APEC 2021

# APPLIANCE & HVAC REPORT

Reaching Design Engineers at the OEM Level

April 2021

VOLUME 3 ➢ NUMBER 2



# What's the right level of torque?

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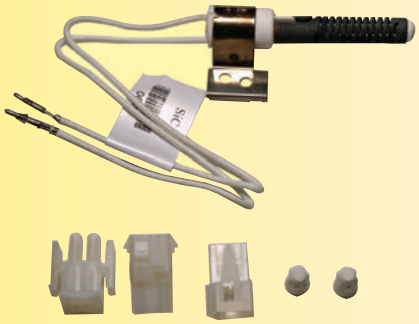
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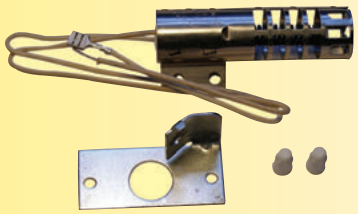
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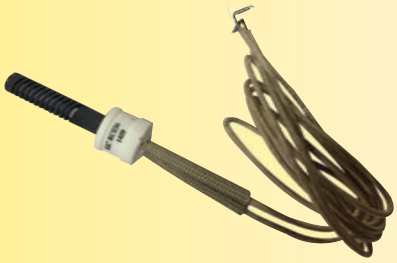


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# Welcome to our second of four quarterly issues of 2021



As usual we are publishing whitepapers and technical articles, that helps our readership do its work more effectively. That's one of our editorial missions, our most important actually.

Here is the list of 10 companies and organizations that have whitepapers in this issue:

The Air Movement Control Association (AMCA), Avery Dennison, Continental Fan, eFile Cabinet, Kaeser Compressors, Kenneth Ross, Esq. (legal), Southco, University of Michigan, UV Resources and Vitrek.

Noticed in the NEW YORK TIMES Sunday "Home" section they mentioned the "KitchenAid Artisan Series 5-Quart Tilt-Head Stand Mixer" as the best of its kind. it was among "The New Essentials: Baking Cookies" section. Also in the TIMES was a note where a writer wrote in a note "And here are some products I hate: Large kitchen appliances. Refrigerators with screens and cameras to alert you when you're low on milk are an eyesore and will be expensive to repair when they invariably break. I have never wished my refrigerator were (sic) connected to the internet." Oh well, you can't please all the people all the time!

Read an interesting article in the 2021 Market Report, published in the January/February issue of Metalforming Magazine. It was entitled "Major Household Appliances - Demand Outpacing Supply".

At the end of October 2020, Whirlpool's expected annual revenue to fall by 1 percent, which contrasted with a mid-summer forecast as much as a 12 percent drop., owing to decreased spending at the pandemic's outset when shutdowns and social distancing were first prescribed.

Whereas the COVID-19 pandemic plunged some industries it did just the opposite for the appliance market. As consumers were forced to remain housebound they gained a newfound indignation of their current appliances, wore them out or just realized they needed more. As a result, the industry quickly depleted inventories and manufacturing shutdowns obliterated the supply chain. With light at the end of the pandemic tunnel the OEMs and their suppliers struggled to meet demand while taking steps to satisfy volume and production demands.

Whirlpool had a reported 1.6 percent drop in 3rd quarter shipments last year due to this production backlog.

Then there is GE Appliances which, as the pandemic hit, found itself immersed in a digital-supply chain upgrade. With demand rising as its supply chain caved due to stay-at-home orders, it decided to double down on the upgrade in hopes of rapidly repairing parts supply and the ability to deliver finished goods to consumers.

Previously the company produced based on demand forecasts and stocked its distribution centers in anticipation of orders. "Now there's no inventory", Melanie Cook, CEO told the Wall Street Journal last December. "Typically, our customers would be used to placing an order - in five to seven days they can get the product. Now we're still building them.

At the pandemic's beginning GE saw a demand drop, according to Cook, followed by a spike for freezers to record levels. With usage levels way up - fridge doors opened 40 percent more frequently and washers and dryers were used 22 percent more often, catching up with demand was difficult.

"We literally can not keep up with demand. We've invested, added capacity and we are still flat out", she offered.

NOW THE GOOD NEWS! Assuming a return to normalcy, the home appliance market should grow through 2025, buoyed by general US trends of increasing disposable income and population movement towards urban settings, according to Pricing Excellence, an economic analysis firm. Styling and technological advancements, including smart appliances are contributing factors.

"The US always has been a mature and homogenous market when it comes to home appliances that have high market penetration", reads the most recent Market Insight report on the industry from Pricing Excellence. "Most consumers choose stylish and modern home appliances that complement their improving living standards. On top of this the market also is introducing products equipped with advanced technological features to cater to their need.

Expect a compound annual growth rate of 6.3 percent in US appliance sales through 2025, according to their report, with the refrigerator segment as the largest contributor among household appliances.

Stay healthy and safe...finally things may be going in the right direction!

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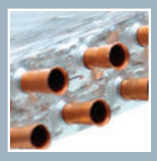
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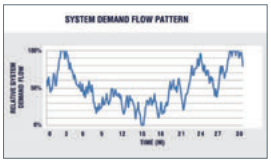
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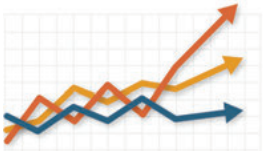
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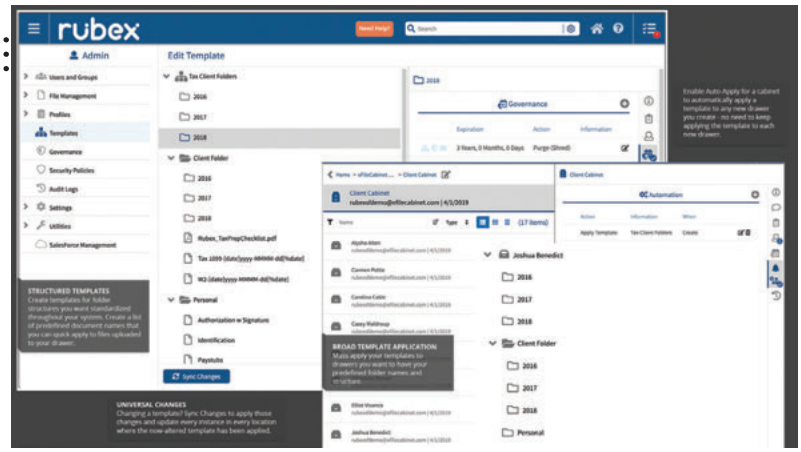

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# Work From Home, But Don't Skip a Beat




**BY ANDREAS RIVERA**

Remote work environments have continued to make strides with new technology that's allowing workers to seamlessly perform their jobs whether in the office or at home. The year 2020 has made this essential for businesses to continue operations while being forced to work remotely.

The Air Conditioning, Heating, and Refrigeration Institute (AHRI) is a trade association that represents manufacturers of HVAC and water heating equipment. Lisa Cardinal is the Senior Director of Human Resources for the organization.

One of AHRI's primary functions is to administer certifications for member companies' products. As such, the organization itself must meet the highest compliance standards in order to set its own standards.

Among Lisa's many responsibilities, one of her primary duties is to ensure that her department's records are organized so they keep strict compliance and that they are prepared for the numerous audits they receive.

However, throughout 2020, Lisa's company has issued stay-at-home orders, opting for employees to work from home.

Prior to implementing a document management system, Lisa says her department's documents were 98 percent physical paper. This led to issues of misfiling, people not filing, and unorganized files.

"With the stay at home orders, one of the things that doesn't stop is business— audits still happen," she said. "If I didn't have [Rubex] everytime we needed a certain file, I'd need to get permission, drive to the office, look through files, scan them in, and then use a file share program to get them to the right people."

## The Solution

Lisa had wanted her department to go all digital for years, and was finally able to make the leap in 2019. She and her team looked into several solutions and sat through several demos. In the end, the team could clearly see that eFileCabinet provided the security and features they needed.

"We needed a better way to be able to maintain this information — so we made the decision to go with eFileCabinet. Nobody likes filing, but we need to be able to review it for compliance and for auditors."

## Results

"Now everything goes into eFileCabinet. Nothing is sitting on our desktops, both our real desks and computers."

Lisa can't imagine what they'd do without Rubex. One of her biggest priorities is ensuring that her department is following the best practices for organizing personnel records, benefits information, and private medical information. Rubex makes it easy for her and her team to organize everything exactly how it needs to be.

"When we're preparing for an audit, I don't have the fear of wondering if a document is missing."

One of Lisa's favorite features in Rubex is the built-in help function. It allows her to get a virtual, step-by-step walkthrough for different features and functions she wants to learn more about. Just a single-click gives her access to quick guides, the full support page, and live chat with a support team member.

"Support has been awesome. They check up on us—make sure we have everything we need. I've never felt abandoned."

Having a reliable system that's supported with a top-notch cloud infrastructure and award-winning technical support is crucial for organizations trying to perfect their remote work strategy. Rubex keeps your documents both accessible and secure, all with the tools you need to stay efficient and productive. ●



***Andreas Rivera*** *is a technology writer with experience in both reviewing and marketing tech services and products. His areas of expertise include writing about B2B, SaaS companies and how they best address the pain points of businesses. Since early 2019, he has been the Marketing Content Writer for eFileCabinet and has become well versed in how document management software helps businesses reinvent their manual processes and spur growth.*




# Importance of Labeling

**BY IGOR DIAZ**

Driven by the need to differentiate, as well as emerging trends such as connectivity and personalization, appliance manufacturers are turning to new materials, new surfaces and adding new capabilities. In addition, new standards, increased concerns about counterfeiting, and changing consumer preferences are adding complexity to already demanding identification, tracking and branding issues.

Yet, labels, which play an important role in each of these areas, often don't get enough attention early in the design process. Too many manufacturers continue to rely on label specifications developed years ago that either don't leverage new advances in labeling materials or represent over-engineered solutions that add unnecessary costs to each unit manufactured.

By taking a fresh look at the labels used both inside and outside their products, appliance manufacturers can ensure label performance with new finishes and materials, enhance differentiation and reduce costs.

Applications for Appliances Labels

While some applications for labels in the appliance industry contribute directly to consumer education at the point of sale, others are less noticeable by consumers but equally important. Key applications for labels on appliances include:

**Branding and Differentiation**

Building and protecting a known and differentiated brand is key to success in the appliance industry and that extends to how the brand is presented on the product. Labels provide a cost-effective and durable vehicle for accurately presenting the brand at point-of-purchase and ensuring that the brand remains fixed to the product throughout its life.

For this application, the choice of label material should be dictated by brand positioning. Label materials commonly used in this application include polyesters, vinyls and polycarbonates. These materials can have a glossy or matte finish and can also have special topcoats that will allow for the use of different printing technologies. If the product is going to be exposed to different chemicals or household cleaners, the use of a lamination is recommended. For products exposed to outdoor environments, a lamination with a UV barrier is strongly recommended. Regardless of materials, these labels should be paired with a strong adhesive that will keep the label attached to the equipment throughout the life of the product.

**Track and Trace**

Labels play an important role in optimizing supply chain efficiency. Digitally printed durable labels featuring variable data barcodes can be used for component tracking between internal departments during the manufacturing process and for tracking of the finished product as it travels through distribution to the point of sale.




Variables to consider when choosing a label and adhesive for this application include whether traceability requirements are short or long term, the environment of the facility producing the goods, and the printing techniques being used. Abrasion resistance and barcode readability should be priorities. Paper and films labels are typically used for this application. There are also eco-friendly alternatives that can be paired with permanent adhesives to ensure labels remain on the product for the length of the manufacturing process.

**Product Identification**

Product identification labels can simplify service and troubleshooting, while helping limit manufacturer liability should a recall be required. This application requires a material that offers good legibility and tear and abrasion resistance. Aesthetics are typically not a high priority in this application so white or silver polyesters are commonly used. Laminations and fade resistant inks will provide long lasting legibility and the material should be paired with a strong permanent adhesive that will keep the label on the product for its service life.

**Consumer Education**

With more appliances now being sold through large big box stores, rather than specialized appliance stores, consumers are often making their decisions without the benefit of knowledgeable sales support. Labels, including both EnergyGuide and product feature labels, become an important tool for consumers making their decisions at the store.

Selecting a label color that complements the product color can help attract the consumer's eye and enhance the effectiveness of point-of-sale labeling. A variety of paper or synthetic paper materials can be used. The use of glossy or metalized label materials can also help draw a consumer's eyes to the label. If a "no label look" is desired, the use of clear materials paired with clear and removable adhesives deliver an impactful product message. Adhesives used in this application must ensure sufficient persistence through the sale while not leaving a trace of adhesive on the unit after removal by the end user.

**Cautions and Warnings**

Of all the labels used in appliances, caution and warning labels may be the most critical as failure of the label adhesive or fading of the ink used in this application can leave a manufacturer subject to legal liability. Labels for this application need to meet UL and ANSI requirements.

These labels may be attached to bare aluminum or stainless steel or powder-coated metal. The material and adhesive must be matched to the specific surface. The goal is to select a material-adhesive combination that isn't over specified, which will increase costs, or under specified, which will compromise long-term adhesion.

It's also necessary to understand the working environment and potential exposure to water, dust, chemicals and household cleaners as well as the application and service temperature when selecting the adhesive. Rubber, solvent acrylic and emulsion acrylic adhesives can all be used for this application depending on the specific requirement. Polyester, vinyl and polycarbonate label materials should be considered for these labels to ensure they can withstand temperature fluctuations and deliver excellent abrasion resistance.

**Authenticity**

With counterfeiting a growing problem across the consumer sector, labels can communicate authenticity. Different types of counterfeiting tools can be added on label materials, including holograms that can be printed on the label material, adhesives that will leave a trace if the label is peeled, and materials that will fracture and self-destroy if they are removed from the product.

**Protection**

With more appliances now using digital displays, labels help protect sensitive glass and plastic displays from damage during shipment and installation.

*Matching Labels to the Application* – The ability of a label to adhere over time within a particular environment is determined by three factors: the material the label is made of, the type and thickness of adhesive used, and the surface to which the label is applied.

*Surface energy* – a measurement of a surface that indicates how something will bond to it – affects an adhesive's ability to bond to that substrate and the choice of adhesive. The higher the surface energy, the easier it is for the adhesive to bond. Adhesive type and quantity must be precisely matched to the surface energy of the material to ensure the desired bond is created.

*High surface energy materials* – include most metals. But adding paint or powder coating to metals changes that classification to a low surface energy material. Plastics such as acrylonitrile butadiene styrene and polycarbonate have a high surface energy. Polyethylene and polypropylene have a low surface energy and tend to present a larger challenge in regard to adhesives.

*Appliance Industry Trends Impacting Labeling* – While labels have always been critical to the appliance industry, several trends are creating new applications or forcing manufacturers to consider changes to existing label specifications.

**Personalization**

Increased personalization and differentiation requires manufacturers to continue to expand color and finish options. These changes, such as the addition of varnish to a stainless steel to resist fingerprints, can change the surface energy of the material to which badging, EnergyGuide and point-of-sale labels must adhere. Any change to material or surface coating should be accompanied by a review of the labels and adhesives being used.

Using clear or metallized label materials can provide a high-scale look while matte and textured materials can reinforce a brand image based on heritage and solid reputation. Other materials can imitate the finish of the appliance to support a clean, modern look.

**Connectivity and Intelligence**

Appliances keep getting smarter and more sophisticated. That means more wiring harnesses and circuit boards on the inside and more displays on the outside. Wiring harnesses require proper labeling to prevent manufacturing defects and those labels typically have to be able to tolerate extremely high temperatures during the manufacturing process.

Displays, whether a video monitor integrated into a refrigerator or a touchscreen control panel on a stove, should be covered with a removable screen protector to protect against scratching or other damage during the journey from manufacturing line to the home. The adhesive on the transparent protector must have the persistence to stay adhered during this journey while enabling removal without adhesive residue. There are different clear films that will provide protection during the production process and also at the point of sale. Some of these labels may also have message or instruction to be printed on the labels so good printability may also be required.

**Portability**

From vacuums to small clothes dryers to camping stoves, more appliance manufacturers are cutting the cord and giving consumers the freedom to operate off batteries. To maximize the efficiency and profitability of these appliances, manufacturers should have a strategy to combat battery counterfeiting. Battery labeling can demonstrate authenticity and minimize counterfeiting. Working with the battery manufacturer to design labels that reduce the use of counterfeit batteries can help reduce liability and ensure proper product performance.

**Conclusion**

While manufacturers need some stability in their label specifications, using the same specifications year-over-year can compromise label adhesion with new finishes and result in higher-than-necessary costs. The best time to develop labeling solutions is early in the design phase, before production begins. Design engineers can bring to bear the expertise of the label converter and manufacturer to prove out new, cost-effective solutions. ●



***Igor Diaz*** *is business development manager, Durables, Avery Dennison Label and Packaging Materials. He is a sales professional with 22 years of experience in providing creative solutions to overcome challenges and generate growth for our customers.*

# Determining the Right Level of Torque When Specifying Hinges

**BY JAMES STROUD**

One of the most common and widely used devices in today's world is the door hinge. It is so ubiquitous that it's often overlooked and in many cases, taken for granted. On closer consideration, however, industrial and systems designers often discover that hinge technology offers a sophisticated range of functionality that can be useful to improve the operation of the systems they design.

When designing an application that hinges two panels together, whether it's for a simple enclosure or a large, complex piece of medical equipment, choosing the appropriate level of torque is essential to creating reliable operation and an intuitive end user experience.

Understanding the different levels of torque and which applications they are best suited for can help device and systems designers choose the hinging solution with the appropriate level of torque, in order to enhance the end user experience and reliability of the application.

