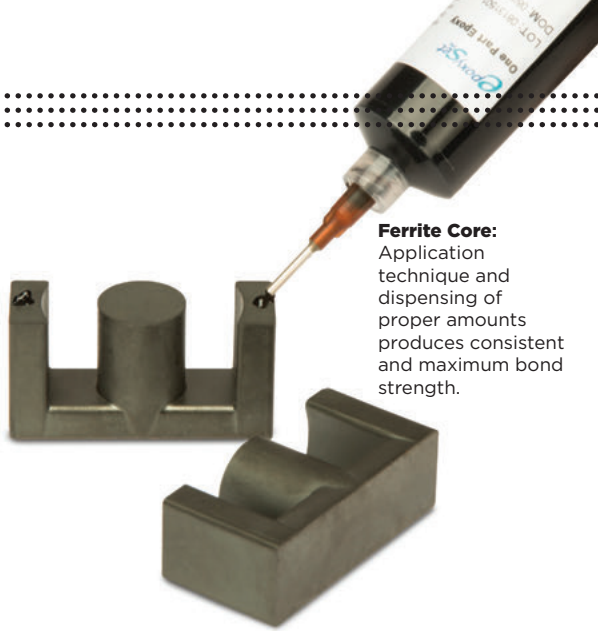




Courtesy of 3M



**Cohesive Failure:** Improper surface preparation can lead to undesirable adhesive failure (adhesive comes off one substrate). Desired results (seen here) yield cohesive failure (adhesive remains on both substrates).



**Ferrite Core:** Application technique and dispensing of proper amounts produces consistent and maximum bond strength.

# Common Causes for Adhesive Problems

**BY BARRY SIROKA**

High tech adhesives are very reliable and issues do not occur often. When used correctly, these adhesives can resolve many design issues while also saving money, time and effort. However, there are many potential reasons for a possible failure when using these materials. Failure can be defined as no adhesion upon cure, reduced adhesive strength, or loss of adhesion over time. When any problem occurs, the adhesive is very often one of the first components to be examined. Finding the cause of a failure can sometimes become difficult, especially when a failure is intermittent or it started after a long period of success. There are a number of standard issues that should be considered to determine the cause of a failure.

• **Contamination** should be one of the first considerations. Any grease, oil or other impurity on the surface can potentially cause loss of adhesion. Dirty substrates are an obvious potential problem but contamination can be inadvertent. Oils from skin contact, especially on very small parts, could be enough to cause a problem. Components may have been improperly cleaned. Component manufacturers sometimes change a production process that does not affect the component performance or tolerances but can unintentionally effect the bonding of that component. Controlling the cleaning process at the usage sight is the best method to ensure occurrence of this potential problem does not arise.

Another possible source of contamination is silicone release agents that can settle onto surfaces and prevent adhesion. Care must be taken to prevent cross contamination if using silicones or any release agent. For this reason, some manufacturing facilities will not allow the use of any silicone compounds.

• **Surface preparation** is essential for bond consistency. There are many methods to prepare surfaces, including washing, abrasion and plasma/corona treatment. The best surface preparation will depend upon the specific substrate and adhesive chemistry used. Consult with your substrate provider or adhesive manufacturer for the appropriate preparation. Lack of consistent surface preparation can be a big contributor to adhesion issues.

• Mix Ratio for many two part materials can be a major issue. Some systems are very sensitive to minor changes in the mix ratio. Many materials are stoichiometrically balanced and an off ratio mix may cause the material to cure erratically and/or not perform to its optimal capability.

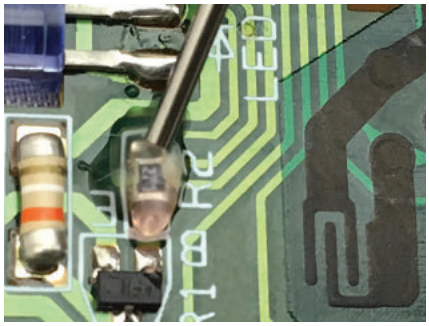
Even some materials that are not as sensitive to the mix ratio may exhibit slightly different characteristics when the ratio is varied. Materials that do cure with an off ratio mix may have slightly different finished hardness and tensile strength thus effecting the final performance.

• **Mixing of two part adhesives** is a basic process function but is essential for of these adhesives to work properly. Insufficient mix may result in a partial chemical reaction which leads to partial curing. An insufficient cured material will most likely result in poor bond strength and lower physical properties.

Also, mixing of the original container can be very important. Fillers or other




**Dual Barrel Cartridges:** Many adhesives can be supplied in dual barrel cartridges or other special packaging to ensure proper mix ratio.



