APPLIANCE & HVAC REPORT

Reaching Design Engineers at the OEM Level

May / June 2020 VOLUME 2 ➢ NUMBER 3

Engineered Latching

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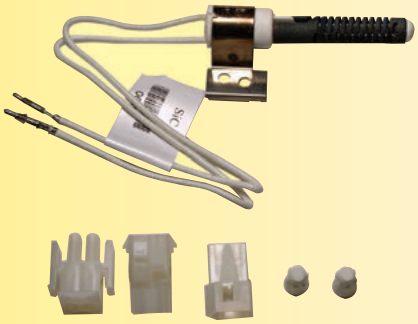
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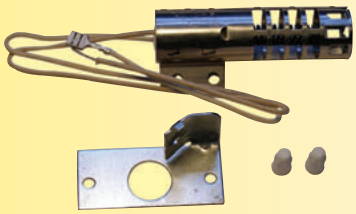
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THE PIONEER IN HOT SURFACE IGNITERS

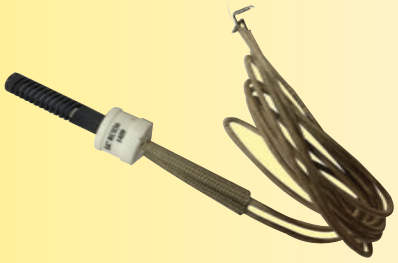


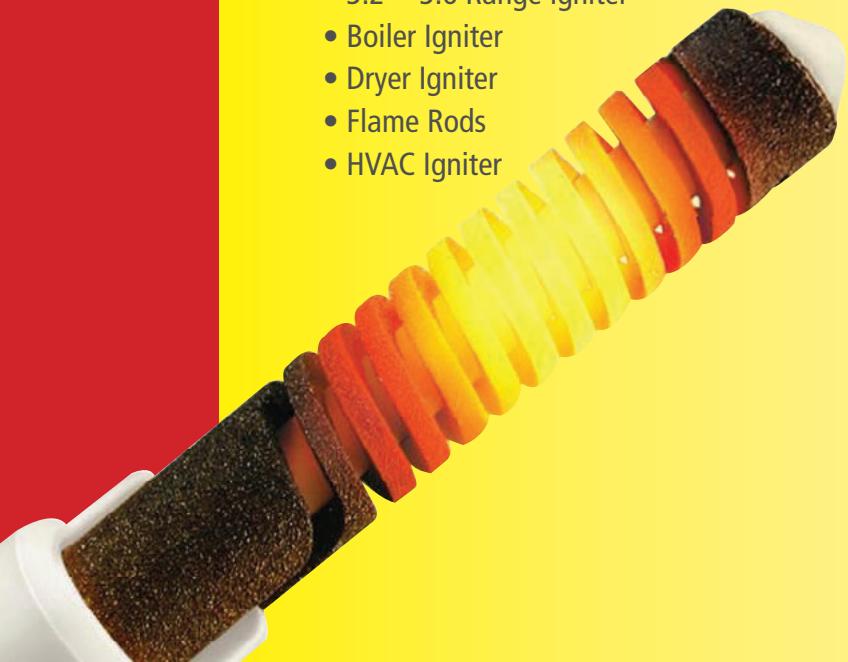
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Coronavirus Crisis



Like many Americans I felt somewhat ambivalent about the Coronavirus crisis. Terrible as it is, are the ways we are dealing with it (closing schools, restaurants, and harming or possibly destroying for good the livelihoods of many…I wanted to get a haircut today, March 19, but the barbershops here in Ohio are closed too) correct?

Then I read this from the New York Times: ***https://www.yahoo.com/news/coronavirus-ravages-7-members-single-125000381.html***

Two adult children and their mother all dead from this plague. One of the worst things I have ever read in my life. Not only scary but sad beyond belief. I trembled reading it, thinking of my kids and grandchildren. Without a thought I would surrender my existence to preserve theirs. This story reminds me of "Saving Private Ryan" and the calamity of the Sullivan Brothers in World War II.

I am also thinking of the trade show industry. This issue would have been at one but it was postponed as were two others I have thought of attending. All postponed for about 6 months. Suppose those shows do take place…and the trade show owners want to put them on again in 2021 at the usual date. That means in effect the same trade show would occur twice about six months apart. Would the exhibitors participate in both, considering the investment required? Would the buyers and others attend? Who knows?

I have seen my share of great music over the years. McCartney, Simon, Billy Joel, Bruce Springsteen, Rod Stewart, U2, James Taylor and others. I had tickets to see The Rolling Stones in June. Tour postponed. Will I ever see them? Who knows? Mick isn't getting any younger, nor am I.

And publishing this issue proved to be a challenge too. Contributions of white papers failed to meet deadlines…perfectly understandable. Fortunately, most came through. Thanks to them and the advertisers…not one who was scheduled "pulled out".

Recently we exhibited at the Air Conditioning, Heating and Refrigeration (AHR) show, in Orlando. Good place to be the first week of February. As a new publication, we were lucky they had room for us. We were in booth 9547…the highest numbered booth at the show. That means technically we were further from the entrance than any other exhibitor. Fortunately we were on a corner, meaning attendees could and did find us from two directions.

It's an important event. Here are some interesting stats from it (all numbers rounded to the nearest thousand)

- Total attendance: 50
- Total non-exhibitor attendees: 32
- Total exhibitor attendees: 18

Yep, more than a third of attendance is from the exhibitors themselves!

- First time attendees: 11
- International attendees: 6

So one-third of attendees are "first timers" to AHR and 12% are international

- One hundred twelve (112) countries had people at AHR
- Next year AHR moves back to McCormick Place in Chicago.

We will be there!

Thanks. Here is to both your health and prosperity.

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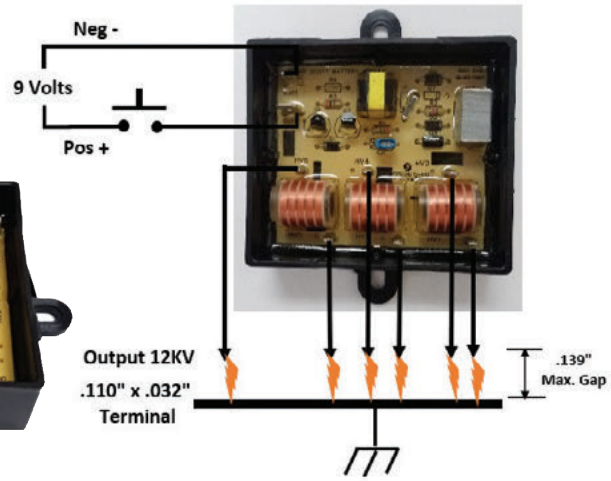
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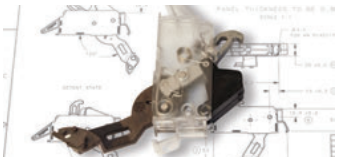
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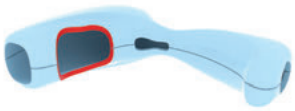
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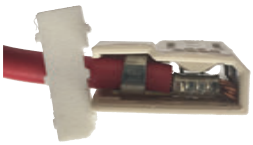
Square ends, concentric chamfers, and lower insertion forces make them ideal for easy installation.



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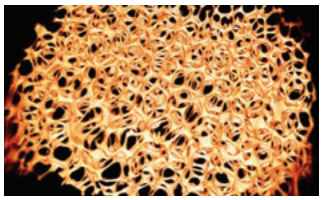
Ceramic and glass materials are integral to the construction of residential buildings—and to homes of the future.

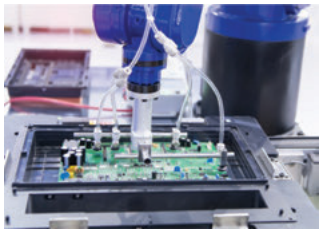
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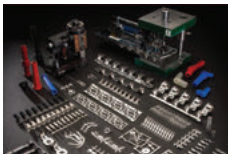
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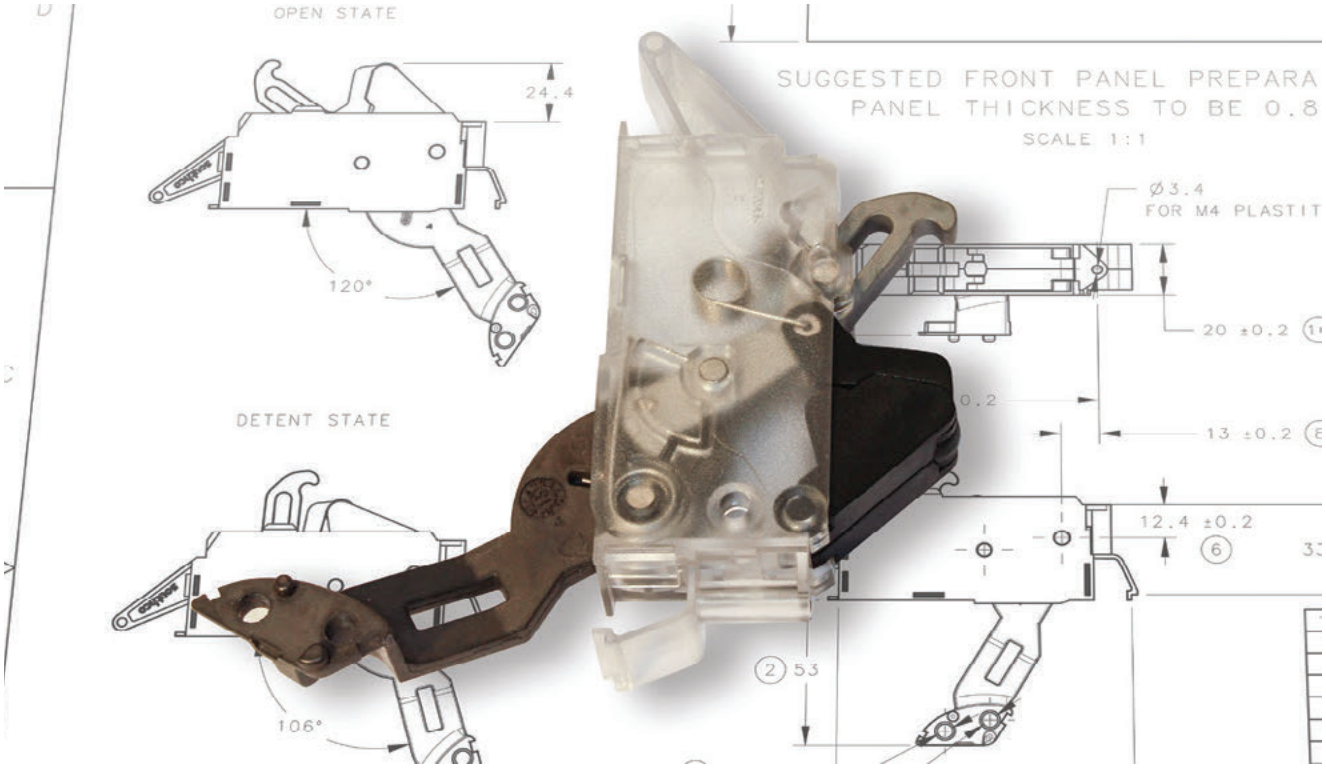












Engineered Latching For Enhanced Usability

BY SOUTHCO

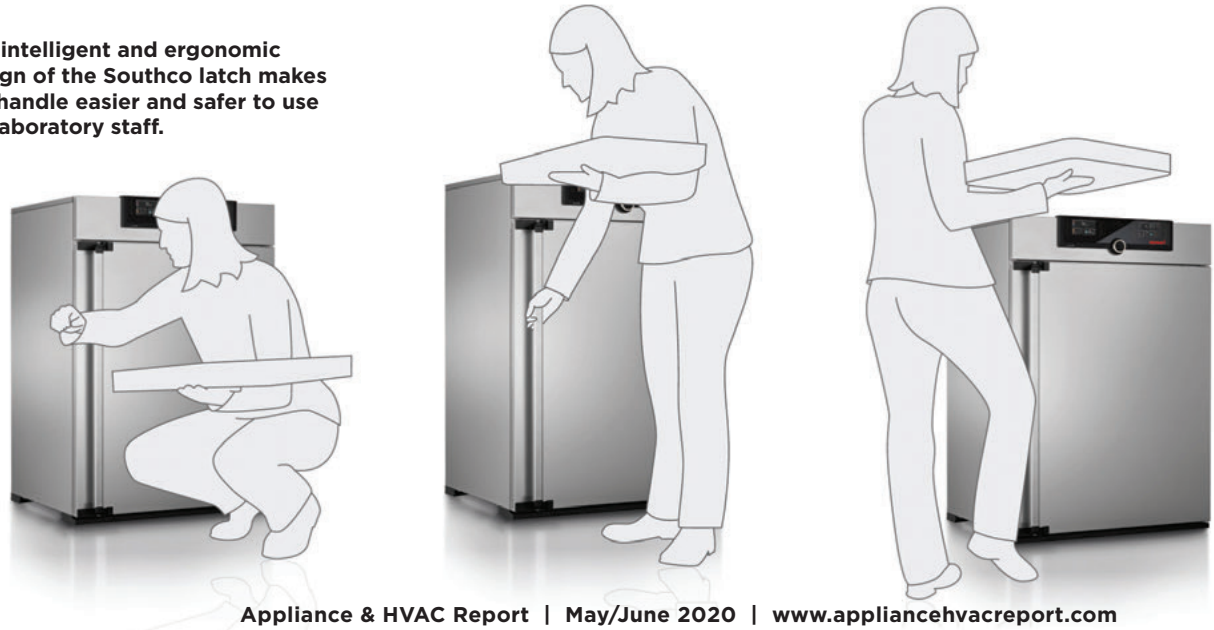
The Challenge

The previous generation of Memmert appliances incorporated a multipoint latching system into the outer main door, which sealed the door panel against leakage and contamination and helped to maintain constant temperatures.