## Understanding Torque

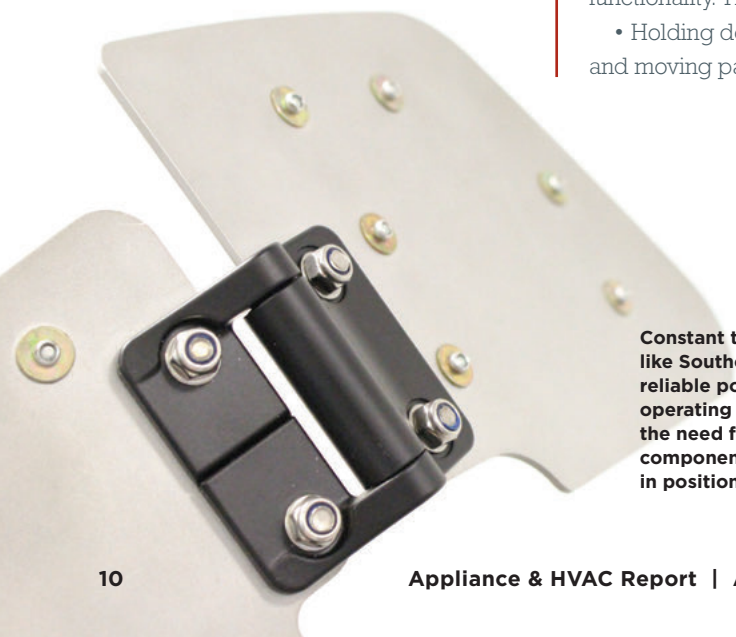
Torque has a relatively simple definition: It is the amount of energy or effort needed to move a door or panel from its closed position to an open position. The energy required is based upon the weight of the door, the travel distance or arc of motion from closed to open (and back again) and whether there is a desire to move the panel to one point in the arc of motion and hold it, or always have the motion go from fully open to completely closed.

Today, leading suppliers of hinge and positioning technology have portfolios that supply a "torque continuum," or a range of hinge products with different torque characteristics. Industrial designers choose from different options within this continuum to satisfy functional and ergonomic requirements and supply touchpoint experiences that convey unique impressions of quality and functionality. These include:

- Holding doors open or closed, and moving panels securely into position without secondary supports or additional components
- Creating an intuitive, zero-drift motion so that when a door or cover is opened, it holds a user-defined or predefined position securely, and with one motion
- Providing specific tactile feedback to enhance the quality perception of the hinged device
- Eliminating additional components (such as gas struts) or routine maintenance (tightening screws to maintain hinge resistance), thereby helping to lower overall costs
- Providing a smoother, more substantial feel to opening and closing action, or to eliminate vibration

The torque profile in a selected hinge can change – or elevate – the user's perception about a particular device. Consider the airplane tray table. Seating designers must use extremely lightweight plastic components in these applications to help airlines reduce fleet weight and conserve fuel.

However, a tray table that flops down upon opening can lead a passenger to question the quality of the aircraft itself. Using a constant torque hinge with a factory-set level of resistance, the tray can be lowered by the passenger with just the right level of force, making the tray feel more substantial and thus creating a positive perception of the inflight environment. In addition, constant torque hinges designed and manufactured with high-quality materials retain the desired resistance after thousands of flights, without maintenance or replacement of parts.



**Constant torque positioning hinges, like Southco's E6 Series, provide reliable positioning with consistent operating efforts, and eliminate the need for secondary support components to hold doors or panels in position.**



**Newer innovations in Counterbalance Hinges use torsion bar technology to create the counterbalance energy, combined with cam and roller systems to meter out that energy through the full arc of motion. In this concept, opening an 200-pound engine hood for instance feels like lifting a door weighing just five 10 pounds, and the effort is balanced through the whole range of opening and closing motions.**

## Selecting The Right Hinge With The Right Torque

The most common hinge is also the simplest: the standard, free-swinging hinge for opening and closing, with no resistance. It requires people to exert all the necessary energy to open or close a panel or uses gravity to complete the same operation.

Beyond this basic device, hinge technology can be broken down into four major categories, or ''building blocks,'' based on the type of torque and controlled motion they supply.

- **Constant torque** – enables the device to be held securely at every position along the range of motion
- **Detent and bistable** – these hinges automatically drive to and hold a specific position, such as to 90 degrees
- **Damping** – hinges that control the speed of motion automatically, without holding
- **Counterbalance** – hinges with technology that enables heavier objects to feel lighter when opened, or pop open with a simple touch

Although many applications would require only one type of hinge, these different categories can also be combined into hinges that provide multifunctional positioning options in a single device.

There are three key factors to consider in order to select the right hinge with the right torque profile: weight, center of gravity and direction of movement.

Weight: If a panel is sufficiently light — under a few pounds, for example — then a simple hinge with no torque can offer the most cost-effective solution. As the weight of the door or panel increases, constant torque or detent hinges become more effective solutions. The level of torque in these hinges does require the user to exert some force, but prevents the door from falling. As a door panel's weight approaches 15 to 20 pounds, and upwards of 500 pounds, counterbalance technology begins to provide a more effective option. With a counterbalance hinge, the hinge prevents the door from falling and makes that door feel lighter so that the end user is not putting towards any extra effort into overcoming the door's weight to open or close it.

Center of gravity: The center of gravity for a door or panel is affected by the width and shape of the panel, as well as the location of additional components that are attached to the panel. A light door that has a center of

gravity far from the hinge point might feel the same as a heavier door with a center of gravity close to the hinge point. For example, a tractor hood covering an engine compartment might be narrow and made of lightweight material, but because it's so long, the center of gravity is farther out and requires more torque to lift it than a box or a panel that's only 12 or 18 inches deep.

Direction of movement: For direction of motion, it's important to determine whether the panel or door is hinged vertically or horizontally. If it's hinged vertically and moves side to side, it is not working against gravity the same way a horizontally hinged panel does, which needs to move up or down. In some situations, a horizontally hinged door may also need to be moved and held in place in a vertical position. This way, a technician can access and work on the interior of a machine. The energy needed in this situation to move the door from horizontal to vertical will be higher, so a constant torque or counterbalance hinge might make more sense, especially wen the technician is working underneath a door that needs to be held open overhead.

### Constant Torque: Hold Securely at Every Position

Constant torque hinges provide intuitive movement of a device so that the amount of effort to move it is just enough to respond to deliberate motion, while holding it in place for more casual or touch interactions. A now-common example of this is a touchscreen monitor at a checkout counter, in a supermarket for instance.

A constant torque hinge attaching the monitor to the base lets the cashier or user tilt the monitor up and down for optimum viewing and interaction. Tapping the icons on the screen can be performed without the screen moving from the desired position. In addition, a constant torque hinge provides one-handed operation of the screen, rather than pushing a button or flipping a lever in order to position it.

While constant torque hinges have been available for some time, there are suppliers who continue to introduce new innovations in this technology. One -way, constant-torque hinges for instance, provide constant torque in only one direction of movement against gravity, while providing free-swinging motion in the other. This type of product can be useful in applications such as storage cabinets with large doors. By removing the friction from the hinge in one direction the door can be easily opened, while torque applied in the other direction holds the door open for access.

### Detent Hinges: Drive and Hold to Presets

Detent hinges provide very specific motion and tactile feedback: The door or device is opened and locks into place at a preset angle, usually with a distinctive "click" that can be felt. These types of hinges are often useful for lightweight cabinet doors or other devices that must be consistently opened to remain out of the user's way. Detent hinges require the user to keep moving the device until it reaches the right position for the working environment — for instance, a preset angle of 90 degrees.

A variation on detent hinges is called bistable, which contains a built-in spring mechanism that automatically drives the door or device to the preset angle once the door is open. This functionality is useful for doors, access panels or covers that must be opened to a minimum angle for easy entry, or to avoid collisions with surrounding equipment.

### Damping Hinges: Controlled Opening

With a door, compartment or other device using a damping hinge, it moves steadily to the open or closed position when force is exerted, rather than popping open or requiring the user to push it all the way closed. This smooth, steady motion is becoming widely preferred in a number of high-end applications, such as car interiors, where the operator expects a more intuitive user experience. For items like eyeglass storage compartments, USB port carriers and other compartments that are opened and closed, damping hinges add to the impression of a high-tech, finely engineered interior — a crucial element that many designers seek to achieve.

### Counterbalance: Move Heavy Objects With Minimal Effort

Counterbalance hinges expand the torque continuum by allowing heavy doors and panels to be easily opened and moved. They incorporate spring mechanisms that store energy when the door or panel is closed; upon opening, the energy is released and balances the effort required to move the panel through its range of motion to a fully open position.

For applications where operators are routinely opening and closing heavy doors – industrial copiers are one example – counterbalance technology can help reduce fatigue and improve operator efficiency. For instance, a door with a symmetrical torque hinge may require 56 pounds of effort to open from fully closed to 90-degrees open. Utilizing a



**Counterbalance technology can help reduce fatigue and improve operator efficiency by making heavy lids and panels on large pieces of equipment, such as industrial copiers and blood centrifuges, feel lightweight.**

counterbalance hinge instead, the energy required to open the door can be reduced to 3 pounds.

In the past, to enable the opening of heavier doors, designers would incorporate gas struts or other devices, which are prone to technical issues and failure over time, to provide the added lift. Counterbalance hinges now provide a more economical, single-device solution. And the newest counterbalance hinges can incorporate a latch to support pop-up opening: When first opened, the heavy door lifts a few degrees, allowing the end user a firmer grip on the panel when they are trying to move it to the desired position.



**For applications that require the lifting of larger lids and panels, counterbalance torsion spring systems like Southco's CB Counterbalance Hinge series can be used to neutralize the weight of heavy doors, providing motion control for easy and safe opening and closing.**

Newer innovations in counterbalance hinges use torsion bar technology to create the counterbalance energy, combined with cam and roller systems to meter out that energy through the full arc of motion. In this concept, opening an 80-pound panel feels like lifting a door weighing just five pounds, and the effort is balanced through the whole range of opening and closing motions.

## Adding Tactile Value To "Open and Close"

Leading suppliers of hinge technology have recognized that every time an end user opens, closes or moves a hinged device, the individual is both exerting force and experiencing a distinctive tactile experience. The advent of more hinge technology that incorporates a range of torque options and touchpoint experiences gives industrial designers a new set of tools to enhance the user experience and thus, the impression they have of the devices being used.

This torque continuum offers the opportunity to create more sophisticated solutions. Different types of hinges with different torque profiles can be combined to satisfy multiple requirements – for example, detent and damping functionality can be combined in a single hinge, so that a door easily opens to a fixed position and clicks in place, and then moves on its own in a controlled fashion to the closed position when it is pushed shut.

The key is to determine the full usage case for each application– what ergonomic effort should be expended to open, position and close a device, what user feedback is needed or desired to accomplish this motion effectively and on a repeatable basis. The ability to fully customize the torque level allows the designer to ultimately define what the end user experience will be. The industry's leading hinge suppliers have extensive experience working through these usage cases to help define the optimum solution and can provide in-depth expertise to cost-effectively configure the right hinge with the right torque for each application. ●



***James Stroud*** *Business Development Manager, Southco, Inc. To learn more, go to* ***www.southco.com****.*

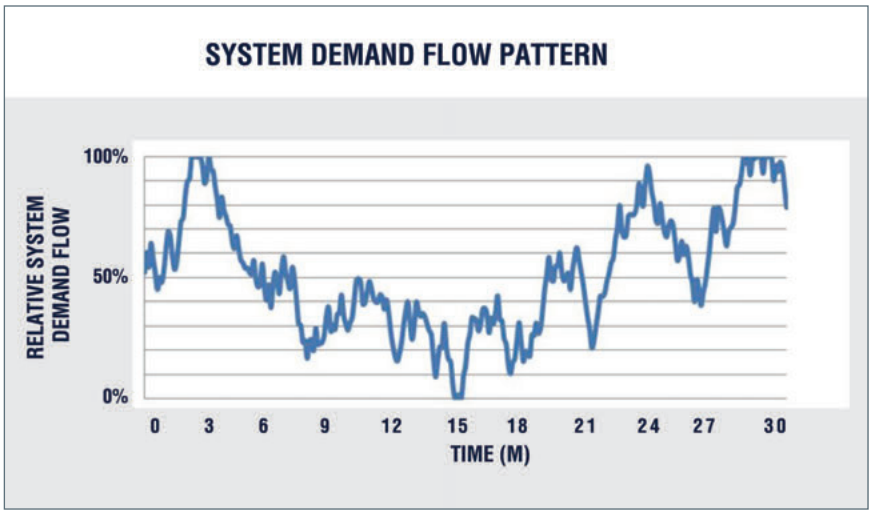



**Figure 1:** Sample demand flow profile

# Successful Application of Variable Speed Drive Compressors in Multiple Compressor Systems

**BY NEIL MEHLTRETTER**


## Abstract

Variable speed control is widely available for many types of motor driven industrial equipment. In recent years, pricing for variable speed compressors has made them attractive and popular alternatives to fixed speed units. By varying the frequency of the input electricity to the motor, a variable speed compressor can speed up and slow down to match supply output to the customer's demand while maintaining a stable operating pressure within the system. There can be significant benefits for systems where the demand varies widely and changes frequently; however, several factors should be considered when selecting new air compressors – especially for multiple compressor systems.


## How Variable Speed Compressors Fit within the Overall System

**• Variable Speed Compressors**

While variable speed compressors can significantly improve energy efficiency in some cases, they are not a "one-size-fits-all" solution. Several factors must be considered before choosing to employ a variable speed compressor. We'll address some of these below.

The first thing to understand is that there are efficiency losses caused by harmonics in the power supply and the efficient operating range of the compressor. Drive losses can reduce efficiency 3-5% when compared to a fixed speed compressor. A variable speed drive improves the total energy efficiency only if such additional losses are exceeded by the benefits resulting from the capability to regulate the speed at less than full load conditions. An application where the compressor runs at any steady speed for prolonged periods of time could be made more efficient by using a properly-sized and controlled fixed speed compressor (or compressors), which do not have these drive losses and cost less to purchase.

**• Fixed Speed Compressors**

Fixed speed compressors are typically switched between load (the compressor is running and producing full flow), idle (the compressor is running but is not producing air), and stand-by (the compressor is off but ready to restart). Idle operation is necessary when the required switching frequency between full flow and zero flow exceeds the maximum permissible starting frequency of the motor.

Power consumption during idle is typically 15-35% of full load power consumption. However, for lubricated screw compressors, this low power level is reached only after the pressure in the separator has been vented. This can take 30-60 seconds. In poorly designed systems, it is not at all unusual for compressors to switch from load to idle every 20 seconds. This can result in an average power consumption of 90%+ to supply a demand of 50% flow.

## System Sizing and Compressor Selection

**• Overall System Design**

Designing a proper and efficient compressed air system requires knowledge of the strengths and weaknesses of each compressor type and how they should be applied. Because compressed air is an essential part of the manufacturing process and therefore an indispensable part of the infrastructure like electricity, interruption of compressed air supply can cause an interruption of production or reduced effectiveness of pneumatic equipment. Reliability and availability of compressed air supply should be ensured by a certain redundancy to allow for planned maintenance or repairs. Generally this means that the number of compressors, the individual compressor sizes and the total combined flow of all compressors

have to be chosen in such a way that an uninterrupted compressed air supply is ensured, even if the largest compressor is shut down for maintenance or if it fails. This philosophy can be extended to dryers and filters to ensure complete system redundancy.

In addition to the multiple compressor considerations, weighing the costs and the benefits from including one or more variable frequency drive compressors should be analyzed. The costs would include capital as well as potential increased maintenance cost over the lifetime of the equipment, plus the increased complexity of the compressor requires advanced training in maintenance and operation.

**• Measuring the System Demand**

Assuming that a variable speed compressor will be one of several compressors employed to meet the total demand, the first thing required to properly size a variable speed compressor, or any fixed speed compressor for that matter, is a demand profile. Without a profile, it is difficult to properly size the compressor(s) that can cover the variations in demand in an efficient manner. It will also be impossible to accurately assess the cost/benefit of any proposed mix of compressors.

A simplified example of a flow profile is shown in Figure 1. The overall flow percentage is graphed against time in minutes.

Figure 2 shows how system controls manage individual compressors (e.g. two fixed speed compressors and one variable speed compressor) to match the system demand illustrated in Figure 1 with minimum pressure fluctuations.

The compressors have been sized for the application so that the base-loaded, fixed speed compressors have a capacity that fits within the control range of the variable speed compressor. This allows the fixed speed compressors to be started and stopped when significant changes in demand occur while the variable speed compressor adjusts for variations in demand that are within its control range. The fixed speed machines are either at full load or stand-by (offline entirely), eliminating frequent switching and reducing idle time, which has the added benefit of reducing wear.

In this example, the compressor sizing includes two smaller fixed speed compressors and one larger variable speed compressor. When base-load compressors are sized within the control range of the variable speed compressor, this ensures the ability of the station to maintain a stable plant pressure and maintain the highest efficiency possible throughout the prevailing demand profile.

## Mind the Gap

The control range of the variable speed compressor is defined as the difference between maximum output flow of the compressor at rated pressure and the minimum flow of the compressor at rated pressure. When the base-load compressors are sized within this range, and the compressed air station includes a master controller, then the compressed air station can maintain a stable operating pressure at various flow levels. Note that the most efficient points are typically between 40% and 85% of full load which is supported by the data in Figure 3. These efficiency gains using a single variable speed drive compressor can be expanded to a multiple compressor station as a whole through advanced compressor controls.

**• Control Gap Explained**

Too often variable speed compressors are selected with maximum flows equal to or less than the fixed speed units they work with. If the control range of the variable speed compressor is not larger than the full flow of the smallest fixed speed machines, a "control gap" will result in one or more fixed speed compressors rapidly cycling between load and idle, while the variable speed unit may

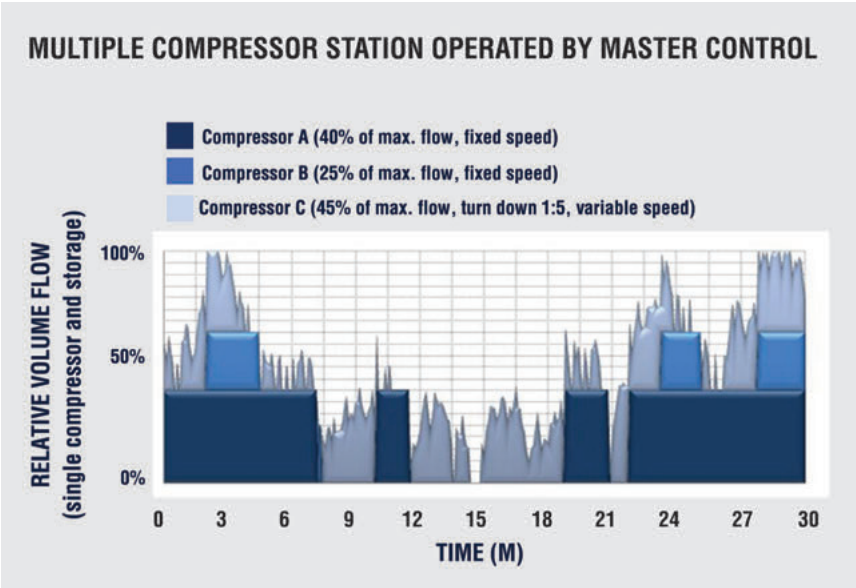



**Figure 2:** Multiple compressor system operated by a master controller

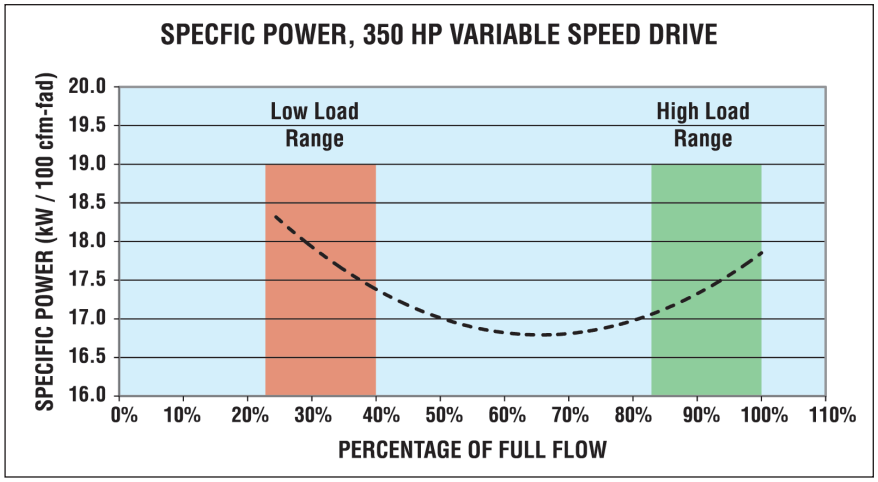



**Figure 3:** Sample efficiency of variable speed compressor

ramp up and down in an attempt to maintain system pressure. When these types of events occur, the plant often refers to the compressed air system as "out of control," and an unusual pressure fluctuation in the facility persists which can affect production.