**Electronics:** Contaminated substrates are a very common cause of failures. Cleanliness of the surface is essential for reliable results.

constituents could settle. Ensuring a homogenous mix of each component prior to mixing (for two parts) is vital to achieve maximum properties.

• **Application technique** can be critical. If material is manually applied, ensure that the amount is consistent for each unit. Most adhesives work best with an appropriate bond line. Too much or too little material could produce variable cured strengths. If applicable, make sure that the adhesive is applied in the same location on every component.

If automated placement is used, ensure that the equipment is clean when starting and remains clean during use. Some adhesives can partially cure in the dispensing apparatus thus clogging the unit and preventing a consistent amount of material being applied to each part. Less adhesive could result in decreased strength.

Air entrapment can be a source of inconsistent failure especially in small applications. Removal of air from a system, prior to application, may be a necessary processing step. Air gaps could prevent the adhesive from interfacing fully with the substrate surface which may result in decreased strength.

• **Incompatibility with substrates** can also be a contributor to failure with some adhesives. Certain plastics may contain plasticizers which could seep to the surface over time, causing a bond to fail. This seepage could be inconsistent from lot to lot so that some parts never fail while others lose adhesion.

Some substrates can actually interfere with the cure mechanism of an adhesive. This is usually an issue that is addressed when selecting the adhesive but sometimes appears later.

• **Cure time and temperature** can be major factors contributing to incomplete cure and performance of many systems. Some materials must be exposed to certain temperatures in order to cure. Many ovens can vary considerably and thus an adhesive does not seem to cure in its allotted time. Too high a temperature may cause a material to polymerize incorrectly and cause degraded properties.

Some materials may cure at lower temperatures but not produce the same physical characteristics as when cured with elevated temperatures. Alternatively, certain chemistries designed for low temperature cure should not be heated when cured.

Products cured with UV energy have the same issues. They must be cured with the correct wavelength and energy level. Certain chemistries will not cure with low light exposure and others can burn if subjected to high dosage. Some of the UV chemistries must be heat post cured to achieve their maximum performance.

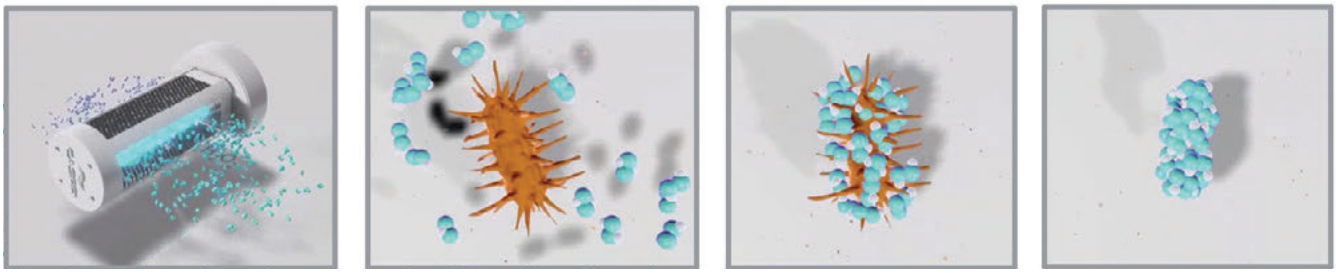
• **Environmental conditions** should also be noted as many materials can be effected by their surroundings. For example, high moisture levels can prevent cure in some materials while it speeds up the reaction in others. Carbon dioxide, PH, Oxygen and environmental temperature could all adversely affect the finished adhesive.

As stated earlier, intermittent problems are the hardest to resolve. These are almost always due to a factor other than the adhesive. Of course a batch of adhesive may have been produced incorrectly but this is actually very rare as reputable manufacturers use reliable raw materials and process controls to ensure a consistent finished product. Greater than 98% of problems with adhesives are not due to the adhesive itself but due to one of the causes previously discussed.

Speaking to experts is always useful. At Epoxyset, we encourage conversations with our technical team to find resolution to any specific problem. ●



***Barry Siroka*** *is Business Development Manager at EpoxySet Inc. with a innovative technical expertise in Adhesives, Potting compounds and Sealants with emphasis on problem solving. To learn more, go to* ***epoxyset.com****.*



# NCC: Improving Indoor Air Quality and Killing Germs with Hydrogen Peroxide

**BY DR. CHRISTOPHE SUCHY**

Clean air has never been more important than it is today.