When working with highly sensitive items, like blood samples and hazardous chemicals, the end user must have the confidence to deliver accurate results, ensuring there is no probability of contamination. This created the need for a latching system that delivered the necessary level of compression without comprising the aesthetic design or user experience.

"We were looking to improve the functionality and design of our handle and locking mechanism," said Christoph Oster, Project Management R&D, Memmert. "We needed a system that was innovative, easy to use and a lock that provided consistent, reliable

The intelligent and ergonomic design of the Southco latch makes the handle easier and safer to use for laboratory staff.



performance. It was also important that the door had a smooth push lock system, which minimised vibration that could potentially effect the loading, when locking and unlocking.''

When handling sensitive elements in a laboratory environment, accessibility and usability of the equipment is crucial. Therefore, Memmert sought a latching solution which would allow the user to access the interior of the oven without having to use their hands to open the door. However, the latching mechanism was still required to prevent the door from opening accidentally.

''The usability of the latch was a vital element, we needed to create a system that was easy to open and close regardless of whether this is with one hand, knee, etc., which comes in handy during daily laboratory use and gives flexibility in usable height,'' said Oster.

The Solution

The concept for Memmert's new oven latch was based on Southco's R5 Draw Latch – a heavy duty mechanism chosen for its high tensile load, concealed installation and proven functionality in industrial applications.

However, in addition to functionality, the latch also needed to fit a restricted space within the application, without compromising the aesthetic design or the end user experience. Memmert worked alongside Southco's engineering team to develop a completely bespoke product that met all these design requirements.

The latch design incorporated over centre locking functionality, ensuring vibration resistance and an integrated secondary latching feature, which created constant compression of the door seal.

The latching systems helped to improve and simplify the ergonomics of use by making it easier for the operator to open/close regardless of height or body part, a key objective identified at the start of the project.

The Implementation

The locking and unlocking of the door works smoothly and reliably over the product lifespan. The handle mechanism offers an ergonomic and safe handling for the user.

With regard to production, Southco's solution provides reliable operation, simplified integration into the production process and a pre-assembled design for east mounting and installation, allowing for easy maintenance/service and usability for the end customer. End users value Memmert's new generation of appliances because of their overall quality, but also for their ease of use, with the door handle playing an important role in their perception. In sensitive medical laboratory applications, the handle provides safety for tests and allows for smooth operation. For industrial use, it is sturdy enough to ensure longevity for years of multiple repetitive stress tests. Customer reactions have all been very positive and the new latching system adds real value to Memmert by enhancing the end user experience.

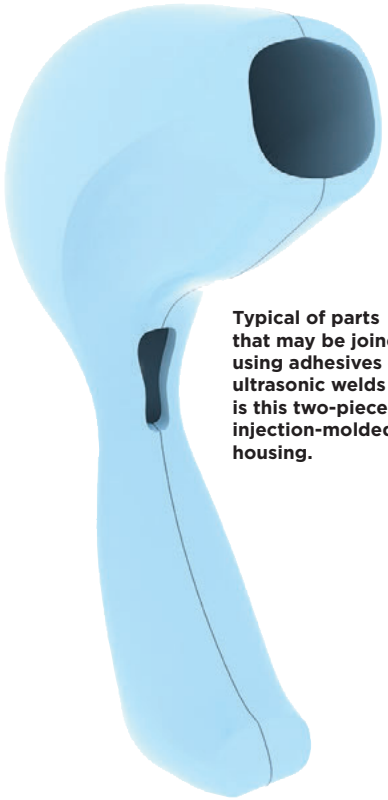
The Results

''The new latching system has been a fantastic addition. The enhanced functionality and improved design has added value to our range of products by improving the quality and efficiency of the locking mechanism and handle,'' said Oster.

''Memmert prides itself on providing a premium offering to our customers and with Southco's contribution, we have been able to push the boundaries of innovation within our markets. Southco's products have complimented our solution and we have been extremely pleased with the feedback and usability of our next generation products.''



The new latching system adds real value to the Memmert oven, boasting a more ergonomic and more competitive product in the marketplace.



Typical of parts that may be joined using adhesives or ultrasonic welds is this two-piece injection-molded housing.

Adhesives or Ultrasonic Welding for Plastic Component Assembly?

BY TARICK WALTON

This article will take a brief look at two of the more popular methods for assembling textile materials or plastic parts into finished products -- adhesives and ultrasonic welding – and focus on questions that product design and manufacturing teams should consider when making decisions about why and when to adopt these assembly methods.

While there are many important considerations involved in making a part assembly decision, I find that they generally fall into two broad categories. One set of considerations has to do with your business, its product lines and production needs, and the degree of speed, flexibility, and scalability that is needed in your assembly operations. The second, narrower set of considerations goes right to the nature of the part itself, notably the materials used and the shape, or geometry, of the part.

The first consideration with both adhesives and ultrasonic welding is that they are permanent joining methods. Both create a strong bond between components that won't come apart. So, consider: will the part, once assembled, ever have to be disassembled to allow for maintenance, component repair, or replacement of a battery or bulb? If so, permanent assembly methods like adhesives or ultrasonic welding may only be part of the solution. To allow for disassembly (such as to replace a battery or bulb), a product design probably will need to incorporate either mechanical fasteners or snap-fit components.

Flexibility

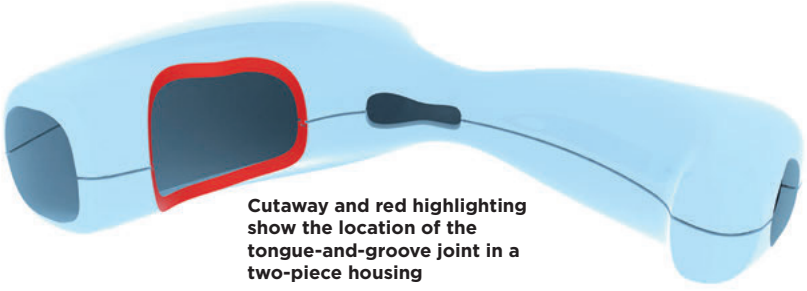
Of the two assembly methods considered here, adhesives often provide more flexibility in the assembly process. By flexibility, I mean that adhesives can create bonds between plastic components that utilize a wide range of materials and shapes. And, if there's a need to modify the design of one of the plastic components – to make one of the dimensions longer or shorter, for example – the adhesive joining process remains the same. It is comparatively easy to change components and then adapt the adhesive assembly process. If adhesive dispensing is done manually, simply inform the assembler of the change. Or, if automated, adapt the robot's programming to change the pattern of its adhesive dispensing motion.

The notion of flexibility can also make adhesives a good solution for assembly of products in small quantities, including:

- Prototype designs
- Product samples
- High-mix production runs that include parts of differing sizes or shapes

For all their flexibility, adhesive joining methods come with some constraints, too. The first involves maintenance. Anyone who has ever used a bottle of glue knows that when the glue is in use, the applicator must be kept relatively clean and the glue applied with consistency and care to ensure a complete and cosmetically pleasing bond. When the number of adhesive applicators is increased, the challenge of ensuring process control grows. Assembly managers must ensure that adhesives are flowing smoothly and consistently to assure part strength, necessitating periodic purging and cleaning of adhesive systems and applicators. When not in use, adhesive applicators must be cleaned and capped to prevent the exposed adhesive from curing and clogging, which can lead to waste or production delays.

Another constraint on adhesive methods is that adhesives are consumables. Every adhesive bond that is made represents an incremental production cost that rises in direct proportion to output. And, if production rises beyond initial cost estimates – if for example, product sales and production ramp up rapidly, perhaps breeding new product variations or



Cutaway and red highlighting show the location of the tongue-and-groove joint in a two-piece housing

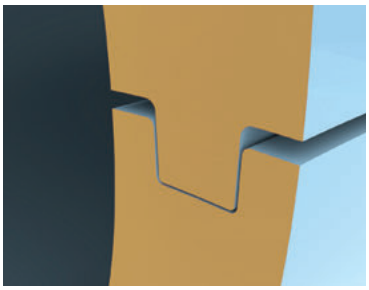
options – production costs will likely be reevaluated as management sees the product moving from a developmental to a growth phase.

Production Volume

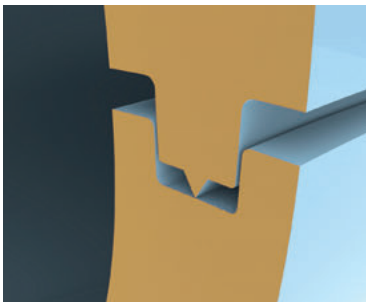
The point of change – in production volume and expected sales – offers a great opportunity to consider, or reconsider, the benefits of ultrasonic welding.

Using ultrasonic welding for part assembly requires some up-front investment, starting with the welder. Then, there is product-specific tooling, which precisely holds the various plastic components in place before and during the welding process. But, you only make this investment once. With these elements in place, you're in position to begin managing your assembly costs, amortizing a single fixed investment over the ongoing assembly volumes for that part. Whether you're welding 1,000 or 1,000,000 of that part, you don't have to worry about incremental consumables or assembly costs.

The same favorable economics for ultrasonic welding apply to those who plan high-volume part production from the outset. As soon as a product design is finalized, weld tooling can be completed and high-volume production can begin. The key to amortizing



Close-ups of the joints show the difference between a tongue-and-groove joint designed for adhesive joining and ultrasonic welding.



Note that the ultrasonic joint has been modified to include a triangular "energy director," which melts when welded to form a strong bond between the parts.



An ultrasonic welding system, like the Branson 2000X includes a power supply (lower left), and "stack" (right).

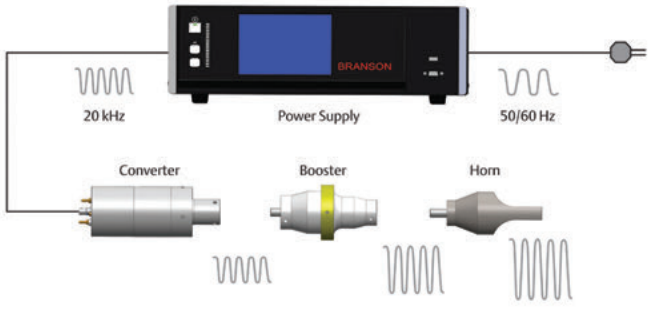
Understanding the Ultrasonic Welding Process

In ultrasonic welding, high-frequency vibrations are applied to two parts by a vibrating tool, commonly called a "horn" or "sonotrode." Welding occurs as the result of heat generated at the interface between the parts. The ultrasonic vibrations are created by a series of components – the power supply, converter, booster, horn– that deliver mechanical vibration to the parts.

As seen below, the power supply takes a standard electrical line voltage and converts it to an operating frequency (in this illustration, 20 kHz). This electrical energy is sent through an RF cable to the converter. The converter utilizes piezoelectric ceramics to convert the electrical energy to mechanical vibrations at the operating frequency of the power supply.

This mechanical vibration is either increased or decreased based on the configuration of the booster and horn. The proper mechanical vibration, known as amplitude, typically is determined by an applications engineer and based on the materials being welded.