Figure 5 shows an example system with 150 hp variable speed drive compressor and multiple 100 hp fixed speed compressors. The maximum flow of the 150 hp variable speed compressor is 735 cfm-fad at 110 psig and the minimum speed is 150 cfm-fad, therefore the control range of the variable speed compressor is 585 cfm-fad at 110 psig. The two fixed speed compressors are both rated for 497 cfm-fad at 110 psig and therefore fit within the control range of the variable speed compressor. As can be seen in Figure 5, the system can provide a steady operating pressure throughout the flow range of the system as long as the system is properly sized, and properly controlled with a master controller.

**• Advanced Compressor Controls**

The key to effectively addressing changes in demand within a multiple compressor system is the correct type of system control. It is well known that in multiple unit systems the energy efficiency is significantly improved by the use of a master control which coordinates the operation of the individual compressors. The most important aspect of "coordination" in this context is to control the operational modes and the transition between these modes appropriately (e.g. load, idle, and stand-by for fixed speed compressors, operating speed of variable speed compressors, shut down or start-up for all types of compressors). While individual compressors may have excellent specific performance values on paper, if they are not well controlled the system efficiency will suffer.

The controller must be able to maintain the desired plant pressure by controlling all compressors in concert. It continuously monitors the rate of change in system pressure, calculates the change in demand and activates the appropriate (most efficient) mix of compressors to meet demand. Ideally it will also monitor the starting frequency of all compressors in the system so that they can be quickly or immediately switched to stand-by and avoid any idling. However, even with a sophisticated master controller, if the compressor sizing is not based on the demand profile, energy efficiency can suffer and machines will cycle on/off too much.

Figure 4 illustrates how the master controller translates changes in system pressure into a suitable control scheme for the compressors using the same example in Figure 1 and 2. Note that none of the compressors are following the system demand. The controller separates their controls from the demand and determines how they should run to maintain a stable pressure and above the minimum required pressure.

By using the correct combination

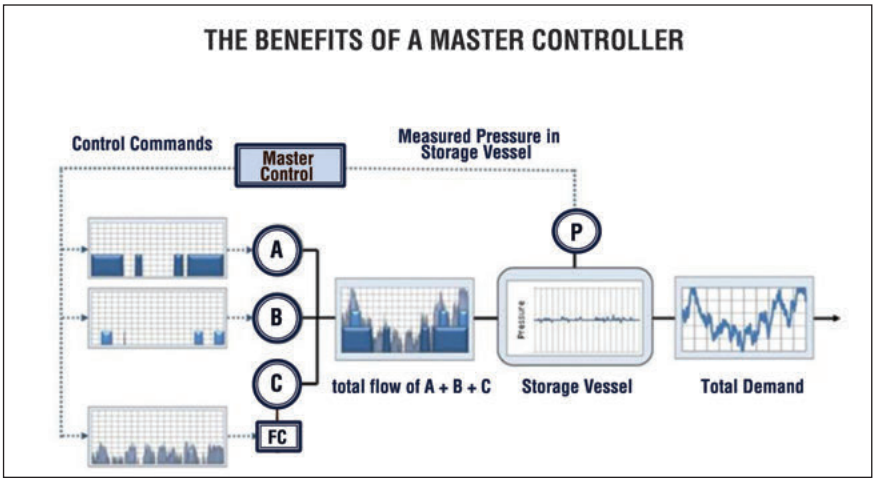



**Figure 4:** Characteristics of a compressed air system master controller

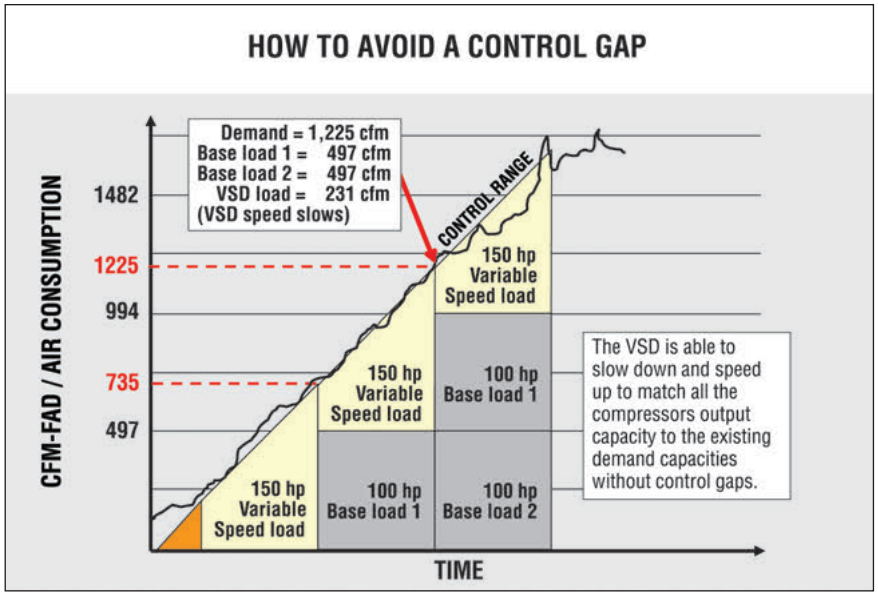



**Figure 5:** System selection to avoid control gap

of master control and properly sized compressors, concerns about part-load efficiency of the fixed speed compressors is eliminated. Further, breaking the demand into smaller units could reduce the size of individual compressors and allow for a smaller back-up or back-up covered by multiple machines.

**• Selection by Analysis Revisited**

In many cases, compressors are added as production equipment is added to the facility. In these cases, common wisdom suggests that simply adding a variable speed compressor can provide significant energy savings. However, this typically does not include a full understanding of the overall system dynamics. It is always recommended to reassess air demand to understand the current compressed air system dynamics. This is often provided by the compressor supplier and is well worth the additional time and modest expense (if any).

**• Reliability Factors**

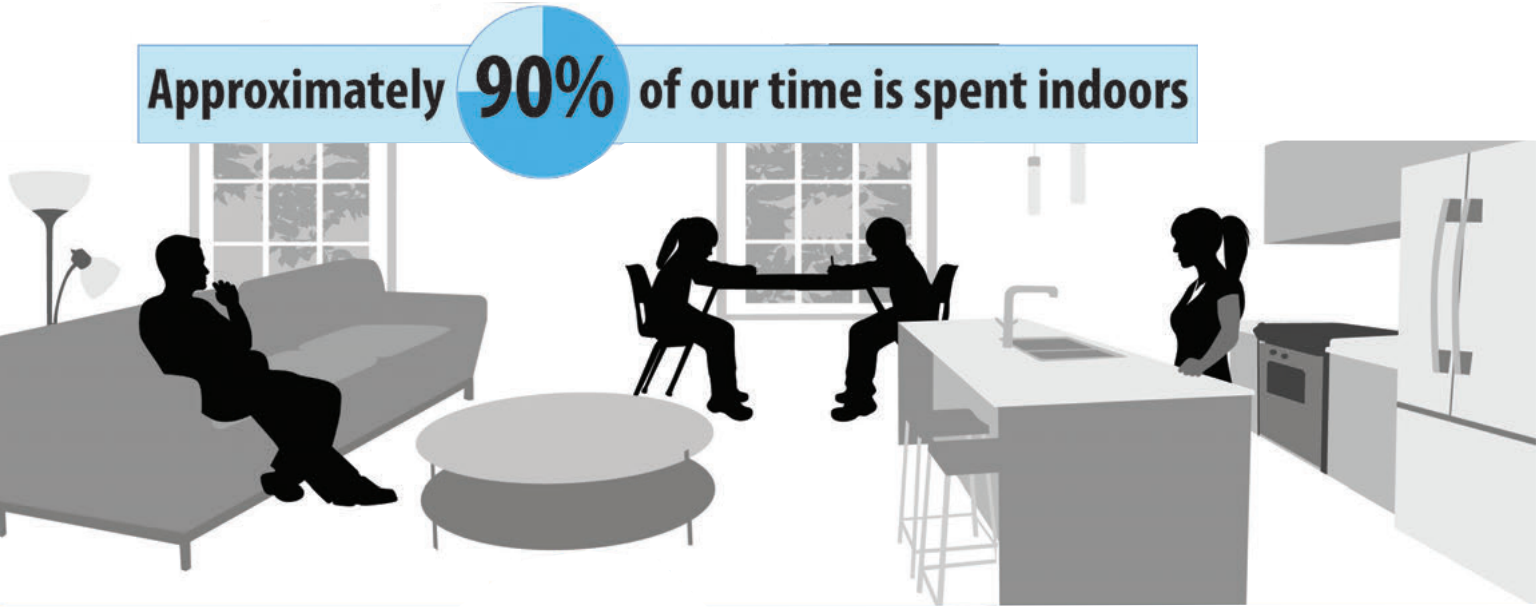
While variable speed compressors can be very effective in many systems, they are too often seen as a panacea for improving compressed air system efficiency. Further, purchasing one large variable speed compressor is sometimes seen as a cost-effective alternative to having multiple compressors that share the load at different demand levels. While there are cases where the flow range of the compressor can effectively cover demand, any operation relying on a single compressor system is inherently vulnerable to downtime for service or repair. Other practical considerations include the installation environment. Variable speed compressors rely on more complex electronics, so the quality of the incoming power supply is important. Depending on equipment design, high heat, wet or dusty installations may also impact life cycle costs of variable speed compressors.

**• Wrapping Up**

The proper design of a compressed air system and the choice of compressors cannot be done without first determining the demand profile. Understanding the demand profile is critical before applying variable speed compressors and sizing all system compressors. Variable speed compressors will improve efficiency if properly sized for systems with widely variable (and frequently changing) flow demands. But they do not replace the need for proper system controls. As emphasized above, multiple compressor systems should be controlled by a master controller. The combined operation of fixed speed and variable speed compressors allows the master controller to leverage the individual advantages of each type of compressor to its full extent by decoupling the compressors from the actual demand so they don't fight each other. The best system design may include multiple variable speed compressors, one variable speed compressor or none at all depending on the prevailing demand profile and other mitigating factors such as capital cost, service costs, return on investment, and application.



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# Indoor Air Quality

BY JALENA PFISTER

## What is Polluting the Air in Your Home or Workplace?

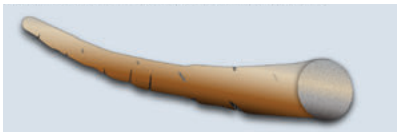
Have you ever taken a deep breath while visiting an ocean or mountain? Our lungs appreciate the clean, unpolluted air that these natural settings offer. Now, have you ever taken that same type of deep breath when you enter your home or workplace? It is probably fair to say that most of us have not because these places do not provide the fresh air that we find in natural settings.

Indoor air quality (IAQ) refers to the quality of the air in an indoor environment like a home, office, or school.

Because as much as 90% of our time is spent indoors, improving indoor air quality is crucial for our health and well-being. For years, indoor air quality has been a leading health concern. In today's current environment, that concern is even greater.

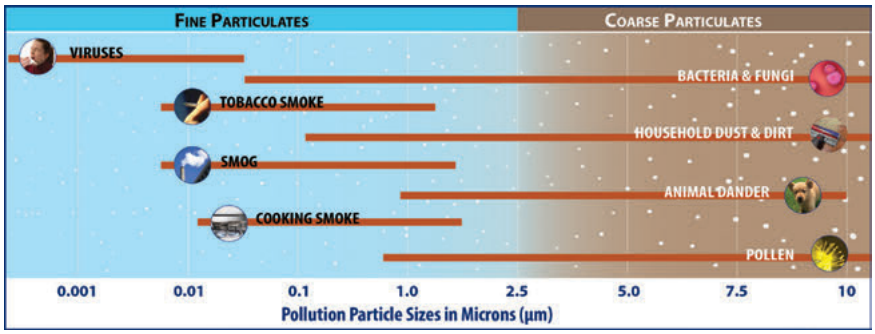
## Three Components of Poor Indoor Air Quality

In order to improve indoor air quality, one must first understand what is affecting it. Indoor concentrations of some pollutants are often two to five times higher than outdoor concentrations[1]. An individual pollutant may not pose a health risk, but unfortunately, most indoor environments have multiple pollutants affecting the air quality. Particulates, microbial organisms, and chemical pollutants are three components of poor indoor air quality that are worth examining further.



**The diameter of a human hair is between 50 and 70 microns.**

***Particulates*** are very small solid or liquid substances, such as inorganic/organic compounds and dormant/living organisms, that are light enough to float in air. These include dust, dirt, pollen, pet dander, smoke, and liquid droplets to name a few. Both natural and human activity attribute to the particles in the air.



Particulates are classified on the basis of size, ranging from coarse particles between 10 and 2.5 microns to fine particles smaller than 2.5 microns. Health problems can occur when particulates contain solid or liquid droplets that are small enough to inhale. Once inhaled, particles can affect the heart and lungs. Particulates that are less than 10 microns in diameter can get deep into the lungs and sometimes into the bloodstream. Fine particulates that are less than 2.5 microns in diameter pose the greatest health risk.

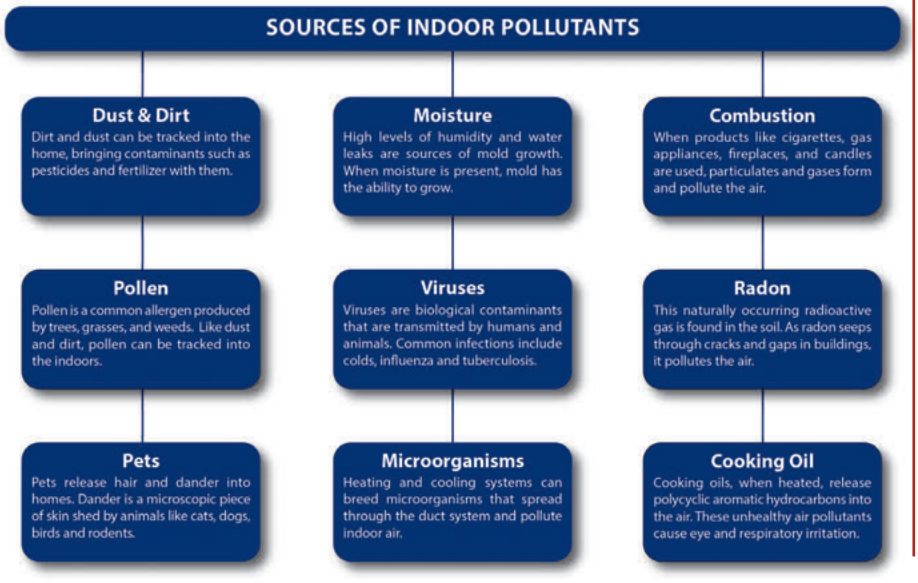
***Microbial organisms*** represent germs, viruses, and bacteria. These microscopic organisms are present in every environment. As an important component of our ecosystem, microbial organisms contribute to the cycle of life and break down dead materials into constituent components. However, when these organisms are left uncontrolled inside buildings, they negatively affect indoor air quality and cause structural damage.

Moisture on indoor surfaces leads to growth of microbes like bacteria, fungi and mold. The growth of these microbes leads to organic compounds that are released into the air. Airborne mold spores are a common cause of asthma and allergy issues.

Occupants often bring viruses and bacteria into a home, school or workplace. One way to help control the spread of these viruses and bacteria is through effective ventilation. When the air in these places is stagnant, the probability of a disease spreading increases. Ventilation can affect how viruses and bacteria spread indoors.

***Chemical (Gaseous) pollutants*** consist of carbon dioxide, tobacco smoke, ozone, and volatile organic compounds (VOCs) to name a few. Hundreds of gaseous pollutants have been detected in indoor environments. Health effects vary widely and depend on the types and concentration of pollutant, as well as the frequency and duration of exposure.

Since the 1940s, VOCs have become common by-products in residential and commercial goods. Everyday products often include organic chemicals in their ingredients. These ingredients become volatile organic compounds when the organic chemicals vaporize and become gases at room temperature. VOCs have a high vapor pressure and low water solubility. There are thousands of products that emit VOCs. VOCs are present in personal care products, cleaning products, furniture, and building materials. These products give off gases that, at high levels, can have adverse effects on one's health.




## Steps to Improve IAQ

Poor indoor air quality can adversely affect our health in a variety of ways. While a pollutant may trigger an immediate and mild reaction like a skin irritation or a headache in one person, it may have a long-term effect that leads to a severe illness like cancer or heart disease in another. Whether it is an acute or chronic disease, it is imperative that measures are taken to improve indoor air quality.