As the world struggles to get back to some sort of normalcy during this gradual re-emergence from the COVID-19 pandemic, people and businesses alike are looking for solutions that can support public health efforts. In addition, as indoor spaces open to expanded capacities, bringing peace of mind to customers, employees and patrons becomes even more crucial.

Vaccines may play the leading role in the trajectory and success of this rebound, but the HVAC industry plays a significant part as well. While medical experts continue to define exactly how the SARS-CoV-2 virus spreads, it is commonly believed that crowded indoor spaces with inadequate ventilation produce environments ripe for virus proliferation.

Thus, there is a clear, focused emphasis right now on the need for clean and well-ventilated indoor spaces. This is confirmed in protocols developed over the past year by the U.S. Environmental Protection Agency (EPA) and backed by the CDC and ASHRAE, that say high-efficiency HVAC filters and air cleaners, combined with other recommended public health measures, "can be part of a plan to reduce the potential for airborne transmission of COVID-19 indoors."

For those in the HVAC industry, this situation presents both a unique challenge and a great opportunity to make the world indoors a safer place. And while COVID-19 receives all the headlines, we know that there are still many other viruses, bacteria, molds and pollutants to contend with in our quest for pristine air. So, while we are collectively solving the coronavirus problem, we want to ensure that the solutions we deploy protect us from a wide range of pathogens and other microbes.

Traditional air filters and UV-C lighting have rightfully received a lot of attention and recognition for their abilities to improve air quality, but we would like to spotlight a technology that hasn't yet received the lion's share of the headlines. Though it's been around awhile, until recently it hasn't been available in product footprints that are as efficient and effective as they are today. This technology I am talking about is photocatalytic oxidation, or PCO.

## Born at NASA, Refined in Healthcare

In a recent study on how to mitigate the effects of aerosolized pathogens, Margaret Scarlett, an international expert on infection control, offered a brief history of PCO. In the report, she explains that the origins of the technology reach back to the 1990s, when researchers at the Wisconsin Center for Space Automation and Robotics, a NASA research partnership center at the University of Wisconsin in Madison, developed an air purifier that eliminated pathogens in the ambient air of spacecraft.

The device drew air through thin tubes of titanium dioxide ($TiO_2$) that were exposed to ultraviolet light, performing a photocatalytic oxidation (PCO) process that decomposes ethylene – the decaying gas produced by plants in greenhouse experiments in space. The first device was used aboard Space Shuttle mission STS73 in 1995, and again in numerous International Space Station expeditions.

Around the turn of the century, PCO technology was brought back down to earth and refined in medical settings, where researchers took the original concept and improved the output of oxidizing molecules. They also improved the overall effectiveness of the process in reducing harmful viruses and bacteria in the air and on surfaces.

Today, PCO devices have been further enhanced through companies such as CASPR Group and are

available to every industry. This enhanced PCO process, called Natural Catalytic Conversion (NCC), now includes high intensity light shining onto a specialized metal alloy surface, and it has been adapted to transform humidity from the ambient air in any indoor space into gaseous hydrogen peroxide (H2O2) that is then dispersed across a targeted area, cleaning pathogens from both the air and nearby surfaces.

NCC products that are adapted for various industries, such as those from CASPR, are now available in multiple product designs that suit nearly any environment. The configuration that offers the widest area of coverage today include HVAC models that can be inserted directly into a duct for total-building applications. There are also mobile compact units available that can be placed in areas that may be difficult to reach by the in-duct units or need concentrated disinfection.

## A Unique Set of Benefits

Compared to traditional HEPA air filters and UV-C lights that also aim to reduce viruses, bacteria and other pathogens, today's NCC technology offers some unique benefits that haven't been realized until recent years and may be worth considering when building out new HVAC systems or upgrading existing ones.

***Performance:*** NCC technology has the double benefit of continuously and simultaneously cleaning the air while also disinfecting surfaces. In typical settings, it can operate as a no-touch solution that provides constant protection if the device is operational.

The best in-duct NCC units are designed to maintain good airflow throughout your HVAC system, and should have minimal impact on your air exchange rates. In fact, some industry studies show that NCC technology results in virtually no pressure drops.

Given these capabilities, an ideal solution is installing a filter with a lower MERV rating and better airflow versus a stronger filter that is more restrictive. Combined with a NCC unit, you'll still receive the level of protection that you need and expect while improving airflow.

***Efficacy:*** Recent independent studies have shown that modern HVAC NCC technology can indeed reduce overall microburdens in the air and on surfaces by up to 99.96%.