Mechanical vibrations are delivered to the parts to be welded. The parts also are put under a mechanical load, primarily with a pneumatic actuator. Under this load, the mechanical vibrations are transmitted to the interface between the parts, where it is focused on a triangle-shaped bead, the energy director, which focuses the vibration to create intermolecular and surface friction. This friction creates heat and a subsequent melt, which solidifies into a welded bond.



assembly method costs, comparing costs over time, and realizing assembly cost savings is to have a firm idea of what annual production volume is going to be. History with our customers demonstrates that those with production volumes ranging from tens of thousands to millions per year can often realize a clear financial benefit with an ultrasonic welding process.

Cycle Time

Adhesive assembly processes range in complexity. The most basic may consist of a relatively simple fixture for one part and a hand-held adhesive dispenser. An individual assembler may lay down a bead of adhesive on one component and then affix the mating component by hand, either pausing to hold it while it sets or attaching a clamp or fixture to hold it steady during the curing process.

A more complex adhesive assembly process may involve automation. Again, you'll need the base fixture to hold one part, plus any clamps or other means to hold the part while it cures. And, you'll have the expense of a robot. But robotics tend to be very flexible: you can change the programming, change the fixtures, change the adhesives, and assemble a number of different parts with different geometries using the same robot.

Perhaps the biggest factor with an adhesive assembly process is the cycle time required. The adhesive assembly cycle isn't done when the when the two parts are brought together; typically, a full strength adhesive bond requires curing time for each part. By contrast, ultrasonic welding provides a permanent, welded bond in one second or less. As soon as the welded part is removed from the weld tooling, the weld cycle is complete. A new part can be loaded and welded immediately.

Materials

Materials selection is an important variable in the effectiveness of assembly processes. In general, it is more difficult to bond dissimilar materials -- rubber to plastics or plastics to metals, for example. In cases like these, mechanical fasteners or adhesives are probably the best places to begin. Also in general, ultrasonic welding is an ideal solution for welding non-woven textiles. Top application examples of non-woven textile bonding include face mask and medical garment production.

When it comes to fully plastic assemblies, similar thinking applies. Material selection may be somewhat more diverse when adhesives are used in assembly, because adhesives are more likely to achieve bonding between dissimilar plastics. There are some exceptions – a few polymers that may react chemically or degrade in the presence of certain adhesives – but relatively few.

When it comes to ultrasonic welding, like – or similar – polymers tend to weld better than dissimilar polymers. However, some dissimilar polymers may also be welded if they have similar melt temperatures and melt flow characteristics. Also, amorphous polymers tend to weld better than semi-crystalline polymers, since they have more gradual melt curves and more predictable melt flows between parts, which help to create more consistent bonds. ABS, polystyrene, and polycarbonate are examples of amorphous materials that weld very well.

Semi-crystalline polymers are more challenging to weld because these materials tend to melt and solidify more abruptly. These characteristics that can make achieving a consistent melt and melt flow more difficult, making it correspondingly more difficult to get a consistent bond. Examples of semi-crystalline materials that are more challenging to weld are polyethylene, polypropylene and nylon.

Geometry

The use of adhesive joining methods allows for considerable variation in the geometry of parts. As long as the edges to be joined offer surface area for the adhesive to be placed, it's a workable method for joining.

Part geometry imposes a few more challenges when it comes to ultrasonic welding, since the structure of the part itself must adequately transmit the energy received from the horn down to the weld joint. As any

Adhesives vs Ultrasonic Welding

Adhesives		Ultrasonic Welding	
Pros	**Cons**	**Pros**	**Cons**
Flexibility in Part Design	Adhesive is a Consumable	No Consumables	Requires Capital Investment
Can Adhere Dissimilar Materials	Cure Time Adds to Cycle Time	High-Volume Production	Specific Joint Design (Energy Director) Required
Low Capital Expense	Equipment Maintenance (Dispensing Machine)	Easy Setup and Fast Cycles	Vibratory Energy Can Impact Delicate Components
Works With a Variety of Part Sizes and Geometries	Parts Must Be Clamped While Curing; Some Need Extra (UV) Curing Process	High-Strength Seals	Typically Requires Dedicated Tooling
Great for Low-Volume Production and Prototyping	Requires Chemical Compatability; Certain Plastics Will Degrade	Minimal Equipment Maintenance	Limited to Certain Part Geometries/ Contours
	Setup Can be Cumbersome	Easily Integrated with Automation	Noise; Depending on Frequency and Part Size

engineer knows, some part shapes will inherently do this better than others. A great example of an easy-to-weld shape would be a cube with walls that are rigid enough to direct energy straight to the weld joint. A more difficult shape to weld would be a sphere, since one half would tend to flex under load, and therefore not transmit the energy as efficiently.

Easy-to-weld parts tend to have these characteristics:

- Relatively flat surfaces (limited contours) so that good horn contact can be achieved
- Surface area on the top of the part over the weld joint area
- Side walls with enough rigidity to transmit energy to the weld joint
- A properly designed weld joint

Every part is unique, of course, so the only way to know whether any design will work with any assembly method is to speak with a knowledgeable professional who can help you evaluate your design, consider your assembly needs, and find the right solution.

Design with the future in mind

One of the wisest things that you can do for your product design – and for your company's bottom line – is to make design choices that keep your assembly options open to both adhesive and ultrasonic welding methods. Perhaps the easiest way to do this is to design a simple "tongue and groove" joint into the mating surfaces of the components that will comprise your part. This type of joint offers an inherent alignment feature – the groove – that's ideal for capturing adhesive and aligning the tongue of the mating surface, or for making a strong ultrasonic weld.

Should production needs or volumes change, it is easy to convert a tongue-and-groove part from adhesive assembly to assembly using ultrasonic welding. All that is required is to add an "energy director" – a small bead of sacrificial weld material – to the bottom of the existing tongue. Typically, this can be done with a modest "steel safe" change to the mold. Then, during the weld process, the energy director on the tongue melts neatly into the groove, resulting in a very precise weld joint that offers high strength and good sealing properties. ●



Tarick Walton *is global product manager for Emerson and led the company's launch of the Branson GSX Ultrasonic Welding Platform. Additionally, he provides strategic support for performance and quality assurance across the Branson ultrasonic portfolio.*

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IoT for Appliances

BY AYLA IOT

Manufacturers of small (e.g. coffee brewers, blenders) and large appliances (e.g. refrigerators, dishwashers) are increasingly seeing demand for internet-connected products, averaging 100% annual growth. In parallel, they are undertaking digital transformation initiatives for greater competitiveness.

Smart appliances that connect with mobile phones, voice assistants and other systems can enhance a manufacturer's revenues and help differentiate its products in a crowded consumer marketplace.

But creating home appliances for the so-called Internet of Things (IoT) requires more than simply imbedding a wireless chip or adding a sensor. Home appliance manufacturers need to consider everything from network security to application software design. Furthermore, they need to know how to budget, scale, distribute and future-proof their products.

Ayla Networks has been working with some of the worlds largest appliances brands including De' Longhi, Keurig Dr. Pepper, Kenmore, Hamilton Beach, Nestle, and more to drive IoT-led transformation in the appliance market space. Ayla's cloud platform enables appliance brands to develop and launch connected products and scale it through the transformation journey.

Benefits & Value Proposition

Heads of product development, product management, service operations, IT and new technologies in leading appliance brands are seeing material benefits from IoT projects including:

- Reduce support and service costs
- Enhance product quality and reduce return rates
- Identify new sources of revenue and upsell opportunities
- Improve user experience and facilitate an ongoing relationship with the customer

Why IoT for Appliances?

Turning your traditional home appliances into successful IoT connected appliances means making dozens of small and large technical decisions and applying a broad range of technology expertise. For almost every appliance manufacturer, it makes more sense to buy this expertise from an established IoT platform vendor than to try to assemble all the IoT expertise needed—and then to make sure you stay up-to-date on fast-changing security practices, networking protocols, user experience design and other IoT necessities.

As an appliance manufacturer, the important question to ask is: Do you want to master all the skills, technical expertise and nuances demanded by the IoT, or do you want to focus on harnessing the value of the IoT to build and sell the best possible connected appliances?

Ayla IoT *If you're a multi-brand appliance manufacturer interested in starting an IoT project, inquire about Ayla's Explorer package, a low-cost, low-risk option designed specifically for those companies starting off on IoT. To learn more about Ayla IoT for appliances, or to schedule a consultation please contact us or drop an email to info@aylanetworks.com.*



Information Management for Product Safety and Product Liability

BY KENNETH ROSS

Information is key to any design engineer. And with new technology, it is even more important today since it is easier to create, keep, find, receive, transfer and destroy information. All of this information is important to show why your product turned out the way it did and why it is reasonably safe. It can also show that the manufacturer did not do enough to consider safety and product liability during the development of the product or can confirm that the product is unsafe and could have been made safer.

While employees come and go and change jobs within an organization, the design plans, engineering drawings, production procedures, safety memoranda, and marketing strategies that they have created represent a historical record of the safety that a manufacturer included in the product. These records can significantly help or hurt a manufacturer or product seller, especially in the event of product liability litigation.

Unfortunately, no one knows whether this information will help or hurt until a lawsuit is brought and the manufacturer has to respond to discovery and produce information asked for by the plaintiffs. In addition, there may be information that could be helpful, but which was written in a way that could possibly benefit the plaintiffs. And, perhaps even more frustrating, there may also be records reflecting safety activities that were created but then destroyed before litigation arose.

The pervasiveness of electronic records has changed how manufacturers create, store, and destroy all types of records, electronic and otherwise. In addition, the growth in popularity of the Internet and social networking media has created more opportunities for the dissemination of potentially harmful information to the government, and to potential plaintiffs and their attorneys. Retailers and standards groups have started demanding that manufacturers employ state-of-the-art safety processes and provide evidence of that compliance. And product liability and product safety laws have proliferated around the world, making it necessary for a manufacturer to keep track of and record everything that is going on with its products and all of its components inside and outside the U.S.

Bottom line, a manufacturer must create records, electronic or hard copy, to confirm its efforts to make safe products and to possibly fix unsafe products that have been sold. In doing so, a manufacturer should create records that will accurately and completely describe these efforts and

think about how it might need to tell its story to a jury, customers, plaintiffs' attorneys, or the government.

Importance of Information for Product Safety and Liability

During the design, manufacturing, and marketing phases, a manufacturer's goal is to make a product that reasonably balances the risk of injury from use of the product against the product's functionality, utility, durability, price and other attributes. If accidents do occur and product liability claims and litigation result, a manufacturer will hopefully have evidence that it undertook sufficient measures to make a product that is reasonably safe. Thus, a manufacturer should have created and retained information that evidences its interest in safety and regulatory compliance, and which describes the procedures that were used to evaluate a product's safety.

However, many lawyers feel that records that identify and quantify risk and describe design, production, and marketing processes can only hurt manufacturers and rarely help their client's case. So, they may discourage manufacturers from creating or retaining such information, especially those that deal with safety. Invariably, those lawyers view such information as potentially harmful and difficult to explain. Those lawyers do have a point, especially when engineers challenge and question safety during a product's development phase.

Despite that, each manufacturer must decide how to balance the risk of creating and retaining information that hopefully will help but could, in the wrong hands, be misconstrued, taken out of context, and used against the manufacturer in a product liability lawsuit. The goal is to create truthful and complete information concerning product safety and product liability that will hopefully be helpful. There is no choice – documentation will more likely help than hurt a manufacturer.

Information That Can Hurt

Instances where manufacturers have suffered substantial losses because of "bad documents" are well-known. For example, juries sometimes react angrily toward manufacturers that consider the value of lives during design. What juries apparently don't like is that the records do more than consider cost and safety and instead associate product cost with the value of human life and the value of settling cases for presumed future incidents.

The lesson that can be drawn from such cases is not that manufacturers should avoid creating or retaining such information concerning design and manufacturing processes and procedures. Rather, the lesson is that they need to train employees on how to write truthfully and defensively, as will be discussed in a subsequent article, and how to respond to someone who raises safety concerns. Manufacturers should do this not only for litigation purposes, but also to clearly and accurately record the rationale for their design and manufacturing decisions.

A Lack of Information Can Also Hurt

In addition to having information that cause problems, a lack of information can also hurt the defense of a case. For example, even if an engineer can remember doing safety testing, a jury may not believe that a manufacturer performed the tests if the manufacturer did not create or keep records about those tests. In addition, in many cases, there may be no one available who remembers the reasoning behind certain decisions. Testimony about tests that an engineer remembers conducting years ago may not sway a jury if there are no records supporting the testimony.

In addition, one of the most significant defenses against a product liability claim is that there were no prior, similar accidents involving a product or earlier versions of that product. Without good records supporting the lack of similar accidents, an opponent can defeat efforts to present this defense. Therefore, getting rid of records describing prior accidents or the lack of accidents can be harmful to the defense.