The energy crisis in the 1970s started the movement to airtight construction in homes and buildings. While this change led to improved energy efficiency, it contributed to an unhealthy indoor environment. However, there are steps that allow us to improve IAQ:

- Source Control
- Improved Ventilation
- Air Purification

***Source Control:*** Some pollutants can easily be controlled at the source. For example:

1. Choose green products when building and decorating a home or office.
2. Use cleaning products with lower VOC content when cleaning a home or office.
3. Repair leaks and water damage to prevent mold and mildew from growing indoors.
4. Open windows or doors when participating in activities that use products with VOCs.
5. Don't smoke indoors or idle a car in an attached garage.

***Improved Ventilation:*** When outdoor air is brought indoors, it promotes good indoor air quality. There are three ways to improve ventilation:

1. Infiltration is a natural way in which air leaks through crack, joints and openings in a building. Infiltration is more common in homes and buildings that are older but is less likely to occur when a structure is newer or remodeled.

2. Natural ventilation takes place when doors and windows are opened so that air can enter.

3. Mechanical ventilation occurs when devices exchange outdoor and indoor air.

Residential and commercial dwellings need ventilation to reduce and control excess moisture, humidity and indoor air pollutants. The amount of time required for the air in a room to be completely exchanged is known as the air change rate. Pollutants can accumulate to unhealthy levels when the air change rate is too low due to a lack of infiltration, natural ventilation, or mechanical ventilation. Oftentimes, mechanical ventilation is required to expel the concentrations of indoor air pollutants and to bring in fresh air from the outdoors.

***Distinct settings require different types of mechanical ventilation.***

Whole-house ventilation provides continuous ventilation to a dwelling. According to the EPA, most home heating and cooling systems, including forced air heating systems, do not mechanically bring fresh air into the home[2]. Today's energy-efficient homes are installing HRVs and ERVs for improved ventilation. An HRV (heat recovery ventilator) is designed to supply fresh air to a home and to extract stale air from a home. An ERV (energy recovery ventilator) does everything that an HRV does but with the added benefit of humidity control. Regional climate is the deciding factor whether an HRV or ERV will be more effective.

Spot ventilation is intermittent ventilation that is applied to a single room. A bathroom ventilation fan is a form of spot ventilation that mitigates excess moisture during use of a bathroom. Similarly, a range hood exhaust fan controls cooking fumes and odors when a stove is in operation. If necessary, a ceiling or wall exhaust fan can be added to help remove fumes and odors. A radon fan is another form of spot ventilation that helps to remove radon gas, which is the second leading cause of lung cancer according to the American Lung Association[3]. Exhaust fans should never vent into attics or crawl spaces because the moisture can cause structural damage over time. These devices should always vent through the space and into the outdoors.

***Air Purification:*** Another approach to improving indoor air quality. Oftentimes, a person with asthma and allergies finds air purification helpful in alleviating symptoms. There are a variety of ways to purify indoor air, ranging from filtration to ultraviolet germicidal irradiation (UVGI). The impact on indoor pollutants is dependent upon the method of purification that is used. Let's take a closer look at the different ways of managing indoor air pollutants with air purification.

Before looking at the different types of air purifiers, let's provide a simple definition. An air purifier is a device designed to cleanse the air in a home or workplace. Some air purifiers are portable while others are incorporated into an HVAC system. Some air purifiers utilize filtration while others use UVC light and some incorporate both. It is important to understand the different methods of air purification:

- Air filtration
- Ultraviolet light
- Photocatalytic oxidation (POC)

***Air Filtration:*** One of the three components of poor indoor air quality is particulate matter. An air filter can physically trap these airborne particles and prevent them from recirculating or spreading. That is why most air purifiers and HVAC systems incorporate some type of air filter into their systems. The most common air filtration ratings are MERV and HEPA.

MERV is a rating methodology that stands for Minimum Efficiency Reporting Value. The MERV rating, which ranges from 1 to 16, is an effectiveness scale that represents the expected performance of a filter.







The MERV rating measures the filters ability to trap particles from 0.3 to 10 microns in size. For example, a MERV 16 filter is capable of trapping particles as small as 0.3 microns whereas a MERV 11 filter is designed to trap particles between 1–3 microns. The higher MERV rating indicates a higher efficiency for trapping smaller particles.

HEPA is a type of filter that stands for High Efficiency Particulate Air. It is a designation used to describe filters that trap at least 99.97% of particles that are 0.3 microns in size or larger.

In order for filters to be effective, a high degree of air circulation is required. A filter cannot remove particles in the air unless the particles pass through the filter. The pressure drop through a filter must be accounted for when selecting a fan.

***Ultraviolet Light:*** For years, ultraviolet (UV) light has been used in food processing, water purifying and medical equipment sterilizing. Today, the HVAC industry is utilizing UV light to improve indoor air quality.

Ultraviolet light is a type of electromagnetic radiation, transmitted by the sun in waves at different frequencies. The wavelength is measured in nanometers (nm) as follows:

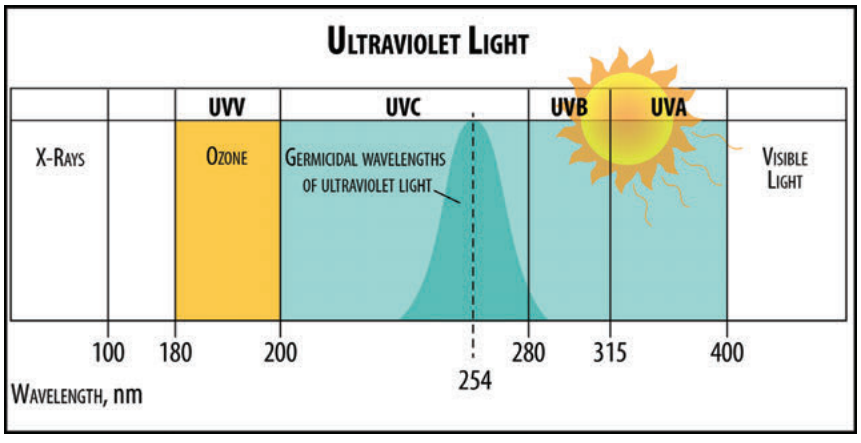
- UVA 315 – 400 nm
- UVB 280 – 315 nm
- UVC 200 – 280 nm

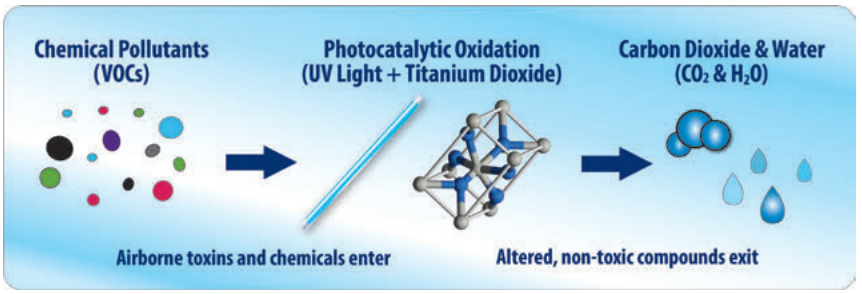
In order to kill microbial organisms like viruses, bacteria and fungi, an air purifier needs to utilize UVC light. In this process, a UVC lamp, also known as a germicidal lamp, uses UVC radiation to damage an organism's DNA. To be effective, the airborne microbes must pass through the treatment zone of the germicidal lamp. It is important to note that not all air purifiers utilize a UVC light. An air purifier without UVC light only traps airborne particulates. It is not designed to kill viruses or bacteria.

Maintenance is a key element in air purification. A UVC bulb loses its effectiveness over time. Filters cannot function properly if they are clogged with particles like dust and dirt. Without regular maintenance, which means following the manufacturers' recommendations, an air purifier will not remain effective.

***Photocatalytic oxidation, also known as PCO:*** A reaction that occurs when Titanium Dioxide (TiO2) is exposed to ultraviolet (UVC) light. This process converts harmful and toxic compounds into benign constituents, such as water and carbon dioxide. To put it simply, this process takes toxins and chemicals from an airstream and chemically

| MERV 1 - 4 | MERV 5 - 8 | MERV 9 - 12 | MERV 13 - 16 |
|---|---|---|---|
| Pollen<br>Dust mites<br>Textile fibers | Mold spores<br>Dusting aids<br>Cement dust | Legionella<br>Pet dander<br>Auto emissions | Bacteria<br>Sneezing nucelli<br>Tobacco smoke |
| > 10.0 (microns) | 10.0 - 3.0 (microns) | 3.0 - 1.0 (microns) | 1.0 - 0.30 (microns) |
| APPLICATION EXAMPLES | | | |
| Window A/C | Paint Booth | Laboratories | Hospitals |
| Residential | | | |
| | Commercial | | |
| | Industrial | | |
| | | Medical | |



alters them into non-toxic compounds. When an air purifier incorporates the photocatalytic oxidation process, it cleanses the air of volatile organic compounds (VOCs) that cleaning products, paint, pesticides and other everyday products produce.

Each method of air purification provides a different approach to combating the various components of poor indoor air quality. Users who want to combat microbial organisms, like viruses and bacteria, will benefit from air purifiers that use UVC light. Users who want to combat particulates, like pollen, dust, and pet dander, will benefit from air purifiers that focus on filtration. Fortunately, there are air purifiers on the market that fit different needs and budgets. While some air purifiers focus on one method of air purification, there are air purifiers that combine filtration, UVC light, and photocatalytic oxidation into one powerful air purifier.

### Ventilation Products to Improve IAQ

Whether implementing source control, improving ventilation, adding air purification, or applying all of the above, there are measures that every homeowner, building manager, and homebuilder can take to improve indoor air quality. In order to achieve these steps, one needs the right devices. From bathroom exhaust fans to air purifiers, Continental Fan offers a superior line of ventilation products that will improve indoor air quality. All have features that result in improved air performance, sound characteristics, and durability. ●



***Jalena Pfister*** *has managed all aspects of marketing for Continental Fan since 2005. She has 20+ years of experience within the ventilation industry.*

**Sources:**

[1] U.S. Environmental Protection Agency. The total exposure assessment methodology (TEAM) study: Summary and analysis. EPA/600/6-87/002a. Washington, DC. (https://www.epa.gov/report-environment/indoor-air-quality#note2 )

[2] United States Environmental Protection Agency (https://www.epa.gov/indoor-air-quality-iaq/improving-indoor-air-quality)

[3] American Lung Association (https://www.lung.org/lung-health-diseases/lung-disease-lookup/lung-cancer/learn-about-lung-cancer/what-is-lung-cancer/what-causes-lung-cancer)

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**Henkel** recently announced that **Steven Essick** has been named its president of the North America region. Essick, who also serves as the regional head of Finance, is a 23-year Henkel veteran who has served in global financial and commercial leadership roles with Henkel across Asia-Pacific, Europe, and North America.

"Our employees and our North American leadership team are well-positioned to stimulate further growth, innovation and sustainable value in the years to come," said Essick. "We have a lot of opportunities ahead of us."



In addition, Nicolas Krauss was recently appointed Henkel's global head of Industrials and Electronics, as well as regional head of Adhesive Technologies Americas, and will join Essick on the North America leadership team. Krauss, who joined Henkel in 2012, was most recently head of Adhesive Technologies Industrials and previously held leadership roles in the company's Automotive Electronics and Electronics Materials business, as well as Global Strategy and Business Development Adhesive Technologies.

Rounding out the North America Leadership team are Alan Wolpert, corporate senior vice president and regional head of Laundry & Home Care North America; Filippos Minaidis, senior vice president and general manager, Beauty Care Retail North America; Jenny Schiavone, vice president, Corporate Communication; Frank Steinert, senior vice president, head of Human Resources; and Marcy Tenaglia, senior vice president, chief legal officer and secretary.

"I am excited to head this team of seasoned leaders for North America who bring a wide range of perspectives, an exceedingly strong set of business experiences and talents, and passion for building diverse, empowered and collaborative teams," said Essick.



**The Adhesive and Sealant Council** (ASC) recently announced changes to its officers and members of the Executive Committee for 2021-2022. It also announced directors who have been reelected for another three-year term on the board of directors, beginning January 1, 2021. Newly elected officers include: **Matt Devine**, former president of DHM Adhesives, now at H.B. Fuller—chairman of the board, through January 31, 2021; **Heather Campe**, senior vice president, H.B. Fuller—will succeed Devine as chairman of the board beginning February 1, 2021, through December 31, 2022; **Forest Driggs**, senior vice president and chief financial officer, Franklin International—treasurer, beginning January 1, 2021, through December 31, 2022.

In addition, **Brian McSwigan**, vice president, Packaging and Consumer Adhesives at Henkel Corp., will serve as past chair for two years and remain on the ASC Executive Committee. The board elected **Tom Stewart**, senior director, Performance Adhesives, at Ashland, to a two-year term on the Executive Committee, beginning January 1, 2021. **Gerhard Haas**, vice president, Research & Development, Technical Service, Purchasing at Jowat Corp., was reelected to another two-year term on the Executive Committee, beginning January 1, 2021.

Reelected members of the ASC board serving a three-year term beginning January 1, 2021, include: **Darius Deak**, global R&D director–Nonwovens, Corporate R&D Director-Americas, Bostik; **Damon Hollis**, sales manager-Americas, Eastman; **Mark Schneider**, president, Albion Engineering Co.; **Tom Stewart**, senior director, Performance Adhesives, Ashland; **Dave White**, senior vice president, Quality and Risk Management, Sika; **Chuck Williams**, senior technical director, Global Adhesives, Polymers, Adhesive and Coatings Center of Excellence, Avery Dennison



**Littelfuse, Inc.** a global manufacturer of leading technologies in circuit protection, power control, and sensing, today announced it has acquired **Hartland Controls**. Headquartered in Rock Falls, Illinois, Hartland Controls is a manufacturer and leading supplier of electrical components used primarily in heating, ventilation, air conditioning, and refrigeration (HVAC/R) and other industrial and control systems applications. For 2020, Hartland Controls had sales of approximately $70 million.

"Hartland Controls is a premier provider of control products and assemblies, with an outstanding reputation for quality, engineering, and customer service," said Peter Kim, Vice President and General Manager, Littelfuse Industrial Business. "We are excited to welcome Hartland Controls' associates to Littelfuse as we combine our capabilities and strong customer relationships."




# The COVID-19 Cold Chain:

## Why Refrigeration Logistics of Vaccine Distribution are Critical

As we prepare to immunize the world against COVID-19 in the coming weeks and months, there will be real logistical challenges involving the storage, transportation, and distribution of the vaccine under temperature-controlled conditions throughout the entire cold chain. Because of the required two doses for full effect of the vaccine, there will be a need for more than 15 billion doses to cover the entire population.

While the two vaccines that are currently approved for emergency use both need to remain frozen, they require different freezer temperatures. Moderna's vaccine is stable at a regular freezer temperature of -20 degrees Celsius for up to six months. However, the Pfizer vaccine must be kept extremely cold, at a temperature of -70 degrees Celsius — a temperature colder than the Arctic. This will require an ultracold freezer to keep the vaccine effective.

### HOW THE COLD CHAIN WILL PLAY A ROLE IN DISTRIBUTION

The cold chain, a temperature-controlled supply chain infrastructure that includes airplanes, trucks and cold storage warehouses, will play a major role in the successful rollout of the COVID-19 vaccine. The vaccines will start at cold storage units in the manufacturing plant, then be transported in refrigerated planes or trucks, and finally be properly stored at the provider facility. At any point in this process a disruption to the cold chain would deem the vaccines too warm and therefore ineffective.

According to the Center for Disease Control and Prevention (CDC), manufacturers, distributors, and health care providers will share the responsibility of ensuring the vaccine cold chain is maintained from the time vaccines are manufactured until they are administered. Disruptions or issues with the cold chain have caused issues in the past. The World Health Organization estimates that nearly 2.8 million doses of vaccines were lost in 2011 because of a broken cold chain. Losing this many doses would be disastrous for gaining control of the COVID-19 pandemic.

### THE IMPORTANCE OF SYSTEM MONITORING

In addition to proper storage at these super cold temperatures, system monitoring will be crucial to ensuring the integrity and quality of these important life-saving products. Regal's newest solution, Scandia™, utilizes connected motors with EIA485 Modbus communications, temperature sensors, and networking capabilities that provide 24/7 real time access to motor functionality and system performance.

In the past, medical refrigeration systems have utilized double condensers to allow for a backup mode in case a failure occurred with the standard condenser. If the motor on the condenser side failed, the second fan could be started without any disruptions to the temperature of the cooler. With the Scandia™ cloud-based asset monitoring solution, it's possible to automatically detect equipment problems well before they become a problem. This allows for immediate corrective actions and maintenance planning in order to help avoid the time and expense of troubleshooting and most importantly – prevent loss of vaccines.

### MOTOR OPTIONS FOR MEDICAL REFRIGERATION SYSTEMS

Regal's wide array of motor offerings include Shaded Pole, Permanent Split Capacitor (PSC), and Electronically Commutated Motors (ECM) with power output from 2W to 75W. These products are ideal for ensuring evaporator and condenser applications in medical refrigeration systems are functioning properly.

All of our Shaded Pole and PSC motors can be sold with a variety of mounting brackets and fan blades in order to optimize airflow and system efficiency. Regal's global manufacturing footprint gives us the ability to quickly adjust our production location to support the increased demand and provide the most cost-effective Shaded Pole and PSC motors for refrigeration equipment needs. In fact, our PSC motors are already successfully being used in vaccine coolers to support the Center for Disease Control and Prevention (CDC) during project Warp Speed.

Our ECMs can operate at up to 72% peak efficiency, which means they dissipate less heat and allow the refrigeration system to operate more efficiently. Our products are certified for use in low Global Warming Potential (GWP) refrigeration systems that are commonly used for vaccine storage, as well as being ATEX certified for being intrinsically safe. Another key benefit of our ECMs is the superior sound performance, which is well-suited for hospitals so healthcare workers and patients can enjoy a more comfortable environment.

### HOW REGAL CAN HELP

In order to support the rapid ramp up in refrigeration equipment needs, we are increasing production of our motors and our manufacturing facilities have developed streamlined procedures to process and ship as quickly as possible. By leveraging our large global manufacturing network, we have motors ready to ship and can supply your demands from multiple manufacturing locations.

Regal is honored to partner with other essential businesses all over the world in the fight against COVID-19. We will continue to do our part in developing reliable solutions that will help to ensure vaccines are safely stored in high-volume cold storage units, refrigerators, and freezers.

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**TTI Floor Care**, the company behind the Hoover and Dirt Devil Brands is closing its facility in Glenwillow, Ohio, according to a letter filed with the State. TTI North America in Charlotte, North Carolina is part of the larger Chinese company. In a WARN letter the company said it planned to close the facility in April. An expected layoff of 65 is part of the closure, as positions are both being eliminated and transferred to a facility in South Carolina. (News release courtesy of Crain's Cleveland Business Feb. 8, 2021 issue).