This was recently illustrated in a report from the University of Wisconsin-Madison that showed these NCC solutions produced a 97.8% reduction of SARS-CoV-2 particles within the first six hours of testing, and up to 99.991% reduction within 24 hours.

Additional studies show similar findings for other common viruses, bacteria and fungi across multiple settings, including healthcare, transportation, education and hospitality, among others.

***Safety:*** Unlike episodic cleaning methods, NCC products continuously disinfect occupied spaces without causing disruptions or delays. They do so by producing trace amounts of gaseous hydrogen peroxide at safe levels and they leave no residue.

Studies by the U.S. Federal Aviation Administration (FAA) have shown that using hydrogen peroxide as a cleaning agent, even at much higher concentrations than today's NCC processes, resulted in no degradation or corrosion on sensitive aircraft surfaces and equipment.

Additional studies in healthcare and transportation settings also measured the amount of hydrogen peroxide and ozone produced by those modern PCO technologies (NCC) and compared those findings against safety benchmarks.

The tests showed that hydrogen peroxide levels never exceeded 0.03 ppm (parts per million), with most samples registering less than 0.01 ppm. Compared against OSHA and NIOSH's standards of 1 ppm, the levels of H2O2 produced are deemed safe. The study also showed that no ozone was detected throughout the testing.

***Installation:*** The most advanced HVAC-based NCC products today come in relatively small product footprints that are easy to install within the existing ductwork. The units are usually placed on the supply side versus the return, so the hydrogen peroxide particles can be optimally spread across the target area.

Installation for these devices is both















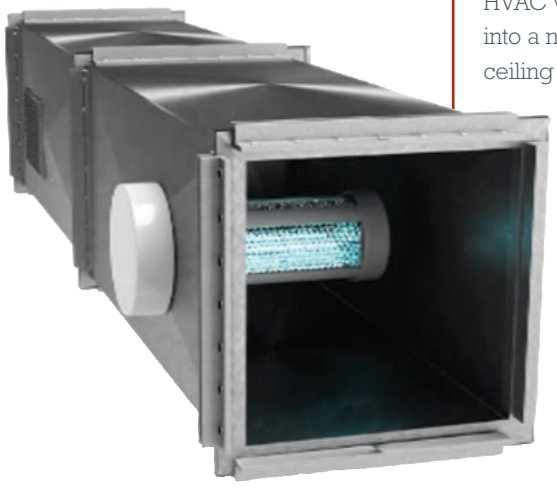
minimally invasive and minimally disruptive. You usually only need to cut a hole in the duct, place the unit inside, screw it in place and connect it to power. And that connection should be wired independent of the HVAC system and be fuse-protected, so if the NCC devices fail, your HVAC system won't go down as well.

In-duct NCC units typically cover up to 5,000 square feet and weigh between 1-5 pounds. Even better, minimal training is required for these mostly plug-and-play devices.

***Maintenance:*** Today's NCC technology can be considered a mostly touch-free, low-maintenance solution. Once installed, it should work continuously and at an optimal level without the need to continually tweak configurations and settings.

For technologies like CASPR's, minimal maintenance required, with the NCC cell needing replacement every two years, compared to traditional air filters that must be purchased and exchanged every 1-6 months depending on a variety of factors.

And NCC technology can also help extend the life of an HVAC system, given the reduced burdens that it provides on airflow and exchange rates.



## The Future of NCC Products

In the near future, we expect new types of NCC products and features to hit the market that will help ensure consistently clean air for everyone.

One such innovation comes from my company, CASPR Group. This summer, we are launching a product called CASPR BLU Tile. It's a NCC device that replaces a tile in a dropped ceiling and does not need to be attached to an HVAC system to protect rooms up to 2,500 square feet.

No more noticeable than a common HVAC vent, you just need to plug it into a nearby 120/240 volt grounded ceiling outlet as you replace an existing tile. The unit also features a swinging door to access the main parts of the device for maintenance, without taking the entire unit down.

We also expect other innovations in the coming year or two that will incorporate wireless air sensors that will give users the ability to check on the status of each NCC device in their facility, while also offering important information such as airflow and exchange rates, particulate reduction rates, and other air quality parameters.

While the past year or so may have presented many challenges, I believe that today's enhanced NCC technologies give the HVAC industry an opportunity to build upon the traditional means of air filtration and cleaning. Now is the time to take the next big step in improving indoor air quality for people all around the world. ●



***Dr. Christophe Suchy*** *is President & Chief Technical Officer of CASPR Group where he recently received the Innovation of Excellence award from NASA for his improvements on NASA's PCO technology into NCC (the technology used in CASPR products). Learn more at* ***https://www.casprgroup.com***

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