Information That Can Help

In addition to a systematic record of prior accidents or lack of accidents, records evidencing a concern for safety and "trying to do the right thing" will go a long way toward at least defusing any thoughts by plaintiffs of seeking punitive damages. Records proving compliance with mandatory or voluntary safety standards are particularly important. And post-sale, records evidencing efforts to investigate accidents and incidents, and to consider appropriate post-sale activities such as a product safety repair program or a recall can be crucial in defending the adequacy of the corrective program, especially when it can be proven that the plaintiff received a recall notice before the accident.

The reality is that if your company doesn't have any safety programs in place, has safety programs but failed to create good records, or has thrown away the records that were created, the plaintiff may believe that they can convince a jury that the manufacturer didn't care about safety. On the other hand, if your company has safety programs and has the records to prove it, the plaintiff will likely obtain them and then will have to decide if that evidence could make the manufacturer look responsible. As an attorney, I'd rather defend the adequacy of a comprehensive and documented safety program any day.

Post-Sale Records

The potential liability of a manufacturer or product seller for negligence after sale of a product is well-known. In addition, current U.S. regulatory and common law requirements apply to information that was obtained or should reasonably have been obtained that identify an unsafe condition. The potential liability for violations of regulatory laws is growing as more foreign governments implement consumer product safety legislation. These laws contain a duty to report to the government if certain threshold safety events occur. This enhanced focus makes it even more important for a manufacturer to gather, analyze, and document safety information received from anywhere in the world.

Anything less than a "reasonable" effort to obtain and analyze post-sale information, wherever in the world it comes from, may be considered negligent by a U.S. jury in determining whether a manufacturer should have known about the problem before an accident occurred or by a government agency in deciding whether the manufacturer should have reported the safety issue to the government.

The growth of the Internet and social networking media have made it even easier to find post-sale information and easier for manufacturers to receive this information from those who want to communicate with them about it. Many of these records and reports will be unverified, overstated, inaccurate, and incomplete. Consequently, manufacturers must decide when to follow up and investigate such reports to determine the facts and to minimize avoidable problems that these reports could cause.

Being aware of all information—good and bad, true and untrue, complete and incomplete—can be helpful if a company can identify the truthful information, adequately evaluate and document it, and take any warranted corrective actions.

Conclusion

In the history of product liability litigation, information has proven both helpful and harmful to plaintiffs and defendants. Even though some records may ultimately turn out to be harmful, a manufacturer must proactively establish a record management system that ensures compliance with legal requirements and results in the creation of a story of the development and life of a product. The system should also include procedures, education and training that will minimize the creation of misleading and unnecessarily harmful information. These subjects will be covered in part 2 of this article. ●



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.*





Installing a Coiled Spring Pin

BY JEFF GREENWOOD

Coiled Pins were designed with assembly in mind. Compared to other pins, their square ends, concentric chamfers, and lower insertion forces make them ideal for easy installation. Additionally, Coiled Pins can accommodate wider hole tolerances than any other pin because they compress during installation and conform to the shape of the hole. All in all, Coiled Pins are the easiest type of pin to install and are designed to be serviceable.

The Coiled Pin's nominal diameter represents the recommended hole size for the product into which they are being installed. Coiled Pin design guidelines will provide the recommended hole tolerance range. The Coiled Pin is designed so that the pre-installed diameter is greater than the hole size, and the chamfer diameter is smaller than the hole. During installation, the swaged chamfer helps align the Coiled Pin with the hole and facilitates compression of the coils as it is being driven into position.

Installation Options

Most manufacturers prefer to use a hammer when only a handful of prototype assemblies are needed. However sometimes, particularly when the pins are too small to hold while hammering into the hole, they may opt to use a pin driving chuck so that they don't have to hold onto the pin while the pin is being inserted. Automatic pin inserters are preferred for high production volumes because they provide a significant return on investment (ROI) over time. Additionally, automatic pin inserters are preferred for small diameter pins that are difficult to handle.

Hammer

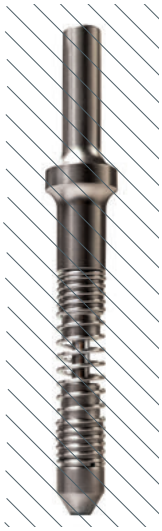
The simplest Coiled Pin installation method is to use a hammer. First, align the Coiled Pin up to the hole by hand. Next, simply hammer the Coiled Pin into the hole as if it was a nail. Drive the pin to the desired insertion depth and be careful not to damage the host.

Using a hammer is great for prototyping a handful of assemblies or trying out a Coiled Pin for the first time. However, this installation method is not recommended for short pins or pins with small diameters because it can be difficult to hold these pins in place by hand.

COILED SPRING PINS
INSTALLATION METHOD COMPARISON

	Hammer	Manual Install*	Automatic Pin Inserter
Ease of Assembly	Good	Better	Best
Prototype	●	●	
High Volume Production			●
Small Diameter Pins		●	●
Critical Alignment		●	●
Critical Insertion Depth		●	●
Poka-Yoke			●
Assembly Cycle Time	◕	◑	◔

*Manual Install with Pin Driving Chuck, Press/Hammer



Manual Press or Air Hammer with Pin Driving Chuck

Coiled Pins can be installed manually with a press or air hammer by using a pin driving chuck. First, secure the pin driving chuck into the press or air hammer. Next, manually insert the Coiled Pin into the end of the driver. Then place the exposed end of the pin into the hole and complete the installation by advancing the press handle or actuating the air gun.

Presses and air hammers with pin chucks allow for better axial alignment, control, and quicker cycle times compared to a hammer. These are great solutions for small to medium volume production. Additionally, pin driving chucks are cost-effective and versatile tools that allow manufacturers to control alignment and insertion depth. Furthermore, the chuck will hold the pin securely in place prior to and during installation. The pin driving chuck has an internal punch with a diameter smaller than the hole but greater than the pin's chamfer diameter. This is critical for effective installation.

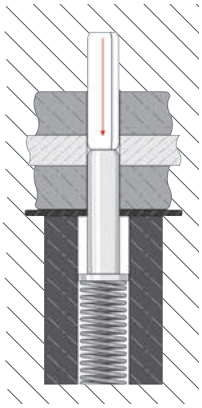
Automatic Installation Equipment

Automatic pin inserters are ideal for efficient, high volume production. Automatic inserters are completely self-contained. The fastener is oriented in a vibratory feeder and fed to a shuttle mechanism that positions the fastener directly underneath the insertion quill. The shuttle is mounted on a retracting mechanism that positions the pin exit bushing as close to the assembly as possible for insertion, then retracts for unobstructed loading and unloading.

The installation steps with an automatic pin inserter are simple. The operator will load the assembly onto the fixture, activate the machine to insert the pin, and then remove the assembly from the fixture. Periodically the supply of pins in the feeder bowl must be replenished. The operator does not need to handle the pins throughout any part of the installation process as he/she simply has to pour the pins from the shipping container directly into the feeder bowl as required.

There are many add-on features available to customize the automatic inserter to suit the manufacturer's needs such as: adjustable work station, infrared safety light curtain, force monitoring, distance monitoring, part presence sensing, rotary index tables, feeder bowl level monitoring, drilling and pinning combination, multiple pin insertion per cycle,etc.
The feeder bowl can also be designed to sort out errant product or debris.





Fixturing

Fixtures are designed to hold, support, and align components during installation. This is a critical element to the performance of the installation equipment and therefore the quality of the final product. Effective fixturing also improves cycle times, reduces the risk of scrapped assemblies, and poka-yokes the beginning of the assembly process.

Spring-Loaded Alignment Pin

The use of a spring-loaded alignment pin is recommended for assemblies with through-holes to ensure alignment is maintained between the pin and the holes of the assembly components throughout the entire installation process. A spring-loaded alignment pin is fixed on the installation table and is used for alignment of the assembly prior to and during installation. Spring-loaded alignment pins (also known as locating pins) have spring mechanisms so they retract as the pin is inserted into the assembly as shown in Figure 1. If the fixture used the periphery of the assembly components as datums rather than a simple disappearing pin, the manufacturer would have to hold tighter tolerances on the parts to maintain proper alignment. This would result in higher manufacturing costs without adding any value over using a disappearing pin for assemblies with through-holes. ●



Jeff Greenwood *is a Product Sales Engineer for SPIROL International Corporation. Passionate about driving growth through quality solutions, strategic planning, and effective project management. SPIROL.com.*

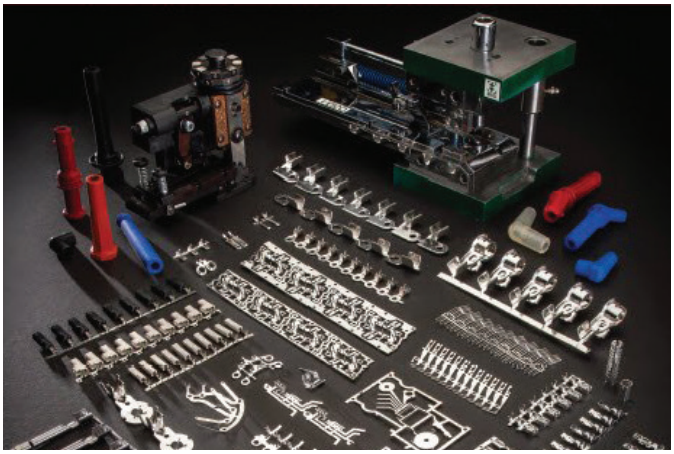
What's Happening



Mactac® announced that it has named **Kevin Clunie** Sales and Marketing director in its Performance Adhesives Group. In this role, Clunie will lead strategic direction for all sales and marketing functions within Mactac's Roll Label business. As part of his responsibilities, he will oversee nearly 30 employees, providing leadership guidance and support; collaborate with internal and external stakeholders; and work closely with Mactac's senior leadership team and Roll Label customer base.



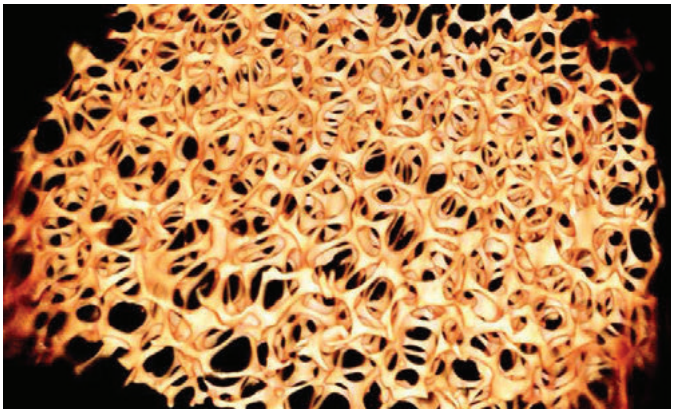
TTI, Inc., a leading specialty distributor of electronic components, announced the company has been awarded the **2019 Distributor of the Year award from SV Microwave**, a leader in the RF/microwave industry. The award recognizes outstanding performance and is awarded based on point of sale growth, program support, customer reach, engagement efforts, market share and more.



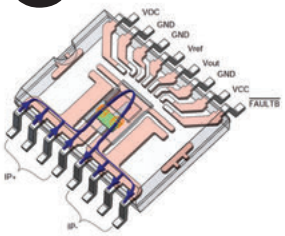
ETCO Corporation announced that it will begin manufacturing **Pancon's** electric terminal product line. Pancon has phased out production in its two manufacturing facilities in Massachusetts and California.

ETCO has purchased many of Pancon's dies which allows ETCO to serve the production needs of former Pancon customers and help minimize any disruption to manufacturing facilities.

Sean Dunn, Vice President of Marketing, said "our ability to engineer custom products means that we can meet almost any product need."



Researchers at **Oak Ridge National Laboratory** demonstrated that metal foam enhances the evaporation process in thermal conversion systems and enables the development of compact heating, ventilation and refrigeration, or HVAC&R, units. Compact and efficient HVAC&R equipment is needed to support the global industry transition to using alternative, environmentally friendly refrigerants. The small-scale evaporator proved metal foam is well-suited for compact systems. "We found that the presence of a porous open cell or sponge-like metal foam layer in an evaporator's tubes increases the liquid refrigerant's boiling rate, creating essentially an enhanced pool-boiling process that can accommodate much higher heat fluxes compared to conventional technology," ORNL's Kashif Nawaz said.



ACEINNA announced that their MCx1101 Current Sensor was named as the 2019 Sensor Product of the Year by Electronic Products Magazine. ACEINNA's AMR based Isolated Current Sensors were developed for use in Server Farm, Telecom and Industrial Power Supplies, IoT applications, Appliances, Inverters and Motor Control, Industrial Robots and Manufacturing Systems, Automotive EV Charging Stations and many other power conversion tech applications.