**Reliance Worldwide Corporation** (RWC) a leading manufacturer of premium branded push-to-connect plumbing products, valves, secondary pipe supports, firestopping solutions and fluid control technologies, is partnering with **Home Builders Institute** (HBI), a national leader in career training for the building and construction industry, as the exclusive Trade Sponsor for its 22 plumbing programs across the U.S., primarily serving Job Corps students and justice-involved individuals.

These HBI programs provide students with the skills, experience and placement services they need to have a successful career while helping the trade address labor shortages.

"We are thrilled to engage with HBI and believe this is the beginning of an important, long-lasting partnership," said Chris Carrier, Marketing Director, Americas at RWC. "HBI's ability to connect, train and place potential new talent into the trade makes them an ideal partner. Not only do we see this as an opportunity to help our trade, but also an opportunity to help the local communities that these programs are in."

This partnership was a natural opportunity for RWC to double down on its commitment to promote and further the plumbing trade after its Careers in Construction Month efforts, through its SharkBite® and HoldRite® brands, in October.

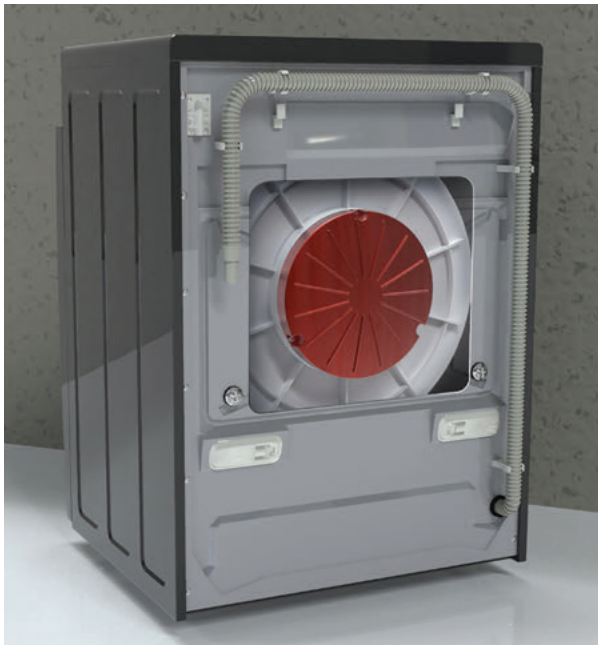
"Our diverse product portfolio enables us to produce solutions that are designed to help plumbing contractors work more efficiently in the field," Carrier continued. "In our conversations with them, we've recognized the need to help the trade address its labor challenge."

HBI's programs help approximately 10,000 students each year receive real life, hands-on training and find meaningful careers in the trades. HBI also provides them with job placement and transition assistance, and qualified graduates are able to enter advanced training programs to expand their education and experience.

"Home Builders Institute is proud to welcome our new partner, Reliance Worldwide Corporation," said HBI President and CEO Ed Brady. "Together, we are training the next generation of skilled labor for the building industry. As HBI's exclusive Trade Sponsor of our plumbing programs, RWC will provide its excellent products to help train our students in 22 locations nationwide. In the process, they will develop customers for life as our graduates enter the industry. I look forward to working with RWC and to seeing how the many resources they bring to the table will help enhance our training programs and ensure the future success of our students."







**Infinitum Electric**, creator of the breakthrough motor that uses a silicon stator, today announced an agreement with a leading consumer appliance manufacturer. Under the agreement, Infinitum Electric will develop its first IEh series motor for consumer appliance applications, to support the creation of a smarter, more energy-efficient, cordless vacuum.

Twenty-five trillion kilowatt hours of electricity are consumed per year, of which 53 percent is consumed by electric motors. This leaves a significant opportunity for the household appliance market to develop or replace machines using traditional electric motors with ultra high-efficiency electric motors, which consume far less energy. Infinitum Electric is enabling this transition as demand increases for eco-friendly products due to both government regulations and consumer preferences.

The market for global smart home appliances is anticipated to reach $92.72 billion by 2027, according to a new report by Grand View Research, Inc., expanding at a CAGR of 14.1% from 2020 to 2027. According to IMARC Group, global electric motor consumption in the household appliance sector is expected to reach a value of US $8.19 billion, growing at a CAGR of 5.04% from 2018-2023.

The IEh Series motors are designed to deliver premium performance for quieter, more efficient consumer appliances with greater durability and connectivity. Infinitum Electric motors are designed with a silicon-based stator used in modern technologies, rather than traditional, cumbersome iron core and copper wire, which drastically reduces weight, size and acoustic noise. Features and benefits include:

• Compact and lightweight: Silicon stator produces the same power rating as an iron core stator, at a 50% lighter weight than traditional electric motors.

• Low acoustic noise: At less than 45 dB for some applications, the IEh motor is one of the quietest on the market. There's no cogging torque and no magnetic force between the rotor and stator to cause magnetic noise, leading to a dramatically quieter motor.

• High operating speed: With a range of 0-110,000 RPM, IEh motors can be engineered for high operating speed.

• Durability: The silicon stator has a 10x longer life than conventional coils and uniform temperature distribution prevents thermal stresses on windings.

• Ultra high-efficiency: With an efficiency rating of greater than 90% for any power rating, stator core losses are eliminated due to the coreless construction.

• Low vibration: With vibration levels of less than .25 mm/sec, simple structure prevents rotors from shifting due to thermal or mechanical stresses.

• Connected design: Integrated electronics and embedded IoT circuitry allow the motor to stay connected to the outside world and with other smart home applications.

"Manufacturers are exploring new ways to incorporate IoT to deliver eco-friendly designs and support digital transformation goals," said Anand Gnanamoorthy, industry principal at Frost & Sullivan. "Infinitum Electric's motors are designed with total efficiency in mind and integrated electronics and IoT circuitry pack a punch, making smart home appliances even smarter."

"Bringing everyday household consumer appliances into a new era of sustainability with our ultra-high efficiency IEh motors is exciting," said Ben Schuler, founder and chief executive officer of Infinitum Electric. "Consumer appliance manufacturers have an opportunity to make an impact on the environment by designing their products in the most energy-efficient way possible. We look forward to helping more customers gain a competitive advantage with differentiated products that decrease carbon footprint, improve performance, reliability and costs."

To learn more about Infinitum Electric's motors designed for consumer appliances, visit https://www.infinitumelectric.com/products/ieh/.



**Megan Fellinger**, CEO of Morrison Products has achieved the **Women of Excellence in Metal Forming and Fabricating award** from MetalForming magazine. The award honors women for their commitment to excellence and for demonstration of excellence in meeting their workplace responsibilities.

"As a provider of information highlighting metal forming technology and productivity, MetalForming proudly recognizes achievement through our Women of Excellence awards program," says Brad Kuvin, MetalForming editorial director. "The 2020 class, like those of the previous four years, represents the best of the best, and provides excellent examples and inspiration for those who may follow in their footsteps."

Fellinger believes the Manufacturing industry is the perfect spot for women who are problem solvers. "It's a fast paced, ever-changing environment where hard work and creativity constantly are required," she says. "Businesses with diversity throughout their workforce have proven to outperform in the industry over time," she adds. "Women are underrepresented in manufacturing today, so the path for success for both you and your future employer is wide open!"

Morrison Products, which also sells under the Lau brand, is a leading manufacturer of fans for the heating, ventilation, and air-conditioning industry. With eight strategically located facilities in two countries, Morrison Products can react quickly to the needs of its customers, shortening the supply chain and saving time and money.




**The Department of Energy's Oak Ridge National Laboratory** recognized its small business partners today at its virtual 2020 Small Business Awards. The annual event, delayed from its usual spring date because of the COVID-19 pandemic, honors the performance of small businesses that have made a positive impact on ORNL's operations.

**Fabrisonic**, a Columbus, Ohio, manufacturer that specializes in 3D metal printing, won in the small business category. The company provides custom-designed equipment in support of ORNL research. "We're thrilled to be selected by ORNL as the small business of the year. This is a testament to the hard work of the Fabrisonic team and unique capabilities of metal 3D printers," comments Mark Norfolk, CEO, Fabrisonic.

"Small businesses are important contributors to ORNL's success, as well as being the cornerstone to ensuring the nation's economic security," said ORNL Director Thomas Zacharia. "Our small business partners have performed outstanding work, despite the challenges posed by a global pandemic."

**The Association of Home Appliance Manufacturers** is pleased to announce the recipients of its 2020 Home Appliance Industry Achievement Awards. This year's awards were presented during AHAM's Special Membership Meeting.

**Dick Topping**, Senior Consultant, P.E., Sub-Zero Group, Inc., received AHAM's Home Appliance Industry Achievement Award, which recognizes exceptional service by AHAM members and is the premier achievement bestowed by AHAM upon a member. Topping has long been a significant contributor to AHAM, serving on numerous committees and chairing the HRF-1 Task Force and HRF-1 Revision Task Force. He is widely respected for his technical and strategic leadership on federal energy standards, and as a role model for volunteer leaders.

**Andy Chinmulgund**, Founder and CEO, Bruviti, Inc., received **AHAM's Gordon Stauffer Liston Durden Distinguished Service Award**, which recognizes significant contributions, by virtue of longevity and quality of service, to AHAM and the home appliance industry. Chinmulgund has established a reputation as a forward-thinking AHAM leader with an excellent understanding of technology trends and their impact on appliances. He played a key role in bringing connectivity and the Internet of Things to the forefront of AHAM's efforts. He serves on AHAM's Board of Directors, as Chair of AHAM's Supplier Division and as a member of the Connectivity Specialists.

Five AHAM members received **AHAM's Emerging Leader Award**. The Emerging Leader Award recognition volunteer contributions and service and encourages continued industry participation. The 2020 winners are: **John Schlafer**, Senior Counsel, GE Appliances, a Haier Company; **Michael McGonagle**, Product Safety and Reliability Leader - Cooking Products, GE Appliances, a Haier Company; **Adam Pope**, Director of Test Engineering, iRobot; **Sean Southard**, Senior Manager Regulatory Affairs, Whirlpool Corporation; **Jason Schmidt**, Director of Regulatory Affairs, Whirlpool Corporation

There were two recipients of the **AHAM Chairman's Partnership Award,** which recognizes significant contributions to AHAM by non-member organization, companies and individuals. The 2020 recipients are: **Caroline Davidson Hood,** General Counsel, Air Conditioning, Heating and Refrigeration Institute (AHRI); **Clark Silcox**, General Counsel, National Electrical Manufacturers Association (NEMA)

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**Bosch Thermotechnology**, a leading global source of high-quality heating and cooling systems, today announced the expansion of its Inverter Ducted Split (IDS) Family to include the market's first 15 SEER rated unitary inverter solution, IDS Light, as well as IDS Plus (18 SEER) and IDS Premium (20 SEER).

Made possible by the new BVA15 air handler and BOVB18 condenser, the new IDS Light system is designed for optimum comfort at an approachable price point. The only 15 SEER (seasonal energy efficiency ratio) unitary inverter system on the market, IDS Light delivers quality engineering, quiet performance and exceptional value to homeowners whose needs may not be demanding enough to require a higher SEER rated system.

"Recognizing a significant need in the market, the Bosch engineering team set out to design a 15 SEER rated inverter to round out the IDS Family, creating an even more expansive solution," said Katie Woodling, Air Conditioning Product Management Group Leader. "Designed with optimum energy efficiency in mind, these systems deliver custom comfort while maximizing value, each packaged in a sleek, quiet unit."

Engineered for high-efficiency, Bosch IDS systems are designed to use the optimum amount of energy to achieve maximum comfort while keeping sound levels to a minimum. One of the quietest systems on the market, the system uses silent blade technology, sound isolating mounts and outdoor condensing section placement to provide sound levels as low as 56 dBA.

Conventional heat pumps' frequent cycling on and off can result in uncomfortable temperature fluctuations. Inverter-driven pumps are able to self-adjust, providing consistent room temperature, even when the outdoor temperature dips below freezing. The on-off cycle of traditional pumps also creates energy surges, while the IDS systems steadily ramp up operation – avoiding energy spikes and protecting the system's life-cycle and energy usage. The high-efficiency systems' ability to operate at optimum energy usage also qualifies for maximum rebates from energy providers, resulting in cost-savings to homeowners.

The Bosch IDS Family now features three solutions to provide homeowners with the right-sized system to fit specific needs:

- IDS Light: Providing the benefits of a 15 SEER inverter system at an approachable price point, this newly designed system combines the efficient and reliable BOVB18 outdoor unit with the BVA15 PSC air handler.
- IDS Plus: Previously IDS 1.0, the 18 SEER IDS Plus system provides a balance of efficiency and comfort through a combination of the BOVB18 outdoor unit with the elevated BVA20 2 stage constant torque ECM style air handler.
- IDS Premium: Delivering the IDS Family's highest efficiency for maximum energy rebates from providers, IDS Premium, previously IDS 2.0, is Bosch's highest efficiency system. Boasting a 20 SEER rating, the system utilizes the top tier BOVA20 outdoor unit with the BVA20 2 stage constant torque ECM style air handler.

Featuring simple installation and service, as well as a ten-year parts residential limited warranty, the IDS Family offers ease and peace of mind for homeowners and professionals alike.



**CASPR Group** announced a reseller venture with **API of New Hampshire / Delta T** (API of NH) to help bring CASPR's disinfection technology to companies and organizations throughout New England.

Since 1969, API of NH has been a renowned sheet metal manufacturer and HVAC distributor in New England. The family-owned company specializes in HVAC and indoor air quality (IAQ) products, giving them the expertise to successfully represent CASPR's portable and in-duct air and surface disinfection products in the market.

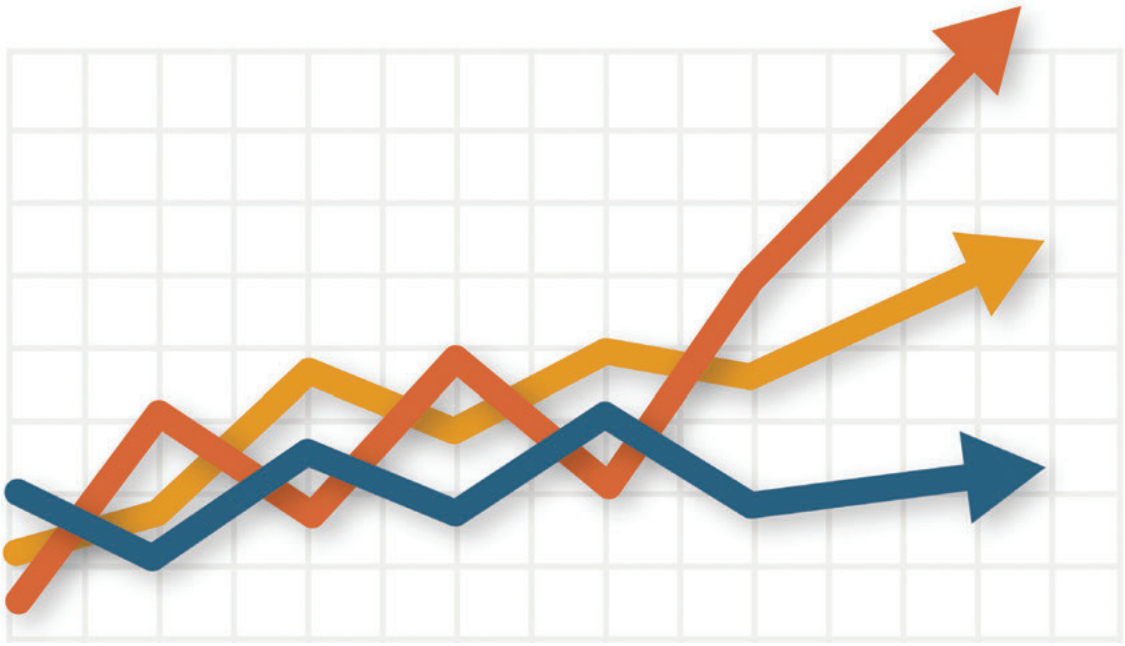
According to Bob Engel Jr, President of API of NH, the quality of CASPR's product line, backed by validated data supporting the products' efficacy, made the company an important addition to their portfolio.

"We pride ourselves on being a value-added distributor that can help our customers grow their businesses with the best products in the market," said Engel. "We've brought on the CASPR line of products because we believe they offer tremendous value and are an excellent offering for businesses and spaces needing continuous surface and air disinfection. When you combine great products with great data to back them up, you have a winning solution."

The agreement with API of NH gives CASPR immediate access to a key market, says Dr. Christophe Suchy, co-founder of CASPR Group and chief inventor.

"API of NH is one of the top HVAC distributors in the country, and they will help us reach companies and organizations throughout New England," said Dr. Suchy. "Our disinfection technology has been proven to kill 99.99% of SARS-CoV-2 viruses within 24 hours, according to a study by the University of Wisconsin, and this new agreement will ensure that we can further expand our solutions to people everywhere."

This article originally appeared in the October 2020 issue of HPAC Engineering and is reprinted with permission.



# Trends in HVAC-Equipment Application

**BY AARON GUNZNER & DAVE MORROW**

An examination of six years of construction-project specifications yields important insights into the state of the HVAC industry, the market for various ventilation-system types in particular.

Technologies and methods used to heat, cool, and ventilate commercial buildings are continually evolving. Those whose job it is to specify, design, install, or operate and maintain building HVAC systems can keep up with the changes or ignore them and risk being left behind.

As part of its continuous surveillance of the HVAC market, AMCA partnered with construction, engineering, and manufacturing-industry consultant Applied Marketing Knowledge (AMK) to study trends in HVAC-equipment application in the United States. The AMCA/AMK team examined six years of construction-project specifications, plans, and addenda within the database of ConstructConnect, provider of construction-management software and tools. This article summarizes the team's findings.

## Data Collection

The authors looked at construction projects from 2013 through 2019, focusing their study on the HVAC zone systems most commonly applied in commercial buildings: ''variable air volume'' (''VAV''), ''fan coil unit'' (''FCU''), and ''water source heat pump'' (''WSHP''), in addition to ''variable refrigerant flow'' (''VRF'') and ''variable refrigerant volume'' (''VRV'').