These highly accurate, wide bandwidth AMR-based current sensors are now available for a wide range of ADC and microprocessor-based power systems and applications. Units are now available for sampling and volume shipments.

"Our award-winning integrated AMR based Current Sensor family provides the best in class performance on bandwidth, output step response and accuracy for all-in-one single chip solution in the industry," says Khagendra Thapa, VP Current Sensor Product for ACEINNA. "Unlike other AMR based current sensing solutions on the market that require an extensive and time-consuming integration to make them work, ours are plug and play."

The MCx1101 are fully integrated, bi-directional current sensors that offer much higher DC accuracy and dynamic range compared with alternative solutions. For example, the ±20A version has a typical accuracy of ±0.6% and are guaranteed to achieve an accuracy of ±2.0% (max) at 85°C.



ASYMTEK, a part of Nordson ELECTRONICS SOLUTIONS, a global leader in electronics manufacturing technologies, announces that their distributor, **neutec electronic AG**, has expanded its representation of all ASYMTEK and DIMA products to the French-speaking areas of Switzerland. neutec electronic AG will distribute conformal coating, fluid dispensing, and hot bar soldering equipment and provide technical support to new and existing Swiss customers. This agreement was effective November 1, 2019.

"With more than 30 years of experience in the distribution of equipment for electronics assembly in the Swiss market, neutec electronic AG has been providing excellent local support to our customers in major parts of Switzerland," says Stéphane Etienne, business development manager, Nordson ELECTRONICS SOLUTIONS. "This expansion will ensure that all Swiss customers have reliable, local support for their ASYMTEK and DIMA products."

neutec electronic AG, based in Mellingen Switzerland, was established in 1989. Their team of experts and highly trained technical staff understand the special requirements of electronics manufacturing and industrial production and can help customers with a wide range of services to ensure that manufacturers get their processes up and running quickly, smoothly, and efficiently.

CAM
Consolidated Aerospace Manufacturing

Stanley Black & Decker announced that it has entered into a definitive agreement to acquire **Consolidated Aerospace Manufacturing** for up to $1.5 billion in cash. Consolidated Aerospace Manufacturing, based in Brea, CA and under the control of Tinicum Corporation, designs and manufactures highly engineered and innovative hardware and fastener solutions for demanding aerospace applications worldwide.

Consolidated Aerospace Manufacturing's products include fasteners, fittings, couplings, latches, quick release pins, tubing subassemblies and other complex components and assembled products. The company was founded in 2012 and has consolidated eight businesses that each carry strong brands, industry leading technical expertise, deep customer relationships and over 40 years of history in providing industry-leading service and solutions to commercial aerospace and defense customers.

Tinicum is a private investment firm with more than 30 years of experience investing in private and public companies, holding its businesses for the long term.

"We have enjoyed tremendous support under the ownership of Tinicum, during which we invested heavily in upgrading the equipment and facilities of the businesses we integrated, in addition to strengthening our engineering and management resources," said Peter George, CEO of CAM.

"The Tinicum partnership was a central part of the company's growth. We are extremely pleased to be taking this next step of joining Stanley Black & Decker. Being part of such a capable industrial company will enable us to further expand our company's resources globally, including accelerating the development of new products and pursuing acquisitions, allowing us to better serve the needs of our customers."

Stanley Black & Decker is a $14 billion revenue, purpose-driven industrial organization. With 58,000 employees in more than 60 countries, it operates the world's largest tools and storage business, the world's second largest commercial electronic security company, and a leading engineered fastening business as well, Stanley Engineered Fastening.

"With its well-recognized brands, proven business model and experienced management team, Consolidated Aerospace Manufacturing will play a significant role in the growth of our Industrial business and company overall," said Stanley Industrial President John Wyatt.





Emerson has launched a new generation of ultrasonic welders to support the growing demand for the assembly of smaller and more intricate plastic components such as those used within medical devices and consumer electronics. The **Branson GSX Ultrasonic Welding Platform** is an advanced and intuitive flexible joining solution, designed to optimize and ensure quality welds, while helping manufacturers meet project timelines and deliver expected return on investments.

Plastic components across the medical, electronics, and automotive industries are becoming increasingly miniaturized, with embedded electronics, intricate designs, and thinner plastic walls. Conventional welders with high or crushing weld forces inhibit safe welding of small and fragile parts. To meet this challenge, Emerson has developed an advanced electro-mechanical actuation system that provides unprecedented control and position accuracy. Its closed-loop force control precisely regulates even ultra-low trigger forces, enabling the GSX-E1 to perform faster, high-performance welding of delicate and intricate components. This advanced actuation system leverages over 70 years of ultrasonic application experience and combines servomechanism, software optimization, and proprietary dynamic follow-through to enable a broad range of weld forces up to 2,500 newtons.

The highly configurable GSX welding platform enables customers to accommodate many different parts and application types by using an array of welding parameters and actuation control modes during a single weld. This ensures better, consistent, quality welds leading to fewer rejects. Tim Herren, Emerson's Western Region Sales Manager for Assembly Technologies states, "I've never been more impressed with the controls and ergonomic interface of a welder. I'm able to optimize the welding parameters in minutes and help the customer weld thousands of parts with zero rejects...something the customer has never been able to do before." Using a multicore processor and a linear encoder drive, the multi-tier advanced actuation system can be instantaneously adjusted based on real-time feedback. This ensures the same level of precision and repeatability across multiple welders, with post-weld tolerance and part variability measured in microns.

Increasingly challenging production timelines, which must be met to ensure a project's expected return on investment, are inhibited by a loss of operator experience and expertise. Helping to bridge any potential skills gaps, the GSX-E1 features simple and intuitive software, supported by a high-definition 12-inch touchscreen HMI, which enables operators to perform faster, correct setups and reduce application testing time. This leads to faster start-up and setup times, which can reduce operator time by up to 60% while assuring weld quality and production efficiency.



Emerson's AVENTICS Smart Pneumatics Monitor (SPM) is an IIoT hub that allows for local data collection and analysis independent of the controller. The interactive, pick-and-place display illustrates how pneumatics and IOT combine to track the health and performance of valves, cylinders and shocks, as well as the energy efficiency of pneumatic systems. This is done without the need to involve machine control. Predictive maintenance minimizes the risk of unplanned machine downtime, increasing ROI and significantly lowers operating costs. The display features RTC rodless cylinders and AV valves with AES (advanced electronic system) fieldbus.



Emerson's ASCO™ proportional valve technology can serve an even larger group of industries, including food and beverage, automotive and tire manufacturing, medical equipment and product packaging. Proportional valves quickly and accurately adjust output pressure or flow in response to changing operating conditions. Precise control of liquids and gasses enables optimization of machinery and processes, increasing efficiency and production throughput and reducing raw material use and energy consumption.

Proportional valves are used in applications that require greater control than on/off valves can deliver. Proportional control is more precise, more dynamic and easier to measure.

Emerson's integration of IO-Link® communications with Sentronic Plus (Series 614) and Sentronic LP (Series 617) proportional pressure control valves provides cost-effective and reliable control and diagnostics in support of predictive maintenance practices.

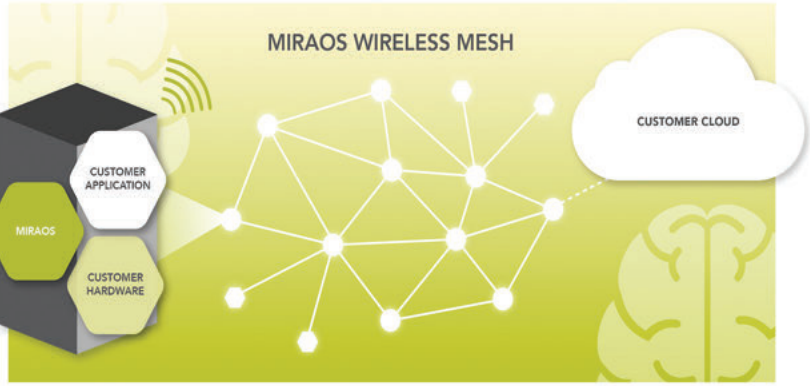


- **Sentronic Plus** digitally operated pressure regulator valves accurately adjust pressure, flow, force, speed and linear or angular positions. They regulate pressure up to 174 psi (12 bar) and are electromagnetic-compatible, according to electromagnetic compatibility (EMC) Directive 2014/30/EU.

- **Sentronic Low Power** (LP) valves are a highly efficient option for pressure regulation requirements, offering a small footprint, an easy-to-use, modular design and advanced software capabilities.



Using IO-Link communications to monitor these devices on the factory floor supports future implementation of Industry 4.0 and Industrial Internet of Things (IIoT) applications that will contribute toward greater plant reliability, availability and profitability.



LumenRadio´s focus is to develop the most resilient and Future-Proof connectivity solution on the market, but their vision is also to make it easier for development teams to implement wireless technology into their products, something that is clearly shown in the new 2.4 version of MiraOS.

Unique features in MiraOS 2.4

• Stand-alone MiraMesh – Use the ultra-reliable mesh technology with MiraOS or with any other operating system of preference
• Universal Radio Protocol Time-Sharing – Run any radio protocol concurrent with MiraMesh, leveraging the same physical layer
• Link Local Multicast – Multicast that can be optimized for data thirsty or ultra-low energy products
Adding to above unique features, LumenRadio has also made a lot of performance improvements, taking the reliability of MiraOS and MiraMesh to the next level.

Stand-alone MiraMesh

For customers who have made major investments into application code, running other operating systems than MiraOS, it can be a quite costly and long process to port already developed product software to a new operating system. The stand-alone MiraMesh feature will yield a quicker time to market for those customers, while still allowing them to migrate to MiraOS over time. The MiraMesh stack can be used with several other operating systems such as FreeRTOS, Zephyr, etc. MiraMesh can also be run bare metal.

Universal Radio Protocol Time-Sharing

Last year LumenRadio released its Concurrent Bluetooth feature. Now MiraOS 2.4 has been further extended with Universal Radio Protocol Time-Sharing, enabling MiraOS to run any radio protocol concurrently with MiraMesh. This enables the possibility of interactions between the wireless product and other devices through e.g. Zigbee, Thread and Bluetooth Mesh, at the same time as the MiraMesh network is kept fully operational, opening up for new functions and possibilities.

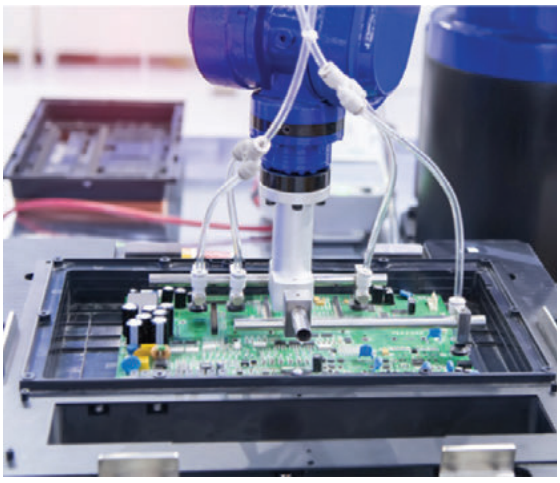
Link Local Multicast

Link Local Multicast is an efficient method for mass distribution of data. It is used for light controls or ultra-low power sensors running on batteries for predictive maintenance. And through a new API the customers have the possibility to optimize and balance data throughput and current consumption.

Wireless Without Worries

Implementing wireless technology has earlier been seen as a daunting project. With MiraOS 2.4 LumenRadio starts a new chapter regarding user experience, both for developers and end users of their wireless technology.





ICM Controls, a leader in the manufacture and supply of electronic controls, was **classified as an essential service provider by New York State** and granted exemption status, and was therefore "not subject to the required 100% workforce reduction mandate pursuant to the Governor Andrew Cuomo's revised Executive Order 202.6. The move allows the company of more than 250 employees to remain operational in full support of other essential service providers standing on the front lines in the battle against COVID-19.

"We manufacture essential products and controls for multiple companies that are providing other essential medical and telecom equipment being used to combat the spread of COVID-19," said Andy Kadah, President of ICM Controls. "Furthermore, our world-class printed circuit board shop, assembly lines and engineering services are at the ready in support of all essential service providers across the country".

Kadah touted the flexibility of ICM Controls' vertical-integrated manufacturing facility and vowed to support as much other essential service providers and our infrastructure as possible. The purpose is to help keep hospitals, government agencies, telecom sites, FEMA trailers, quarantine RV's and other businesses open and the economy moving. This includes major corporations that have had their supply chains decimated as a result of the global pandemic, as well as the essential contractor trying to keep the heat on at a medical facility or nursing home.