The scope of the authors' search was commercial- (broadcast studios, laboratories, offices, parking garages, rental warehouses, transportation terminals), educational- (athletic buildings, cafeterias, dormitories, schools), retail- (automotive, bank, entertainment, food stores, hotels, restaurants, shopping centers), government- (courthouses, fire and police stations, government offices, park buildings, post offices, prisons, miscellaneous government buildings), and military- (military housing, military offices, miscellaneous military buildings) building projects in the planning, bidding, post-bid, or awarded stage with specifications containing Construction Specifications Institute MasterFormat Division 23 (Heating, Ventilating, and Air Conditioning [HVAC]) information. It is important to note that while the authors excluded single-family residential projects, they did include multifamily projects (apartments, townhomes, condominiums), which often have commercial HVAC zone systems.

Data from the authors' search was supplemented with interviews of industry professionals. The interviews confirmed and provided greater insight into the project-search data.

## Project-Search Results

Overall, 2013 through 2019 was a period of growth for the HVAC zone options studied. Growth in the number of projects employing the systems averaged 8.3 percent a year from 2013 to 2017 before settling at 4.4 percent in 2018. 2019 was the only time during the studied period that overall market growth declined, falling 2.3 percent (Figure 1).

Variable air volume. VAV-project growth followed a trajectory similar to that of overall market growth, averaging 6.8 percent a year from 2013 to 2017 before settling at 1.1 percent in 2018. 2019 marked the only decline in VAV-project growth, with a drop of 2.9 percent (Figure 1).

The educational- and commercial-buildings markets drove much of the volume in VAV units over the period studied. Educational was the largest market for VAV in terms of number of projects (Figure 2). That commercial has the fewest projects in Figure 2 is somewhat misleading, as commercial projects typically have the most VAV boxes of any vertical market.

The retail- and the government- and military-buildings markets showed much greater variability in number of projects than the other sectors. Retail was stronger in growth than government and military from 2013 to 2017 but lost much of that growth in 2018 and 2019. This is consistent with retail's tendency to expand rapidly and then aggressively contract. Retail has begun to show signs of overall construction weakness as brick-and-mortar stores increasingly give way to online shopping.

**Figure 1:** Projects utilizing HVAC zone options

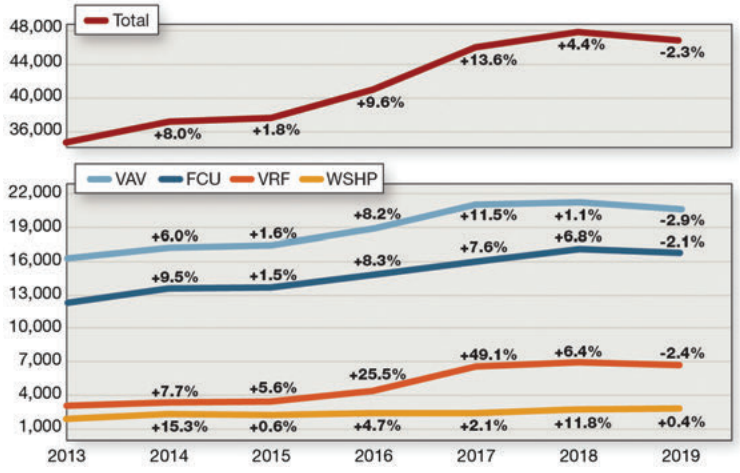
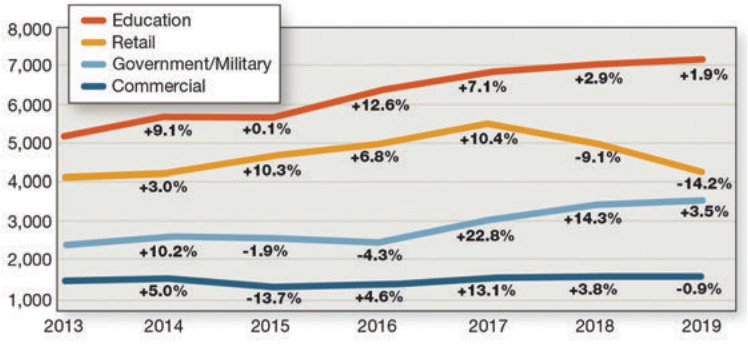



**Figure 2:** . VAV projects by vertical market




Geographically, VAV generally mirrored the overall HVAC marketplace, with the largest concentrations of projects in the most-populated areas. The northeast corridor down through Washington, D.C., as well as Florida, Texas, California, and large cities of the Midwest and Southeast, are where the majority of projects are located (Figure 3).

Fan-coil units. FCU-project growth averaged 6.7 percent a year from 2013 to 2018 before retreating 2.1 percent in 2019 (Figure 1). Volume in the FCU market tends to be dictated by the hospitality market, with the most projects appearing in locations where there are large numbers of multistory hotels, such as California, Florida, Texas, and the Northeast (Figure 4).

Water-source heat pumps. WSHP projects remained largely flat throughout the period examined (Figure 1). The number of projects was relatively small, ranging from 2,000 to 2,700 a year from 2013 to 2019, which can make year-over-year percentage changes seem more dramatic. WSHP projects are most common where adopted by K-12 schools (Figure 5).

Variable refrigerant flow. VRF projects experienced faster growth than the overall marketplace during the period studied (Figure 1). That growth was particularly strong in 2016 and 2017, which saw 25.5-percent and 49.1-percent year-over-year growth,

**Figure 3:**
VAV projects by region

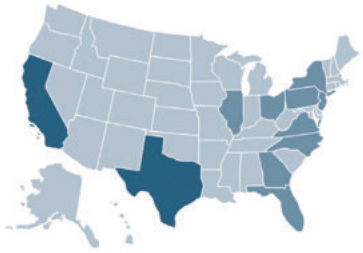


**Figure 4:**
FCU projects by region

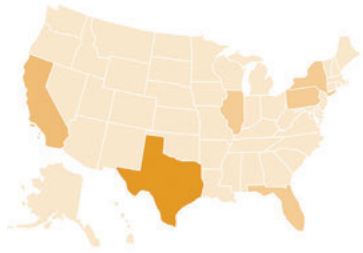


**Figure 5:**
WSHP projects by region

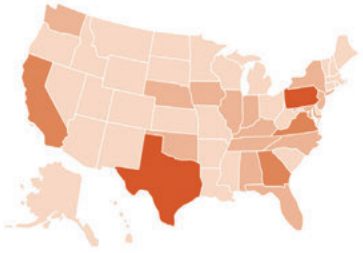
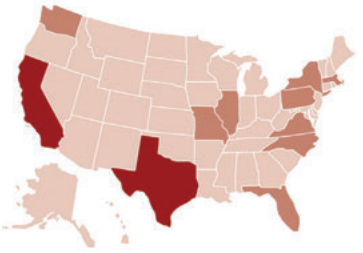


**Figure 6:**
VRF projects by region



respectively. As with WSHP, however, the base of VRF projects is relatively low (approximately 3,000 projects in 2013), which makes for more dramatic percentage increases. But unlike with WSHP, the number of VRF projects more than doubled, to approximately 6,700, by 2019.

Generally speaking, trends in the United States often start in the West and move eastward. This is what the authors observed with VRF project-location data. The West Coast, as well as Texas, have many projects. Additionally, the data show more projects appearing in Missouri, Illinois, Florida, and the Eastern Seaboard (Figure 6).

## Interview Results

Equipment designers, manufacturers, and distributors as well as building owners were interviewed to determine if their experience squared with the data analysis.

The respondents confirmed VRF was growing faster than the overall marketplace. There was no consistent sense of the FCU market relative to the overall marketplace, and it generally was said the market for WSHP was flat or growing slightly slower than the overall marketplace. Many respondents said there is little awareness of the relative health of the market for individual system types when the overall marketplace is growing, that people tend to take notice of individual-system trends only when the overall marketplace slows, as HVAC was doing in 2019.

There was unanimous agreement that, of the technologies studied, VAV and FCU are the best suited for jobs calling for large-tonnage systems. VRF systems were seen as typically being aimed at small to midsize projects. Building maintenance personnel's familiarity with system requirements was seen as heavily influencing the selection of, and ultimate satisfaction with, a system.

All respondents noted the importance of ventilation systems working in concert with heating and cooling systems. VAV stood out for its integration of ventilation with heating and cooling.

## Trends Moving Forward

Though 2020 is shaping up to be a most unusual year because of the coronavirus pandemic and all of the disruptions and uncertainties it has caused, the authors do not expect any sudden or drastic changes to the trends observed in the data from the last six years. VAV likely will remain the dominant system choice for multiple-zone projects, as it is well-known and understood, scalable, and more easily applied to projects with many zones. VRF growth likely will continue at a pace faster than the overall marketplace, as newer products and enhanced ventilation options move the technology along its introductory growth curve. The FCU market is expected to grow more slowly than the overall marketplace, especially if VRF becomes more accepted in such traditional FCU markets as hotels, while the WSHP market is expected to remain mostly flat.

## Conclusion

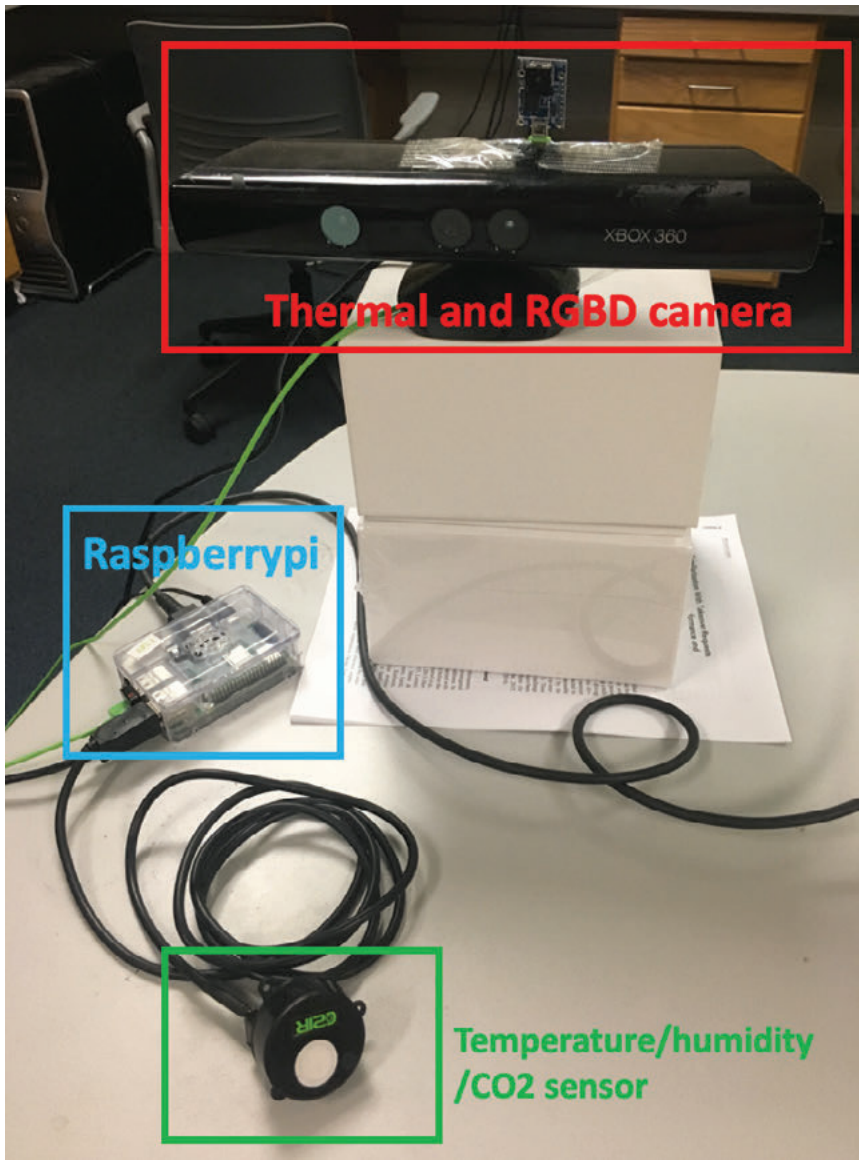
2013 through 2019 was a period of strength and growth for the HVAC industry. VAV is expected to continue to be the leading system type for projects with multiple zones. VRF has grown at the expense of WSHP and is poised to move into more traditional FCU jobs. Moving forward, especially in light of the coronavirus pandemic, building-system professionals will need to apply the same level of focus on ventilation they traditionally have applied on heating and cooling. Reliable market data and analysis of application history will help manufacturers better understand system-use trends and help system designers make the best decisions for their projects ●



***Aaron Gunzner*** *is advocacy manager for AMCA International. Since joining the association's staff in May 2019, he has been assuming responsibility for many advocacy-related initiatives in North America. He has bachelor's and master's degrees in mechanical engineering from Colorado School of Mines.*



***Dave Morrow*** *is managing partner for Applied Marketing Knowledge (AMK), a consulting firm specializing in new-market development and market growth for companies in the construction, engineering, and manufacturing industries. He has a bachelor's degree in mechanical engineering from Rose-Hulman Institute of Technology.*




# Turning Faces Into Thermostats

**BY GABE CHERRY**

As lockdown requirements ease, COVID-19 is changing the way we use indoor spaces. That presents challenges for those who manage those spaces, from homes to offices and factories. Not least among those challenges is heating and cooling, which is the largest consumer of energy in American homes and commercial buildings. There's a need for smarter, more flexible climate control that keeps us comfortable without heating and cooling entire empty buildings.

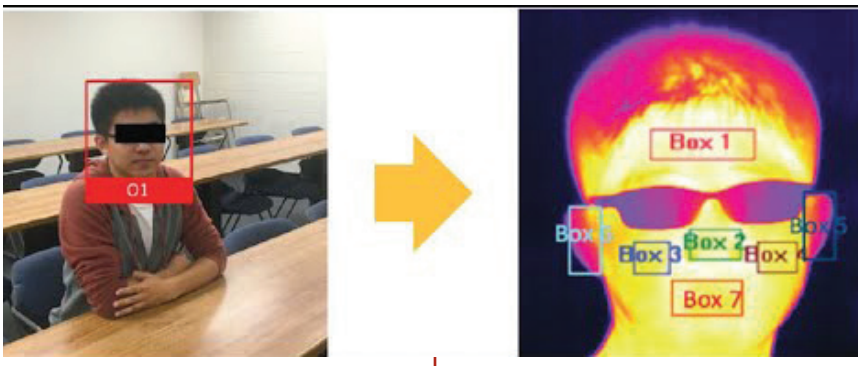
Now, a group of researchers at the University of Michigan has developed a solution that could provide more efficient, more personalized comfort, completely doing away with the wall-mounted thermostats we're accustomed to. Human Embodied Autonomous Thermostat or "HEAT" is detailed in a paper published in the July 2020 issue of Building and Environment.

The system pairs thermal cameras with three-dimensional video cameras to measure whether occupants are hot or cold by tracking their facial temperature. It then feeds the temperature data to a predictive model, which compares it with information about occupants' thermal preferences. Finally, the system determines the temperature that will keep the largest number of occupants comfortable with minimum energy expenditure. The new study shows how the system can effectively and efficiently maintain the comfort of 10 occupants in a lab setting.

"COVID presents a variety of new climate control challenges, as buildings are occupied less consistently and people struggle to stay comfortable while wearing masks and other protective gear. HEAT could provide an unobtrusive way to maximize comfort while using less energy," said Carol Menassa, who is an associate professor of civil and environmental engineering, the principal investigator of the project and an author on the paper.

"The key innovation here is that we're able to measure comfort without requiring users to wear any detection devices and without the need for a separate camera for each occupant."

HEAT works a bit like today's internet-enabled learning thermostats. When it's newly




installed, occupants teach the system about their preferences by periodically giving it feedback from their smartphones on a three-point scale: "too hot," "too cold," or "comfortable." After a few days, HEAT learns their preferences and operates independently.

The research team is looking for commercialization partners to help bring the technology to market, and is also working with power company Southern Company Research and Development to begin testing HEAT in its Alabama offices. Test cameras will be mounted on tripods in the corners of offices; Menassa explains that cameras would be placed less obtrusively in a permanent installation. The cameras collect temperature data without identifying individuals, and all footage is deleted immediately after processing, usually within a few seconds.

Facial temperature is a good predictor of comfort, Menassa said. When we're too hot, the blood vessels expand to radiate additional heat, raising facial temperature; when we're too cold, they constrict, cooling the face. While earlier iterations of the system also used body temperature to predict comfort, they required users to wear wristbands that measured body temperature directly, and to provide frequent feedback about their comfort level.

"The cameras we're using are common and inexpensive, and the model works very well in a residential context," said Vineet Kamat, a U-M professor of civil and environmental engineering and electrical engineering and computer science and an author on the paper. "Internet-enabled thermostats that detect you and learn from you have sort of built a platform for the next phase, where there's no visible thermostat at all."

HEAT's predictive model was built by U-M industrial operations and engineering associate professor Eunshin Byon, who is also an author on the paper. She believes that tweaks to the model could make the system useful in applications beyond homes and offices—in hospitals, for example, where care providers struggle to stay comfortable under masks and other protective equipment.

"The COVID-19 pandemic requires nurses and other hospital workers to wear a lot of protective gear, and they've struggled to stay comfortable in the fast-faced hospital environment," Byon said. "The HEAT system could be adapted to help them stay comfortable by adjusting room temperature or even by signaling to them when they need to take a break."

In partnership with the U-M school of nursing, Menassa's research group has already conducted a pilot study that explored how the system can be used to provide personalized thermal comfort for nurses working in healthcare environments such as chemotherapy administration units.

HEAT is available as a licensable technology through the U-M Office of Technology Transfer.

The paper is titled "HEAT – Human Embodied Autonomous Thermostat." The U-M Office of Technology Transfer has applied for patent protection for the technology. The research was supported by the National Science Foundation, grant numbers CBET 1349921 and CBET 1804321. The research team has filed patent applications related to the technology. The research team also includes former U-M graduate research assistant Da Li, who is now an assistant professor of civil engineering at Clemson University.

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***Gabe Cherry*** *is a Senior Writer and Assistant Magazine editor, Communications and Marketing, College of Engineering, University of Michigan. Gabe has been a writer and editor for the U-M College of Engineering since 2014.*

**Figure 1:** A sampling of NRTL product labeling certifying consumer product safety compliance.




# Electrical Safety Testing for Consumer Devices

**BY VITREK**

Electrical appliances, computers and peripherals, power tools and other devices found in home and office environments must be tested to confirm adherence to a plethora of stringent certification standards.

## Introduction

The vast array of consumer devices for the home and office – from blenders and ovens to computers and high-definition LED TVs -- are becoming increasingly sophisticated. Refrigerators, once basic electrical appliances, now often include adjustable-speed motor controls, digital displays and Bluetooth communications. Even the lowly toaster has advanced models touting color displays.