"There are a lot of companies that source overseas that are unable to get circuit boards and other key products or components right now, or the lead times have been extended by months, which will force their doors to close," said Kadah. We want everyone to know that our doors are open. If we can help them, we will. Supporting other essential providers whose efforts are required to keep the fight against this pandemic is our top priority."

"Similarly, ICM traditionally has not sold its branded product lines direct to the installer base," added Kadah. "But distribution centers all across the country are being severely impacted by states shutting down." Kadah pledged that if a contractor or facility manager is unable to source a product through their regular distribution network, they should contact ICM Controls directly and the company will make its products available, beginning with normal distribution channels, if they are operational. If those channels are impeded by the pandemic then direct shipping will be made available.

"The last thing we can afford is to have the HVAC related control system at a hospital or mobile treatment center break down and require a part that can't be sourced because everything is closed," said Kadah. "It is essential that we all join together to keep our country and economy afloat. Supporting those that respond to this pandemic is critical. They need tools to fight on the front lines of this war on the virus."



Southco, Inc. expanded its line of constant torque hinges with a new version that supports additional friction and reduced weight in limited-space applications. Depending on the torque requirements of the application, Southco's **E6-10E Constant Torque Hinge** with Extended Housing enables the resistance of two hinges to be packaged into one hinge, saving weight without compromising functionality. The E6-10E provides increased asymmetric torque for applications requiring maximum friction in small spaces. Its lightweight and lower profile make it an ideal solution for a variety of transportation applications with reduced packaging space, including aircraft seating and automotive storage compartments. Like Southco's standard E6 series, the E6-10E offers a long cycle life and requires no maintenance or adjustment over the lifetime of most applications.



ZF Electronic Systems presents its proven **D4 series of snap-action switches** with new halogen-free flame retardants, which now meet the harmonized UL/EN 61058 standards. Refrigerators, freezers and air condition equipment are now employing a more environmentally friendly refrigerant; however, this new refrigerant is flammable. Therefore, a special "certification" / approval is necessary--> "Ex proof".

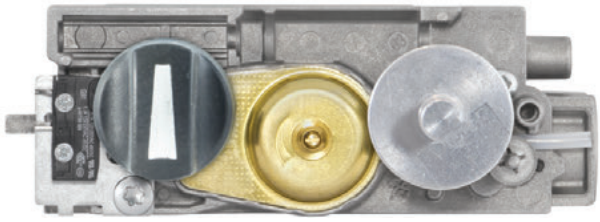
The NEW T85 version of the D4 series snap-action switches with black plastic material give an improved environmental performance and are future-proof to growing customer requirements and compliance.

The D4 series snap-action switches benefit from an increased tracking resistance of PTI 300, a high functional reliability, and excellent switching precision. Using application-specific contact materials for switching currents from 0.1A up to 21A at 250VAC, the switches offer superior contact reliability. Due to several available actuators and mounting points, the devices will prove suitable for many different applications.



H.B. Fuller launched a series of products that are free of epoxy silane commonly known as GLYMO within its **Flextra™** range of adhesives for flexible packaging. According to the company, this range also does not contain organotin or BPA. In addition, specific grades are free of cyclic esters.

Converters and food manufacturers face growing regulation and increased pressure from consumers. H.B. Fuller reports that its Flextra line for flexible packaging provides a compliant and food-safe adhesive solution. The Flextra range includes both solvent-based and solvent-free products for medium- and high-performance applications. Individual solutions also offer additional benefits such as room temperature curing, fast curing, and PAA decay, as well as the option to use an aliphatic system to avoid PAA altogether.



Maxitrol and Mertik Maxitrol have recently developed a couple of interesting new products for gas appliances: the new **GV30C mechanical thermostat** and the **GV30 pressure switch**. Both of these products were well received at the recent HOST Milano, the world's largest and most consequential trade fair dedicated to the cooking equipment, food, and coffee industries.

The GV30C mechanical thermostat is designed to control the temperature in a gas burning appliance. When combined with a GV30 multifunctional control, two main burners can be operated independently with a single pilot burner.



The GV30 pressure switch closes an electrical contact when the gas reaches a set pressure. When used on the main gas or pilot gas outlet, the GV30 pressure switch and an LED will show whether the burner is on or off. On oil pumps, for example, a normally closed relay can be wired in parallel with an LED (e.g. If pilot gas is flowing, the relay will interrupt the power supply to the pump).



Regal Beloit Corporation, a leading manufacturer of electric motors, electrical motion controls, power generation and power transmission components, announced that its **Grove Gear Stainless Steel Worm Gear Reducer** has achieved third party IP69K certification.

Ingress Protection (IP) Marking rates the degree of protection provided by mechanical casings and electrical enclosures against intrusion, dust, accidental contact and water. It is published by the International Electrotechnical Commission (IEC). The IP69K rating is for high-pressure, high-temperature washdown applications. Enclosures conforming to it must not only be dust-tight, but also able to withstand high pressure and steam cleaning.

The Grove Gear Stainless Steel Worm Gear Reducer now joins the Hub City® Hera® Stainless Steel Gear Drive, Sealmaster® PN Gold™ Mounted Bearings and the Leeson® Extreme Duck® Ultra Motor as third party IP69K-certified products from Regal. Together, these four products provide a complete washdown solution for food and beverage, pharmaceutical and chemical processing applications.

"Traditionally, IP ratings have been used for electrical components, but the industry is starting to recognize the benefit of IP rating for power transmission components," said David Silverman, product manager of worm gearing at Regal. "This allows our customers to have a better understanding of the product capabilities for specification purposes. We are pleased that the Grove Gear Stainless Steel Worm Gear Reducer now carries the formal IP69K certification."



Nidec has added two new models to its lineup of traction motor systems for electric vehicles: a **200 kW** model for the D and E segments (large family cars and full-size/ executive cars) and a **50 kW** model for the A segment (micro / city / kei cars). Both models are based on the company's original 150 kW E-Axle—the first fully integrated traction motor system (electric motor, reduction gear box and inverter) in the world to enter mass-production. With the addition of these two new models, the company's E-Axles can now be used by an estimated 98% of all electric passenger vehicles.



The new 200 kW E-Axle, targeting luxury electric vehicles for the European and Chinese markets, features a motor and gears that have been improved to increase the power of the system by more than 30% while the total weight, 95 kg, is only 9% higher than that of the 87 kg 150 kW model.

The 50 kW model, on the other hand, takes aim at Japanese kei cars and similarly sized microcars for the Southeast Asian market. By adopting a coaxial design, the size has been reduced significantly (W 540 mm x H 300 mm x D 330 mm).

Mass-production of the 200 kW and 50 kW models is slated to commence in 2023 and 2022 respectively. The company recently announced during an investor conference in Tokyo that its backlog of E-Axle orders to be fulfilled by 2025 has surpassed 10 million units.



Emerson's ASCO™ Series 158 Gas Valve and Series 159 Motorized Actuator are designed specifically for burner-boiler applications, the new products give OEMs, distributors, contractors and end-users a new combustion safety shutoff valve option that increases safety and reliability and enhances both flow and control.

The new valve offers a higher close-off pressure of 75 psi (5.2 Bar) ensures a safe shutoff in the event of a fuel train system failure and eliminates the need for additional safety components. The valve offers a flow rate which is twice that of other combustion valves on the market. As a result, it offers the highest BTU rating in the industry as well as the ability to deal with varying gas inlet pressures — without a reduction in burner performance and operation. Installation is also made easier with end connectors that eliminate the need for piping unions and a ventless compatible monoblock design that not only does away with the need for additional vent piping, but also limits greenhouse gas and vent emissions.

"We're offering our customers a highly adaptable safety shutoff valve that offers the same high levels of safety and reliability they have come to associate with the ASCO combustion valve products," said Erik VanLaningham, vice president of marketing for industrial automation at Emerson. "We're dedicated to providing easy-to-use, globally applicable combustion control solutions with the flexibility to address a full range of commercial and industrial applications. Because we know our customers are often working with tight deadlines, we've made sure these products are available on short lead times."

The ASCO Series 158 is a gas valve range available in sizes from Ð" NPT to 3" NPT (DN 10 to DN 80) in both single and monoblock constructions. The ASCO Series 159 Motorized Actuator has a rugged construction, can mount in any position and offers a visual indication of opening. This new safety shutoff valve is rated for an ambient temperature range of -40°F to 150°F (-40°C to 66°C) and is offered with an optional watertight National Electrical Manufacturers Association (NEMA)-approved Type 4 enclosure.

The Series 158 and Series 159 meet up-to-date National Fire Protection Association (NFPA), UL, Canadian Standards Association (CSA) and FM Global standards and have earned Restriction of Hazardous Substances (RoHs) and European Standards (EN) approvals.





Figure 1: Power Analyzer screens are designed to display test setup, digital display of measurements as well as scope presentation of data

Power Analyzers: A Designers High-Performance Test Equipment Toolbox

BY CHAD CARK

Introduction

The design of any power conversion system requires the measurement of a large range of electrical parameters that could be made using a lab bench full of instruments. The Power Analyzer pulls all of these measurements into a single instrument replacing meters, oscilloscopes, chart recorders, harmonic analyzers and other devices.

This paper will provide a basic overview of the functions and capabilities of high-performance analyzers. Examples of these functions and how to apply them will make use of details provided in the Operator's Manual for Vitrek's Model PA9xx Series of Power Analyzers.

What is a Power Analyzer?

Power Analyzers are a class of electronic instrumentation that combine the precision measurement and recording of a variety of parameters critical in designing and evaluating systems designed to generate, convert and consume electrical energy. Parameters include voltage, current, frequency, harmonics, RFI/EMI, power, efficiency and others. In addition to performing these measurements, Power Analyzers typically include the capabilities of saving setup data, producing reports, communicating via digital means with external devices and other Power Analyzers to perform and archive testing of complex systems. Some Power Analyzers have built-in functions to test equipment for compliance with efficiency and emissions standards.

In short, Power Analyzers are more than a mere collection of measurement and display functions. These instruments provide an integration of those functions into a cohesive tool required in the design and manufacturing of power electronics equipment.

Power Analyzer Capabilities

By combining the features and functions of a collection of instruments, PAs provide the ability to not only measure a wide range of parameters but also display the information in useful and effective ways, store the test setup information and data acquired and communicate/synchronize the information. Figure 1 presents a sampling of the data that is typically available on a PA screen.

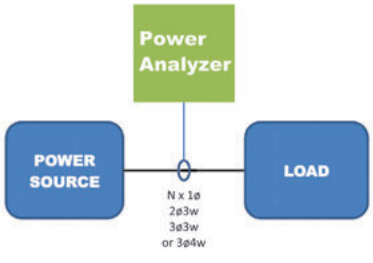
The image on the top displays the real-time data for the AC input of a power conversion device: input power (W, VA and VAR), power factor, voltage (V), current (A) and frequency. The left-hand screen display plots the harmonic content on the output of a converter plus the total harmonic distortion (THD) value. The right-hand screen is an oscilloscope display of the single-phase AC voltage and current of an adjustable-speed drive.

Many other display options are typically available, including 3-phase vector display of voltage and current, historical data, bar graphs of harmonic content and other useful information.

Power Analyzer Applications

Applications where Power Analyzers are commonly used include: By combining the features and functions of a collection of instruments, Power Analyzers provide the ability to not only measure a wide range of parameters, but also display the information in useful and effective ways, store the test setup information and data acquired and communicate/synchronize the information. Applications where PAs are commonly utilized, and the measurements typically made include:

Figure 2: Advanced PAs offer versions to accommodate a selection of single-phase and multi-phase measurements



- **AC to DC Power Supplies** - input power factor, inrush current, efficiency, harmonics, EMC emissions/compliance, current, power
- **DC-DC Converters** - power factor, efficiency, harmonics, EMC emissions/compliance, current, power, ripple
- **Motors** - inrush, efficiency, power, frequency, phase diagrams, speed/torque/direction transducers (analog and digital)
- **Adjustable Speed Motor Drives**- efficiency, harmonics, frequency, power, crest factor, compliance
- **LED Power Supplies** - power factor, ripple, power, efficiency
- **Solar Power Systems** - peak power point, voltage, efficiency,
- **Uninterruptible Power Supplies**- power factor, efficiency, output voltage, output frequency, harmonics, phase to phase measurements and phase angles
- **Battery Chargers** - input power factor, efficiency, harmonics, EMC emissions/compliance, current, power, ripple
- **Electric Vehicle Power Systems**- efficiency, power, voltage, charging current
- **Appliances / HVAC Systems**- standby power measurements and testing (for example to EN50564), power factor, efficiency, EMC emissions compliance

Scope capture and history are valuable tools for short term or long-term characterization during design and development. In addition to these product design, development and manufacturing applications, Power Analyzers are also employed in the field to troubleshoot problems and assess performance of systems in operation.

Power Analyzer Configurations

Many basic applications require the use of a single Power Analyzer. Most analyzers provide the capability of making multi-phase measurements. Here in this section, several applications requiring the application of one or more PAs will be described.

Single Analyzer Applications: Power Analyzers are connected between the source and load, as shown in figure 2. All of the measurements described earlier in this article are possible with a single analyzer, with the exception of efficiency which must calculate this value based on measurements of input power and power output.

Dual Analyzer Applications: In applications where both input and output measurements must be conducted simultaneously, it is frequently necessary to utilize two PAs, as shown in figure 3. (Later in this article, Vitrek's proprietary Virtual Power Analyzer (VPA) will be described that, in many cases can eliminate the need for a second instrument.)

A list of typical applications requiring dual PAs would include the following;

- AC to DC Power Supplies (single or multiple outputs)
- DC to DC Power Supplies (single or multiple outputs)
- DC or fixed frequency AC supplied variable or fixed speed motor drives Power Transformers (single or multi-phase)
- Lighting Ballasts (most types)
- Standby or Backup Power Supplies (AC or DC)
- Photovoltaic Power Generators (DC in; DC or AC out)
- Electric Vehicle Traction Motor / Generator Drive Systems

Triple Analyzer Applications: Complex systems with multiple power conversion stages like these listed would require three synchronized PAs as shown in figure 4.

Examples of electronic systems requiring three PAs to fully characterize performance include:

- Emergency Lighting Ballasts (most types)
- Standby or Backup Power Supplies (AC or DC)
- Solar Systems with Auxiliary Battery Backup

Note that in large systems, e.g., distributed power networks, the input PA can be placed literally miles away from the output PA. In addition, there are very intricate applications, like inductive wireless charging of EV batteries that would require four geographically distributed PAs.

The Virtual Power Analyzer – A Better Solution

The information presented in this article is intended to provide a basic understanding of the utility and effectiveness of Power Analyzers in the design, development and analysis of power conversion systems. In many cases, the application requires the use of multiple PAs to accomplish the task at hand. While nearly all PAs provide

Figure 3: Two PAs are needed in applications where both input and output measurements are required

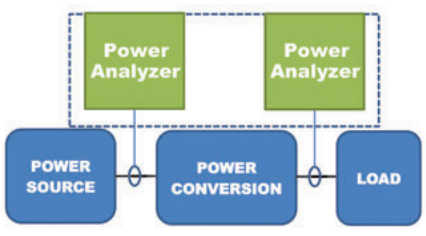
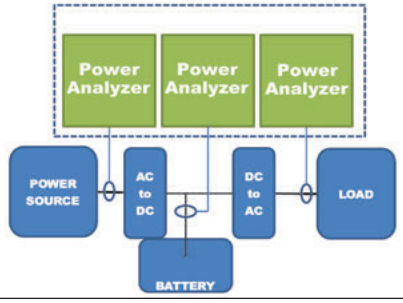


Figure 4: Double-conversion systems, like the UPS shown here would require three PAs to completely characterize performance



versions that can handle either single phase or multiple phase inputs, only Vitrek provides the ability to integrate separate PAs into the same instrument. Vitrek has taken this concept further by essentially making each channel in the device into an individual PA channel. Channels can be combined into Virtual Power Analyzers (VPAs) enabling a single device in some applications to perform the work of multiple instruments.

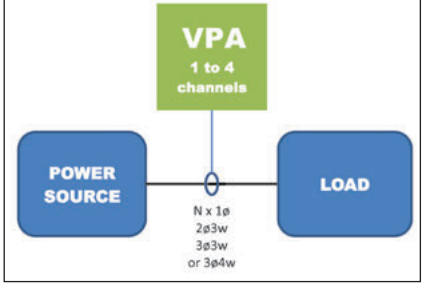
Here is a short list of the performance features of Vitrek PA9xx Series, 4-channel PAs:

- Supply frequency measurements DC and 0.01Hz to over 1MHz (W channels) or 100kHz (L, A or S channels) supply frequencies
- N x 1ø can be up to 4 AC or DC supplies
- 2ø3w and 3ø4w measures neutral current from phase currents
- 3ø3w can use either 2 or 3-wattmeter methods
- 2ø3w, 3ø3w (3ch) and 3ø4w measures phase-to-phase voltages in addition to the individual phase voltages
- Wye (3ø4w) and Delta (3ø3w) voltage conversions for 3ø3w and 3ø4w resp.
- Power can flow in either direction, separately integrates power in each direction (per phase and total) as well as the total
- Total power (W, VA, VAR and PF) measured in addition to the individual phases
- Max. hold maintained for voltage, current and power measurements
- Harmonic analysis of every signal up to the 500th harmonic, <435kHz (W channels) or <115kHz (L, A or S channels)

One special feature, worthy of note, is the built-in compliance test for various industry leading environmental performance standards. These compliance tests are integrated into the PA9xx Series and are selectable from the touchscreen. The test results can also be displayed on the touchscreen with no requirement for PC-based software. This on-display feature significantly improves the user interface and efficiency when performing these critical tests. Engineers and technicians enjoy the flexibility of using the touchscreen at the test station with software available if required. Vitrek PAs' built-in compliance testing support environmental / performance standards include:

- EN60034-2-1:2014 (motor drives)
- EN50564:2011 (standby power)
- EN61000-3-2 and 3-12 and 4-7 (harmonics emissions)
- RTCA DO-160E/F/G (avionics)
- Boeing 787B3-0147
- Airbus ABD0100.1.8 (A380) and ABD0100.1.8.1 (A350)

Figure 5: The Vitrek PA9xx can be equipped with up to four independent channels that can be configured into up three separate PAs



VPA Application Examples

A few examples of the Vitrek VPA architecture will illustrate the convenience and economy of this approach:

- **Power Supplies:** AC-DC power supply with a three-phase AC input and a DC output could be analyzed with a single 4-channel PA9xx Power Analyzer. Three channels would be combined as one VPA to measure and record the 3-phase input. The fourth channel would then measure the DC output. All input/output measurements, including efficiency, are contained within one device without any external synchronization.
- **EV Drive Systems:** The analysis of the performance of an Electric Vehicle drive system can be accomplished by assigning two channels each to the interface between the battery and two channels as a second analyzer between the power converter and the motor. Bi-directional energy flow, efficiency and a full range of performance features can be handled with a single instrument.
- **Photo Voltaic (PV) Inverters:** The output of the PV cell (DC) can be monitored on one of the four available channels, while the 3 phase AC output (output of the power conditioner inverter and converter) can be monitored using the remaining 3 channels. From this, efficiency studies can be performed using the built in VPA's of the power analyzer.
- **Motor Efficiency Calculations:** Motor manufacturers and users can easily perform efficiency studies to IEC 60034-2-1:2014 (built in to Vitrek PA) which classifies the levels of motor efficiency.

Important VPA Features

- **Oscilloscope Measurements:** Many applications require oscilloscope measurements of voltage, current and power. The PA9xx integrated oscilloscope hi-resolution oscilloscope function provides up to 24-bit resolution. Most oscilloscopes only have eight bits of resolution. This means they only have 256 vertical digitizing levels. The PA9xx has 65,536 times better vertical resolution! Typical oscilloscopes are either two or four channels (there are specialized oscilloscopes with more channels). The PA9xx integrated oscilloscope can display up to 12 channels (any six at a time). Any measurement parameter can be plotted as a channel. So, for instance the instrument can display input voltage, current and power and

the output voltage, current and power, simultaneously.

• **Harmonics:** Normal harmonics analyzers measure the harmonics up to 10x or 50x the fundamental frequency. However, some of the new requirements ask for more. The PA9xx Harmonics Analyzer function can measure up to the 500th harmonic of the fundamental! Again, because of the instrument's up to 24-bit digitizing, it performs better than many dedicated spectrum analyzers. This is needed for looking at small signal content in the presence of large signals.

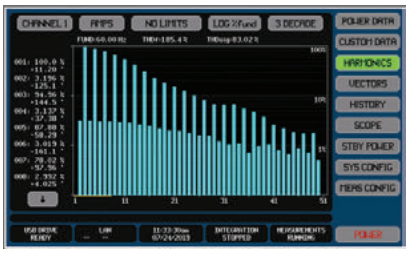
• **Distributed Analyzers:** With the PA9xx, up to three separate Power Analyzers can be combined to get up to twelve time-synchronized, distributed channels. For example, channels of one analyzer can be assigned to the input, and channels of another analyzer to the output, enabling measurement of the efficiency of the system, even if the input and output are geographically separated by miles!

• **Extended Measurement Capabilities:** The PA9xx is also capable of measuring rectified data and signals with crest factors as high as 100. The instrument can also measure load impedance - series inductance and resistance; parallel capacitance and resistance, energy consumption (KWH), average power (W), and calculate energy bought or sold.

• **Datalogging:** The PA9xx datalogger function timebase rescales automatically over the length of the test. So, for a 1-hour test, the display will be for 24 hours. For a ten-day test, it will display over ten days. However, the data logged for any specific moment over the test period can be retrieved as well as the min and max peaks between datapoints. Datalogging can be performed for up to 16 different measured parameters. The time base can scale up to 584.5 million years (collection is automatically stopped after this time has elapsed. This is not fully tested at the time of writing!). Any measurable parameter can be displayed on the screen as a trace and logged data can be saved to an external USB drive.

• **Reporting:** The PA9xx provides the capabilities to clearly document and produce reports of the results of the tests performed. As with other Power Analyzers, data can be exported via Ethernet or RS-232. The PA9xx also features front-panel USB drive access. The USB drive can be used to save and recall configurations, harmonic limits, measurements, spectrum analyzer data, scope data, cycle data, history data and harmonics data. Easiest of all, screen shots can be captured of anything data selected, such as this:

Figure 6: Data selected for display on the PA9xx can be easily exported via the front-panel USB access port.



Conclusion

The Power Analyzer combines into a single instrument that functions and features of several benchtop instruments. It truly is the electronic design engineer's instrumentation toolbox. And none is easier to use or more economical than the Vitrek PA9xx Series. The PA9xx's Virtual Power Analyzer simplifies setup and synchronization of input and output test data, enabling the ability to perform intricate and accurate tests with few instruments. The following is a useful checklist that may be helpful:

• Simple setup and operation via a touchscreen display
• High-resolution digital display
• Supply frequency measurements DC and 0.01Hz to over 1MHz supply frequencies
• Multiple accuracies and frequencies based on your specific application
• Single phase and multi-phase inputs (including all common types)
• VPA (Virtual Power Analyzer) features extending the testing capabilities of the Power Analyzer
• Input voltages up to 600VAC
• Bi-Directional power flow (per phase and total)
• Total power (W, VA, VAR and PF) measured in addition to the individual phases
• Max. hold maintained for voltage, current and power measurements
• Harmonic analysis of every signal up to the 500th harmonic
• Datalogging capabilities with scalable timebase
• Report generation capabilities
• Built-in programming to testing to selected safety and emission standards.



Chad Clark *has been with Vitrek LLC since 2008. Over the years Chad has had the opportunity to work directly with end users to develop safe methods and procedures enabling countless products to be NRTL safety listed. Vitrek is a leader in high voltage compliance test and measurement. Chad holds a BE in Economics for California State University - Long Beach.*

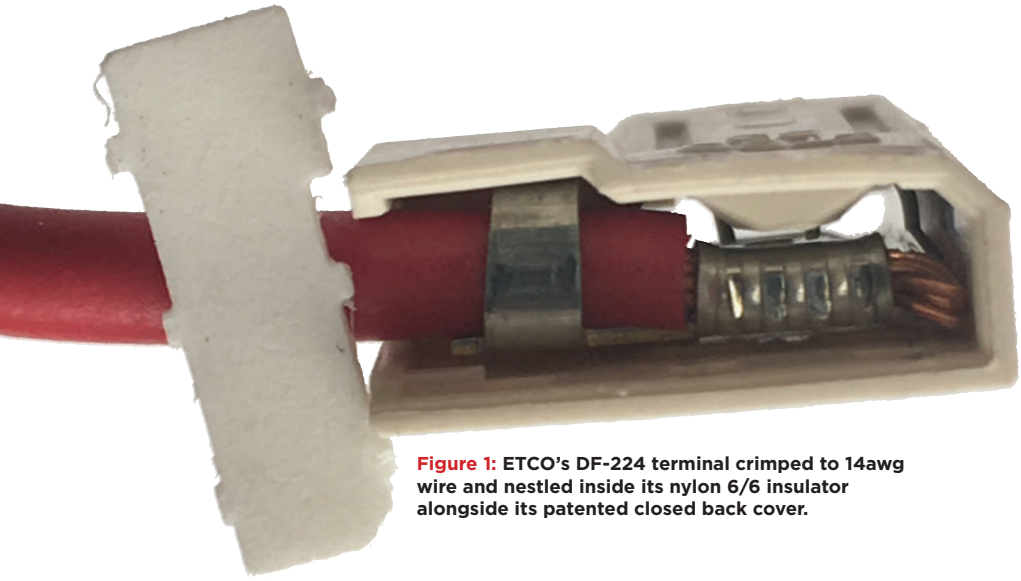


Figure 1: ETCO's DF-224 terminal crimped to 14awg wire and nestled inside its nylon 6/6 insulator alongside its patented closed back cover.