While the complexity and functionality found in this class of devices varies extensively, there is one thing they all have in common when products enter the market: proven safety compliance. It is a foregone expectation that electrical and electronic devices designed for consumer environments will have been tested and labeled as compliant according to applicable safety standards, which means bearing the mark of a Nationally Recognized Testing Agency (NRTL). Depending on where in the world the product will be operating, the labeling could have one or many of those listed in Figure 1.

## Compliance Considerations

Compliance with the applicable standards, which can vary widely from country to country, typically involves both mechanical and electrical safety considerations. Manufacturers must either submit samples of their products to an NRTL for testing or secure the authorization to conduct the tests themselves.

The certification process is conducted to confirm compliance with the relevant standard(s). This compliance evaluation investigates two key areas: **Construction** - mechanical construction, spacing, clearances, etc.; and **Safety** – to ensure safe operation (even under high-stress conditions).

Table 1 lists the details typically required in the certification process. Many of these criteria (as noted in boldface type) are confirmed by using electrical safety (hipot) testing devices.

- Marking and instructions
- ***Protection against access to live parts***
- Starting of motor-operated appliances
- ***Power input and current***
- Heating
- ***Leakage current***
- ***Creepage distances, clearances and distances through insulation***

- Moisture resistance
- Resistance to rusting
- Provision for earthing
- Overload protection of transformers and associated circuits
- Terminals for external conductors, screws and connectors
- Radiation, toxicity and similar hazards
- Stability and mechanical hazards
- Mechanical strength
- Construction
- ***Supply connection and external flexible cords***
- ***Internal wiring***
- Recognized components

## Safety Standards

The details of what constitutes a certified product is dependent upon hundreds of safety standards and the region of the world where the device will be sold and used. Fortunately, work is being done to harmonize this daunting number of international standards. For example, a recent article entitled, "UL 60335-1 Explained: "Safety of Household and Similar Electrical Appliances," points out the nearly identical counterpart in The European IEC 60335-1 standard. Here is how this harmonization is described[1]:

In North America, IEC 60335-1 has been used as the basis for a tri-national standard between the United States (UL 60335-1), Canada (CAN/CSA-C22.2 No. 60335-1), and Mexico (NMX-J-521/1-ANCE). In the US, UL 60335-1, which is in its 6th edition, is harmonized to IEC 60335-1 as part of its participation in the HOUS (Household and Other Similar Equipment) category of the IECEE (ICE Electrical & Electronic Equipment).

In Europe, the harmonized standard is EN 60335-1 and defines how appliances may comply with European directives, such as the low voltage directive. Unlike the United States, the EU recognizes most, if not all, of the 100+ part 2 standards related to specific products.

## Product Classification

For purposes of this paper, the harmonized UL/IEC standards will be used to categorize various classes of consumer apparatus.

- **Class 0**

Products are provided with basic insulation only as a provision for basic protection and have no provisions for fault protection. Due to the limited safety features, their application is limited to areas that are physically protected from the public with fences or other measures that restrict access.

- **Class I**

Products have basic insulation and must incorporate a protective earth (ground) connection to mitigate the risk of electric shock.

- **Class II**

Products feature additional safety precautions such as double insulation or reinforced insulation, thereby eliminating the need for a protective earth (ground) connection. Therefore, Class II input power supplies have a 2-pin input receptacle instead of the 3-pin input receptacles found on Class I input models.

- **Class III**

Products are designed to be supplied from a separated extra-low voltage power source. The voltage from a SELV supply is low enough that under normal conditions a person can safely come into contact with it without risk of electrical shock.

## Types of Tests Required

Electrical safety test equipment utilized to perform the range of tests prescribed in Table 1 will need to perform one or many of the following test procedures:

***Hipot Testing*** is the short name for a high-potential (high-voltage) dielectric withstand test. A hipot test checks for sufficient insulation and isolation between line and neutral to ground. Hipot testing is one of the minimum-production tests of consumer products. Defects that are often detected with the hipot test include contamination (dirt, debris) and lack of proper spacing (creepage and clearance) of components. Contamination would likely cause an unacceptable level of leakage current. Clearance problems could result in breakdown.

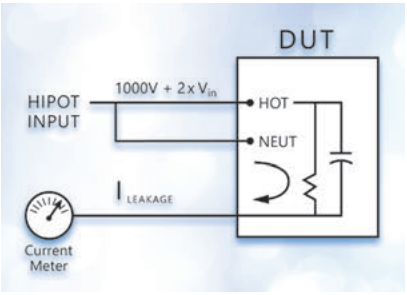



**Figure 2:** Hipot, applied to both conductors and leakage, is measured in return circuit through the ground connection.

***Ground Continuity Testing*** is performed to confirm that the conductive chassis of a device is safely connected to the earth ground pin on the power plug. This assures protection against shock hazards even if the equipment suffers an internal short to the chassis. The current would be shunted via the ground wire and would likely trip the breaker or blow the fuse. Ground continuity is performed by measuring by applying a low current (e.g., 50 mA) and calculating the resistance from the ground pin on the power plug to selected locations on the exposed surfaces of the device under test, or DUT.

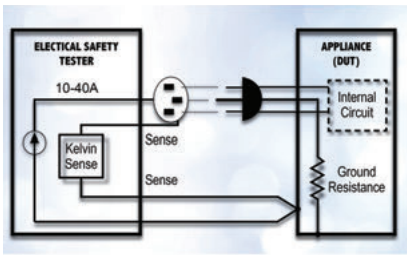



**Figure 3:** Ground continuity measures the resistance from the appliance's ground pin to the chassis.

***Ground Bond Test*** assures the integrity of the connection. Using the same test setup, a high current (up to 40A) is passed through the circuit. If the ground bond is solid, the current passes without a change in resistance. If weak, the resistive heating of the current would induce a failure of the bond. This is one area where the IEC and UL specifications differ. The EU standard commonly includes ground bond testing while the UL standard does not.

***Insulation Resistance Testing*** is likely to be required in motor winding, transformer winding and other applications involving cabling or insulated wire. It typically involves confirming that the resistance exceeds a defined high-resistance value.

In many instances, insulation resistance needs to be measured between several conductors. Examples include cable/connector assemblies, multiconductor cables and relays. To make this measurement, all the conductors except one are shorted together and the test voltage is applied from the remaining conductor across the bundled ones. Each wire is then, in turn, tested in this fashion (Figure 3).

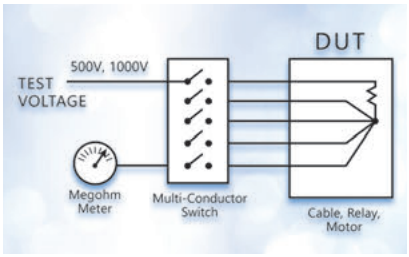



**Figure 4:** An insulation resistance test: voltage is applied to one conductor at a time while adjacent conductors are bundled. Resistance is calculated based on leakage current.

## Application of the IEC/UL Standard

As noted earlier, IEC/UL 60335-1 is a standard covering both mechanical and electrical aspects of the product. The specific area of the standard related to electrical conditions is Section 16.3. Common requirements for these tests include the following:

- Minimum output power rating of 500 VA
- Test voltages
  - 1250VDC – Class 0 and Class I
  - 1750VDC – Class II
- Basic test sequence:
  - Ramp up from 0 V to Test Voltage – 5 seconds
  - Dwell at Test Voltage – 60 seconds

The 60335-1 standard also has a specific section (Annex A) that prescribes specific test conditions and pass/fail criteria utilizing the common requirements listed above.

- Annex A – Hipot
  - Leakage current:
    - ▶ <5 mA (standard)
    - ▶ <30 mA (high leakage equipment)
- Annex A – Ground Bond / Continuity
  - Ground Bond Test Current: 10 A
  - Ground Continuity Resistance
    - ▶ Plug connected - < 200 mΩ
    - ▶ Hard-wired - < 100 mΩ
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## Conclusion

Basic appliances like refrigerators, toaster ovens, air conditioners, microwave ovens, and many others, have evolved to include a range of embedded electronics providing graphic displays, Bluetooth communications and other features. The IEC/UL 60335-1 standard provides a comprehensive roadmap for assuring that consumer appliances and other electrical/electronic devices found in the home are safe. Many of these requirements are confirmed, both in the design stage as well as in production, using electrical safety (hipot) testers. ●

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Figure 2: UV-C's blue color results from the argon gas in the lamp envelope.

# How UVC Improves Efficiency

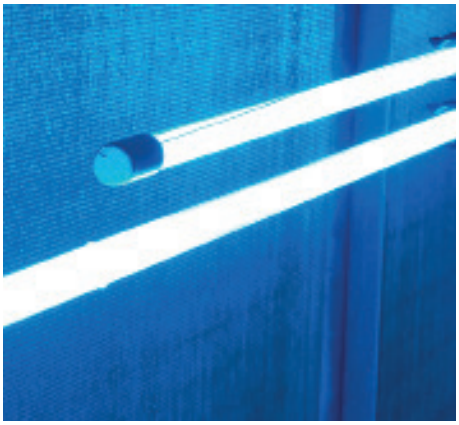
**BY DANIEL JONES**

As air-conditioning / refrigeration equipment ages, its ability to maintain temperatures and humidity levels declines. Most often, the culprit is reduced coil heat-transfer effectiveness, or the ability of air-handling-units' (AHU) cooling coils to remove heat and moisture from the air.

These inefficient heat-transfer rates derive primarily from the buildup of organic contaminants on, and through, the coil's fin areas. Such buildup is eliminated through the use of ultraviolet germicidal energy or light energy in the UV-C wavelength (253.7nm). UV-C works by disassociating molecular bonds, which in turn disinfects and disintegrates organic materials.

## Restoring Cooling Capacity

UV-C lighting systems are not an exotic, new technology. They have been used extensively since the mid-1990s to significantly improve HVAC/R airflow and heat-exchange efficiency, which can reduce HVAC/R energy use by up to 25 percent. Although UV-C by itself doesn't save energy, it restores cooling capacity and airflow to increase the potential for energy savings.



In fact, researchers have found that exposing a fouled cooling coil to UV-C resulted in a 10 percent decrease in pressure drop and a 14.55 percent increase in heat transfer coefficient levels at reference conditions.[1]

In new/OEM equipment, UV-C keeps cooling coil surfaces, drain pans, air filters and ducts free from organic buildup for the purpose of maintaining "as-built" cooling capacity, airflow conditions and IAQ. In retrofit applications, UV-C eradicates organic matter that has accumulated and grown over time and then prevents it from returning.

Although UV-C is a relatively simple technology, i.e., shining lamps onto surfaces and adding simple on/off controls to facilitate maintenance, many professionals are mystified about how UV-C works and how to apply it cost effectively. This article addresses these aspects of UV-C technology and the applications

that seem the most confusing. Our guidance closely follows ASHRAE industry advice found in Chapter 60.8: Ultraviolet Air and Surface Treatment in the 2015 ASHRAE Handbook – Applications.[2]

### UV-C Basics

We all are familiar with the harmful effects of UV from sunlight in the UV-A and UV-B wavelengths, giving rise to sunburn and the need for UV inhibitors, or blocking agents, which are found in such things as glasses and lotions.

However, unlike UV-A and UV-B radiation, the UV-C wavelength has more electron volt energy and is well absorbed (not reflected) by all organic substances, increasing its destructiveness. Given these properties, why don't we hear more about protecting ourselves from UV-C exposure outdoors? The reason is that UV-C is absorbed by the ozone layer and much of the atmosphere, and does not reach the Earth's surface.

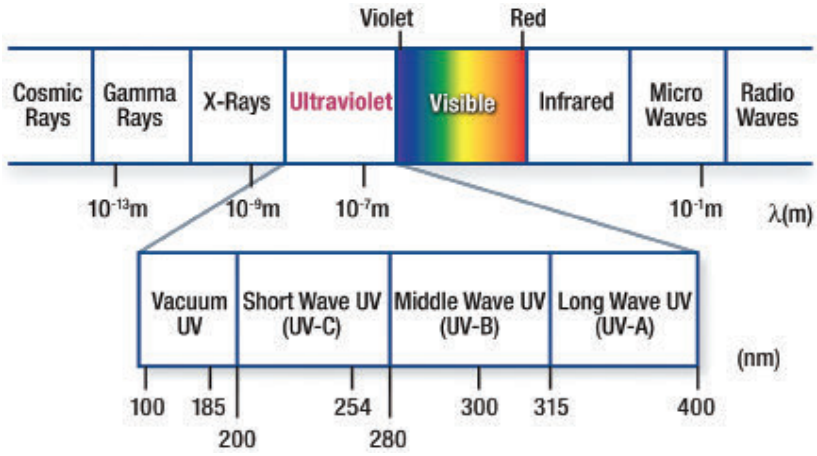



**Figure 1: The electromagnetic spectrum, with a breakout of visible light segments colors. The UV spectrum ranges from 100 nm to 400 nm and is invisible.**

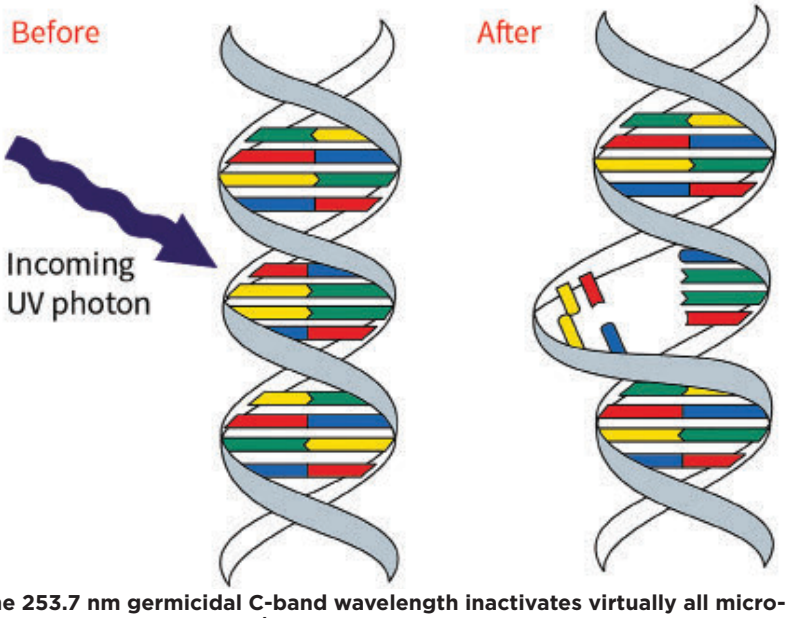
So how much UV-C is needed to destroy organic matter? A 2010 study commissioned by ASHRAE and the Air Conditioning, Heating, and Refrigeration Institute (AHRI) found that even the most sophisticated organic compounds suffer from exposure to HVAC/R dosages of UV-C energy. Because UV-C lamp installations in HVAC/R applications operate continuously 24/7/365, a well-distributed dose similar to visible light is all that's needed.

### UV-C Lamps and Lamp Replacements

Modern UV-C lamps are very similar to fluorescent lamps typically found in ceiling fixtures. Both types of lamps operate using identical electrochemical processes: i.e. an electric discharge through argon gas striking mercury vapor to generate a photon with a wavelength of 253.7 nm (typically called UV-C), which, in and of itself, is invisible.

UV-C lamps differ slightly from their fluorescent counterparts in that the UV-C lamp's glass envelope must be a highly engineered, UV-C transparent shell. This allows the 253.7 nm wavelength to escape through the lamp envelope unfiltered. Fluorescent lamps, however, use ordinary glass which blocks the UV-C wavelength. The glass is also internally coated with phosphors. The UV-C energy is "contained" to excite the phosphors to glow (fluoresce) in the visible light range.

A typical UV-C lamp produces about 90 percent of its energy in the UV-C wavelength. About 4 percent of its energy is given up as heat, and the rest (~5 percent) is in the visible light range that is medium blue in color (Figure 1). This blue color, shown in Figure 2, results from the argon gas in the lamp envelope.




**The 253.7 nm germicidal C-band wavelength inactivates virtually all micro-organisms living on HVAC/R surfaces with a kill ratio of 90 percent or higher, depending on UV-C intensity, length of exposure, lamp placement and lamp life cycle.**



**Figure 3: Single-ended UV-C fixtures can be easily mounted from the exterior of any HVAC plenum or duct, making them ideal for hard-to-access equipment.**

### Change Annually

UV-C lamps typically provide more than 80 percent of their initial output over a 9,000-hour period. Because UV-C lamps should be operated continuously, the corresponding 8,760 hours of a 24/7 schedule also fits conveniently into annual re-lamping schedules of lighting lamps.

Attempting to run UV-C lamps longer than 9,000 hours will produce individual lamp outages, requiring maintenance staff to monitor them routinely to verify operation. This individual monitoring of lamps requires a larger inventory of replacements for when the lamps begin to fail in larger numbers.

Like fluorescent lamps, UV-C lamps come in a variety of types and sizes, including single-ended and double-ended. The single-ended lamps are used in several lamp systems, some of which allow the lamps to be inserted through a plenum or duct into the air stream, typically downstream of the cooling coil (Figure 3). Double-ended lamps have pins at both ends, and are installed into specific length fixtures usually containing the ballast like a fluorescent fixture. Typically, all types are available in standard output (SO) and high output (HO) models. The difference between the two is their Watt and ballast rating. HO lamps are usually recommended because they are less expensive on a per-lamp-Watt basis.

Another consideration for contractors is opting for encapsulated lamps, which have a transparent Fluorinated Ethylene Propylene (FEP) coating over the glass envelope. Encapsulated lamps hermetically seal UV-C lamps in case of breakage. Should an accident occur, broken glass and mercury will remain safely within the lamp.

### UV-C Benefits

UV-C systems provide several benefits when applied to HVAC/R systems: Efficiency; occupant comfort/indoor air quality, environmental impacts and economic impacts.

***HVAC/R system efficiency:*** UV-C eliminates and/or prevents the buildup of organic material on the surfaces of coiling coils, drain pans, and interior air-handler surfaces. This improves airflow and returns/maintains heat-transfer levels of cooling coils to "as-built" capacity. As a result, the HVAC/R system does not use more energy to provide the desired amount of cooling effect and ventilation capacity, which maintains system energy efficiency. On average, UV-C coil installations on existing systems reduce HVAC/R energy use by between 10 and 25 percent.

***Comfort and IAQ:*** Clean coils and drain pans don't contribute odors, allergens, or pathogens to air streams and help the HVAC/R system sustain design temperatures and airflow rates. This means that functional and performance goals communicated by codes, standards and the owner's project requirements can be met. In doing so, UV-C systems help deliver quality comfort and IAQ that lead to occupant productivity, reduction of sick days, and reduced hot/cold calls and other service requests.[3]

***Environmental impacts:*** Reducing energy costs, sick calls, service calls and system downtime for maintenance translate into significant cost savings for applying UV-C in commercial HVAC/R systems. It can also be inferred that buildings with highly functioning HVAC/R systems that deliver the benefits described above will increase the value of building tenant leases because they will have lower HVAC/R-related overhead and lower occupant turnover.

### Summary

UV-C light is an incredibly effective and affordable technology for keeping critical components of commercial HVAC systems clean and operating to "as-built" specifications. Benefits of applying UV-C lamps in HVAC systems include greater energy efficiency, lower operating expenses, fewer occupant complaints, and better IAQ. For all these benefits, UV-C is relatively easy to apply – it's basically installing a bank of UV-C lamps in an air handler, or in a rooftop packaged system, and then replacing the lamps once per year. ●



*The president and co-founder of UV Resources, a provider of UV solutions and replacement lamps for HVAC systems,* ***Daniel Jones*** *is an ASHRAE Member and a corresponding member of the ASHRAE Technical Committee 2.9 and ASHRAE SPC-185.2, devoted to Ultraviolet Air and Surface Treatment. He may be reached at dan.jones@uvresources.com.*

[1] (Firrantello 2016). Firrantello, J.T., Bahnfleth, W. P., Montgomery, R., Kremer, P. K., "Field Study of Energy Use-Related Effects of Ultraviolet Germicidal Irradiation of a Cooling Coil," 12th REHVA World Congress CLIMA 2016, May 22-25, 2016, Aalborg, Denmark.

[2] 2015 ASHRAE Handbook—HVAC Applications -HVAC Systems and Equipment. ASHRAE. Chapter 60: "Ultraviolet Air and Surface Treatment."

[3] Menzies D, Popa J, Hanley J, Rand T, Milton D. Effect of ultraviolet germicidal lights installed in office ventilation systems on workers' health and wellbeing: double-blind multiple crossover trial. THE LANCET 2003; 362:pp1785-1791.



# Information Management for Product Safety and Product Liability (Part 2)

**BY KENNETH ROSS**

## Document Management Programs

An effective document management program includes the development of guidelines and procedures for determining which documents to create, which words to use and not use, how to deal with safety issues, how long to keep documents, when to destroy documents and how to destroy them, and in which format documents should be retained.

The pervasiveness of electronic records as the only record type that many manufacturers now create and keep makes developing a document management system difficult. And, the document management programs of many manufacturers simply address when to discard documents or delete them from the company's database. Such a narrow focus is inadequate; a document management program should consider many other elements, and without proper handling, those elements can lead to liability.

It is helpful for each manufacturing entity to establish a document management policy and guidelines. This policy should confirm that employees are encouraged to bring to management's attention, orally or in writing or both, all good and bad information about the design and manufacturing process of which they are aware. In other words, a company should encourage employees to reveal potentially damaging information and bring it to the attention of supervisors rather than ignoring it.

The policy should also contain guidance on the kinds of documents that employees should create and how to compose those documents so that they are truthful, accurate and complete and will help support a defense or are at least defensible. It should contain retention schedules for all documents, including electronic records.

Another essential part of managing a document program is educating employees about the policy and how to comply. A company's training must clearly show that the company is interested in learning about all good and bad information concerning its products, and its documents should reflect the concern that it has for selling safe products that comply with all applicable laws, regulations, and standards.

## Legal Requirements

Every manufacturer doing business in the U.S. must be acquainted with the safety and quality related document creation and retention requirements imposed by U.S. and international laws and regulations. In addition, a manufacturer must consider mandatory and voluntary

standards or certifications in the U.S. and elsewhere. For example, a manufacturer must develop and maintain certain documents to confirm compliance with certain European Union (EU) Directives and Standards to attach a CE mark to a product sold in the EU.

Documentary evidence of compliance with such standards may strengthen a defendant's case in a product liability lawsuit. You can use that evidence to confirm that a manufacturer took steps to ensure that its products were reasonably safe and complied with all applicable laws, regulations, and standards. In other words, both the legally required and voluntary documents can be used to support claims that a manufacturer considered safety during the design phase of the product.

Last, a manufacturer must be aware of and try to comply with any customer requirements for document creation and retention.

### Defensive Writing

Writing defensively does not mean that a manufacturer tries to hide bad information or evidence or shades the truth. On the contrary, a company's policy and educational programs must stress to employees that they should raise all issues, good or bad, during the development of the product and after sale.

In fact, the documents must portray correctly and accurately a manufacturer's rationale for designing and making its product. A record of this rationale is necessary for designing future similar products and for good historical corporate record keeping. In addition, if the content of some documents challenge or discuss safety, they must be written so that they do not create misleading impressions and allow a plaintiff to use the quotes out of context against a manufacturer in litigation.

Those employees who draft the manuals, plans, specifications, and other documents, especially those written post-sale —the "writers"— should avoid legal terms that describe theories that a plaintiff's attorney may present to a jury in a product liability lawsuit. These include terms such as "defect," "negligence," "misrepresentation" and "reckless." Use of these and related legal terms by internal writers may lead a jury to decide that a company is admitting or has admitted that its product is defective or unreasonably dangerous or legally deficient in some other way.

While a writer will have a chance to tell a jury why the word "defect" did not really mean defect in a product safety sense, the inclusion of such a loaded word in, for instance, a report on the development of a new product or an investigative report after an incident gives a plaintiff an advantage in presenting his or her case to the jury.

Additional phrases and words to keep out of documents include overstated or unsupported expressions, characterizations or opinions. They can cause problems for a company. For example, writers should not use phrases such as "occurs often" or "occurs frequently" when an engineer has only noticed two or three occurrences. Don't use the word "catastrophic" in connection with a product failure unless it truly was catastrophic. "Catastrophic" may be a commonly understood term among engineers, but it may be unnecessarily strong and inflammatory when heard by a jury.

Another term to avoid is "crisis." Writers trying to get the attention of their supervisors may want to call every problem a crisis. This is unnecessary overstatement; it suggests that a company is having huge problems all the time. Similar terms are "smoking gun," "ticking time bomb," and "sitting on a powder keg." They are inflammatory, maybe overstated, and definitely unnecessary.

In addition to choosing words and phrases carefully, a company must organize its flow of documents to ensure that supervisors read and analyze such information, and then respond to bad reports or criticisms written by a company's lower-level employee. This is called "closing the loop."

### The Danger of Not Retaining Documents

Documents that describe a manufacturer's concern for and incorporation of safety into the design of its product are of little litigation value if they are not retained long enough to be introduced in a future lawsuit. In fact, if a manufacturer lacks documents, a plaintiff's attorney might use that fact against the manufacturer by raising a rebuttable presumption that the documents were incriminating and were destroyed for that reason.

Some companies might destroy such reports shortly after a product launch because they do not reflect the final design. This would make it more difficult for a plaintiff to argue that the manufacturer should have adopted one of the rejected alternative designs. However, with no documents on which to rely, witnesses testifying on behalf of the company will have to describe from memory which alternative designs were considered and rejected, which safety tests were performed during the design of the product to select the final design, and how the company incorporated safety into the final product. Moreover, the company's liability may well rest on the company witness' credibility in front of a jury rather than on the facts of the design process. In some situations, it might be better

to retain the documents pertaining to the alternative designs that were ultimately rejected.

## Product History File

A comprehensive retention program should contain a history of the life of a product, from creation through end of life. Having a core history, initially assembled after the development of each product or product line, will allow a manufacturer to prove that it complied with all safety and other requirements on a routine basis. The project manager could gather all documents from all sources within a company pertaining to the project and organize them into a comprehensive, coherent file that describe the history of the development of the product. Drafts and duplicates of documents should be destroyed. Documents should be organized so that an email and its response are grouped together.

Developing this product history file does not mean that potentially harmful documents, such as an internal memo that questions whether a company's current design is reasonably safe, should be destroyed. In fact, attorneys can usually determine if documents have been destroyed and will try to argue that the manufacturer had something to hide.

Juries and judges understand that there may be internal differences of opinion during the development of a product. All a manufacturer will need to explain is how the manufacturer handled this dissenting opinion—that it was fully considered and then accepted or rejected – and the basis of the final decision. Disclosure of dissension within a company can be beneficial; it confirms that a manufacturer encourages varying opinions and does not try to hide bad or potentially damaging information. Of course, it can also be harmful if a jury believes that the rejected opinion was correct.

There are no specific or universal guidelines on how long a company should keep documents related to safety. A company does need to comply with certain legal requirements, any customer requirements, and any requirements in voluntary standards that it complies with. And companies will have an overriding sense of how long to keep documents to support their business purposes. Otherwise, documents that are necessary to explain a product's design should be kept if they might be needed to defend the manufacturer. A company will need to make decisions about retention time on a case-by-case basis, first considering the life expectancy of a product, applicable statutes of limitation and repose, and how long after the product's expected life that the company might anticipate claims or lawsuits, to name a few.

A manufacturer should also consider keeping some documents forever, especially if they represent an old design. Subsequent designs and redesigns are often based on earlier designs. And since products evolve over time, a manufacturer may need earlier product development documents to explain later designs.

As a result, if such a file were developed, a company should keep the product history file permanently in electronic form which would allow specific files to be easily located.

## Conclusion

Implementing a good document management program for product safety, quality, and compliance can be hard. This is especially true if the manufacturer has not had any problems, since it is difficult to know what documents will be necessary or helpful later in the event there are future unknown problems.

So many things can go wrong, especially with complex products such as appliances and HVAC systems that contain many components. Not only should a program consider documents prepared by the manufacturer, but it should also consider documents that should be prepared by component suppliers and those in the distribution chain which will help confirm the safety of the product. And if there is a safety issue, the documents should help pinpoint the root cause and the culpable party. ●



***Kenneth Ross*** *provides legal and practical advice to manufacturers and other product sellers in all areas of product safety, regulatory compliance and product liability prevention, including safety management, design, contracts, warnings and instructions, and post-sale issues including recalls and dealing with the CPSC. He was an attorney at Westinghouse Electric and Emerson Electric and has been active in product safety and product liability for electric and gas appliance and HVAC manufacturers for over 40 years. He is a former partner and now Of Counsel to the national law firm, Bowman and Brooke LLP. He can be reached at 952-210-2212 or kenrossesq@gmail.com. Other articles by Ken can be accessed at www.productliabilityprevention.com.*

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# Appliance Makers Keep It Together With PSAs



**SUBMITTED BY AVERY DENNISON**

Pressure-sensitive adhesives (PSAs) have become a game-changer for demanding assembly applications in a wide range of industrial applications. When it comes to large domestic appliances (LDAs), virtually any place a fastener can be used, a PSA (typically a tape) can perform the same task, offering performance equal to or better than that of a fastener and often with increased reliability and service life.

In every assembly application, selecting the right PSA depends on two primary considerations—the materials being bonded and the environment in which that bond will perform. Manufacturing and design engineers work together with converters and OEMs in the design process to make this determination.

Surface energy—a measurement of a surface that indicates how something will bond to it—affects an adhesive's ability to bond to that substrate. Using the wrong PSA tape on the wrong surface will cause it to slide right off.

High surface energy (HSE) materials include most metals. But, painted or powder-coated metals—basic appliance components—are low surface energy (LSE) materials. Plastics such as acrylonitrile butadiene styrene and polycarbonate are HSE materials. Plastics such as polyethylene and polypropylene are LSE materials. These are more challenging to bond with PSAs.

Generally, the more textured a substrate, the more difficult it is to bond. An adhesive that is too thin or has low flow won't bond to enough surface area. This type of substrate requires a tackier adhesive with a higher coat weight, providing more flow. Rubber- or acrylic-based adhesives modified with tackifiers bond well to LSE appliance surfaces.

Environment is the next issue, with temperature and humidity as key considerations. An adhesive that is a good choice for an oven may not be the best choice for a refrigerator or freezer. Rubber-based adhesives are generally a good choice for temperatures below 150 F; acrylic-based adhesives can generally resist temperatures around 350 F. High-performance acrylic (HPA) and silicone adhesives can be used for higher temperature ranges, which often require testing or existing application data to help support a proper recommendation.

Other environmental conditions—indoor-outdoor use; contact with solvents, chemicals or fuels; and direct or indirect exposure to ultraviolet radiation—must be considered. Generally, acrylic-based adhesives offer better adhesion performance to these conditions compared with rubber-based adhesives. However, if the specific application has an extremely high exposure to these conditions, technical support is recommended to provide a specific adhesive.

## PSAs in Appliances

LDA manufacturers worldwide are taking advantage of advances in PSAs to enhance product aesthetics, performance and reliability.

While some PSAs may initially be more expensive than the fasteners they replace, brand owners can more than make up for the differential through enhanced manufacturing repeatability, precision and performance over the life of the product. The use of tapes also eliminates the need to drill holes or assemble using traditional methods.

Particularly in LDAs, such as

washing machines and dryers, where noise and vibration are constant, tapes provide a more consistent, lighter weight joining method. Fasteners, over time, can break from the back-and-forth motion, leading to consumer dissatisfaction and costly repairs.

Today's smart appliances are equipped with touch screens just like smart phones and tablet computers. These portable electronics aren't held together with nuts and bolts, but PSAs. So, too, are the interactive screens on LDAs. PSAs deliver excellent shock absorption and impact resistance properties for these screens.

Another factor—lightweighting—is a major concern in many industries. Adhesive tapes can replace perhaps 30 to 60 screws, washers and nuts on an appliance, which can help reduce weight. This may measure in ounces, not pounds, on each appliance. Lighter weight, however, translates to savings when a manufacturer is shipping thousands of refrigerators, dryers or washers every year.

## Specific Applications

PSAs for appliances—many of which must be UL-certified—cover a wide variety of applications. For a PSA to be viable for appliance assembly, manufacturers need to be assured of a reliable bond in a manner that is easier to apply than traditional joining methods.

Aesthetic applications. Since brand consistency and presentation are key to a product's branding, nearly every appliance carries a brand badge or emblem, and many have decorative trim or bumper rails for product protection. Durable acrylic foam bonding (AFB) tapes are an affordable option for these applications, providing excellent tack, adhesion and cohesion performance. These also add shock dissipation for appliances where doors are constantly opening and slamming shut, allowing the component to withstand such shocks over the life of the appliance. AFB tapes are also excellent choices for joining metal frames to glass cooktops, providing reliable adhesion while adding thickness to absorb the shocks that may be created by pots and pans being placed on the surface.

Critical joining applications. During refrigerator and freezer assembly, it's critical to prevent movement of components while foam insulation is pumped into wall and door cavities. For this application, high-performance acrylic (HPA) tape provides long-term adhesion with high temperature performance and excellent environmental resistance. It offers high holding power and reliable performance on high-, medium- and low-energy substrates, including a variety of engineered plastics. Foil-based tapes are also an excellent option for attaching refrigerator coils, helping to prevent the coil from moving over the product's life span.

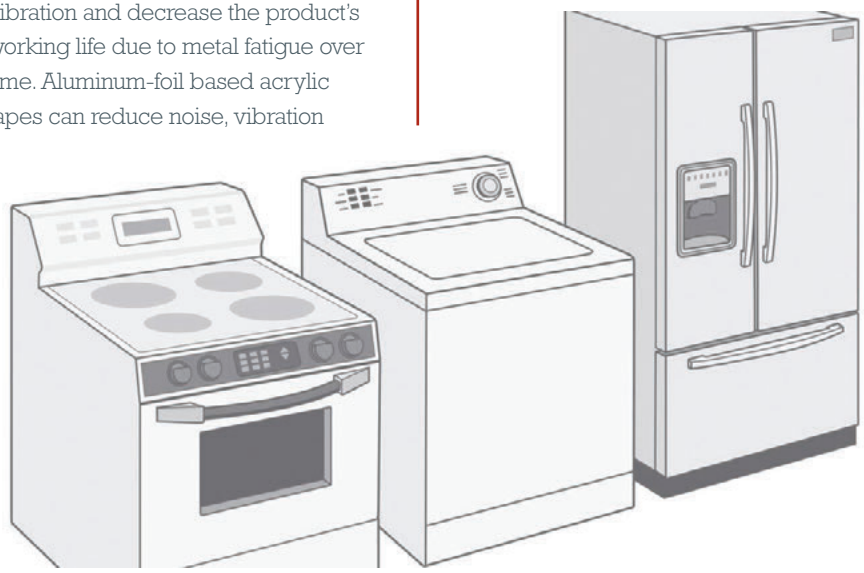
Noise and vibration damping. Appliance assemblers are increasingly using thin-gauge sheet metal in washers, dryers and dishwashers to cut costs and save weight. These thin materials can increase noise and vibration and decrease the product's working life due to metal fatigue over time. Aluminum-foil based acrylic tapes can reduce noise, vibration and stress fatigue by damping vibrations. They also provide excellent resistance to heat and humidity. This type of application typically requires a PSA that is customized to meet the specific damping, heat and humidity requirements of the application. There's no one-size-fits-all product.

Control panels. Depending on the application, flock tapes or HPA tapes allow assemblers to securely attach digital control panels to appliances, providing a tight seal that protects against varying temperature and humidity. To provide the proper PSA, a full understanding of the substrates being joined is key.

## Start at the Design Phase

While it's certainly possible to use PSAs in place of fasteners in existing appliance designs, the best time to develop bonding applications is early in the design phase, well before production begins. Design engineers can bring to bear the expertise of the tape converter and tape manufacturer to prove out bonding applications. Early consultation with these experts is the key to PSA assembly success.

*For more information on pressure-sensitive adhesives, call 866-462-8379 or visit* ***https://tapes.averydennison.com***.





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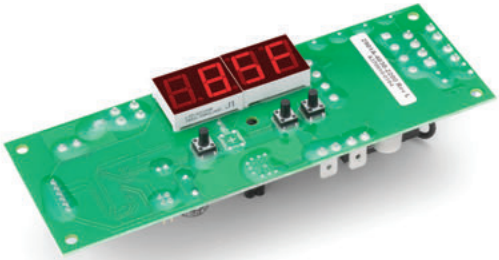
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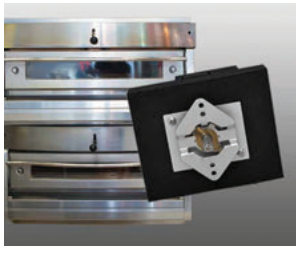
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