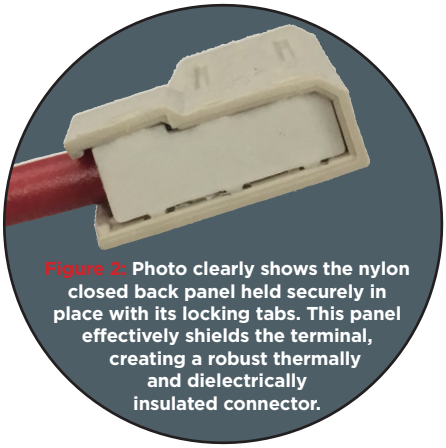


Figure 2: Photo clearly shows the nylon closed back panel held securely in place with its locking tabs. This panel effectively shields the terminal, creating a robust thermally and dielectrically insulated connector.

A New Standard for Appliance Connections

BY EDWARD JACQUES AND ANDREW SINK

The new PDF-225-CB and PDF-224-CB are patented connectors. Specifically, they are closed back, fully insulated, female quick disconnects. These products are made to be incorporated in a multitude of home, office and business appliance applications. ETCO has supplied a Nylon thermally insulated version of this product for years, to all major and opportunistic producers of quality appliances. Its simple design integrates easily into appliance manufacturing and assembly processes. At the center of each connector is a UL and CSA compliant DF-224 or DF225 quick disconnect terminal. This new product configuration features a fully insulated, right angled connection. The device provides a secure connection for assemblies using the following wire ranges: 18-14 AWG and 22-18 AWG. Utilizing the ETCO developed, industry leading'' F'' crimp, the Closed Back connector renders an absolute minimal loss of voltage. Laboratory tests show the connector delivered voltage drop measurements amongst the lowest for this type of product. With the new protective backing, the conductive portion of the connector is thermally and dielectrically insulated. The PDF-224-CB / PDF225-CB connectors meet UL 749 standard's requirements, one of the first connectors in the industry to claim this feat. Multiple strategic tests were prepared and executed in our lab over the course of several weeks, and findings of these tests are included in this document.

UL749

The Closed Back connector line was engineered to surpass safety requirements established as a result of UL749. The patented closed back cover of the insulated DF 225 and DF 224 terminals paved the way for compliance to UL749. This locked in cover offers a fortified hazard defense, inhibiting electrical shock from an accidental probing of a tool or utensil, sometimes referred to as a ''knife test''. Further tests confirmed the terminals readily surpassed UL requirements for temperature rise and millivolt specifications.

Safety/Performance

The connector housing was modified from its original design specifically to enhance safety features. This is a fully insulated quick disconnect. The fire retardant nylon covers are precisely inserted at high rates during the manufacturing process and are held in place with specially designed locking tabs. An advantage of a right angled / perpendicular connection over a typical straight / inline terminal connection is the space saving reduction in height. Using the engineered applicator appliance manufacturers have the ability and advantage of providing a complete product with safety and enhanced performance at nearly the same price as the previous connector.

Test Description

Standard based test specifications and processes have been developed to assist in the development of superior electrical connections. With primary and rigorous focus on all relevant industry standards such as UL and ANSI, the engineering staff has also developed a barrage of unique and demanding strategic tests. These formidable examinations

set parameters exceeding those established as industry standard and are useful analytical tools for improving existing product, comparisons to competitor's offerings or perhaps the creation of something new. The DF224 and DF225 terminals at the center of these new Closed Back connectors have long been established as UL compliant.

The results offered in this document were compiled during R&D augmented testing measuring Heat rise and Voltage Drop. UL guidelines for test samples, test board layout and Amperage levels form the base of the testing. Lab test parameter for power durations exceeded the full current "power on " of the UL Heat Cycling specification from 45 minutes to 2 hours, and the no current "power off" segment was increased from 15 minutes to 30. Selected terminals were properly crimped to appropriate wire AWG and length. Six, 6 inch lengths and an 18 inch length of wire were tailored with terminals crimped to each end. Each wire received precise jacket cutouts centered 3 linear inches from the crimp, exposing the wire's conductor to allow probe contact.



Figure 3: Terminals mounted to test board

The 18 inch wire's center segment was used to establish the voltage required for current to pass its 12 inch length. Per UL formula, that measurement was divided by 4, dictating the voltage demand for 3 inches of that conductor. This 3 inch base value was used to determine voltage drop over the crimp. Each test was composed of 12 terminals crimped to wire and mated to appropriate test tabs. All test tabs were securely mounted to equally spaced stanchions on a phenolic board. Power leads constructed of like wire gauge were connected to a metered power source. As per UL standards, the amount of current supplied to the test circuit was determined by the gauge of the wire.

Voltage Drop Test

In our test, Voltage Drop measurements were accumulated with the test board in its power off cycle segment. All measurements were ascertained in the lab using our calibrated Keithley 2750 DMM. Probe leads accurately spanning from the connecting wire's insulation cutout to the test tab, resulted with the instrument displaying a digital voltage measurement over that connection. This measurement minus the established base value yielded the total Voltage Drop over that test segment. Female terminal to male terminal connections were also measured for Voltage.

A voltage drop is a measurement of the reduction in voltage through the passive elements of an electrical circuit. It's the measure of voltage necessitated to push a known amount of current through a given amount of resistance. Things like connectors, crimps and splices all contribute to resistance along the currents path creating these undesirable Voltage drops. Good terminal connections and proper wire crimps can help reduce the current resistance and produce more desirable, lower voltage drop measurements. In testing, we are looking for voltage drops that fall below those laid out by UL specifications 5 tests for each wire gauge were executed in this manner, each test comprised of 12 separate terminals connections. The results of these 5 tests were averaged and the final figures were used to populate Tables 1 - 4.

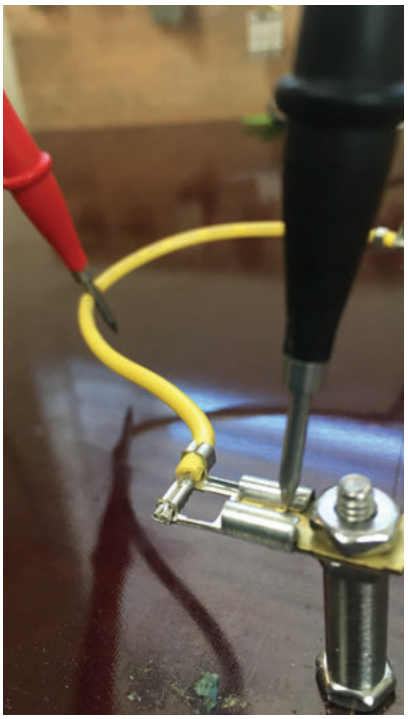


Figure 4: Probes measuring Voltage Drop

Summary of Voltage Drop Findings

The maximum and minimum wire gauges recommended for use with the DF-225 terminal are 18 AWG and 22 AWG. UL specifies a current of 14 Amps be used to test 18 AWG wire and a current of 6 Amps for tests using 22 AWG wire.

DF-225 to 18 AWG

Connections using 18 AWG wire with the DF-225 averaged a total of 12.7 mV drop from cutout to test tab. 2.4 mV of that measurement was attributed to resistance at the M/F connection of terminal to test tab, leaving 10.3 mV as the average voltage drop over the crimp. This meets UL specifications for safety governing Electrical Quick Disconnects which allows for a maximum of 13 mV drop, given a tin to brass .250 inch connection. See Table 1.

DF-225 to 22 AWG

Connections using 22 AWG wire with the DF-225 averaged a total mV drop of 3.8 across the terminal. Of that 3.8 mV, 1.1 mV was dropped across the connection of terminal to test tab, and 2.7 mV was dropped across the crimp of the terminal. This meets UL specifications for safety governing Electrical Quick Disconnects which allows for a maximum 10 mV drop, given a tin to brass .250 inch connection. See Table 2.

The maximum and minimum wire gauges recommended for use with ETCO's DF-224 terminal are 14 AWG and 18 AWG. UL specifies a current of 30 Amps be used to test 14 AWG wire and a current of 14 Amps for tests using 18 AWG wire.

DF-224 to 18 AWG

Connections using 18 AWG wire with the DF-224 averaged a total of 7.4 mV drop from cutout to test tab. 2.1 mV of that measurement was attributed to resistance at the M/F connection of terminal to test tab, leaving 5.2 mV as the average voltage drop over the crimp. This meets UL specifications for safety governing Electrical Quick Disconnects which allows for a maximum of 13 mV drop, given a tin to brass .250 inch connection. See Table 3.

DF-224 to 14 AWG

Connections using 14 AWG wire with the DF-224 averaged a total mV drop of 17.1 across the terminal. Of that 17.1 mV, 4.5 mV was dropped across the connection of terminal to test tab, and 12.6 mV was dropped across the crimp of the terminal. This meets UL specifications for safety governing Electrical Quick Disconnects which allows for a maximum 20 mV drop, given a tin to brass .250 inch connection. See Table 4.

Temperature Rise

Temperature rise tests are an essential factor in the evaluation of a terminals overall performance. Temperature rise tests are used to make sure that a product does not overheat during operation. Whenever current passes through a conductor, heat is generated. Measurements of this heat can be used to establish a connection's quality or indicate an issue. A poor crimp could easily bring temperatures to dangerous levels. Insulated closed barrel type terminals, where an ununiformed barrel crushing method is employed to crimp the terminal to wire can be susceptible to heat issues. This means of crimping greatly deforms the insulation which could affect its dielectric performance as well.

The DF-224 and DF-225 terminals employ the robust "F" crimp and a solid nylon insulator to form the Closed Back connectors. Its insulator is not compromised in the crimping

TABLE 1
DF-225 ATTACHED TO 18 AWG WIRE

Test Amperage	14 Amps	**milliVolt Crimp average**	10.3 mV
Total milliVolt Drop average	12.7 mV	**UL Maximum allowable Voltage Drop**	13.0 mV
milliVolt Drop M/F average	2.4 mV	**All connections surpassed UL by average**	2.7 mV

TABLE 2
DF-225 ATTACHED TO 22 AWG WIRE

Test Amperage	6 Amps	**milliVolt Crimp average**	2.7 mV
Total milliVolt Drop average	3.8 mV	**UL Maximum allowable Voltage Drop**	10.0 mV
milliVolt Drop M/F average	1.1 mV	**All connections surpassed UL by average**	7.3 mV

TABLE 3
DF-224 ATTACHED TO 18 AWG WIRE

Test Amperage	14 Amps	**milliVolt Crimp average**	5.2 mV
Total milliVolt Drop average	7.4 mV	**UL Maximum allowable Voltage Drop**	13.0 mV
milliVolt Drop M/F average	2.1 mV	**All connections surpassed UL by average**	7.8 mV

TABLE 4
DF-224 ATTACHED TO 14 AWG WIRE

Test Amperage	30 Amps	**milliVolt Crimp average**	12.6 mV
Total milliVolt Drop average	17.1 mV	**UL Maximum allowable Voltage Drop**	20.0 mV
milliVolt Drop M/F average	4.5 mV	**All connections surpassed UL by average**	7.4 mV

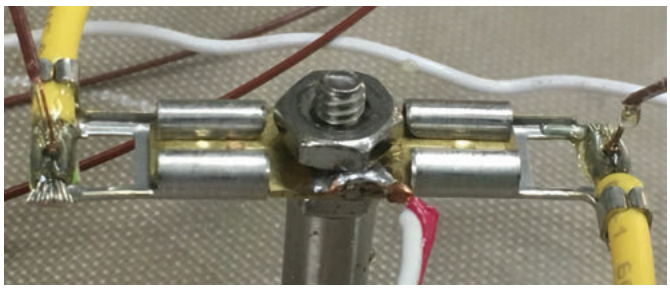


Figure 5: **Thermocouples nestled in valley of crimps to capture temperatures.**

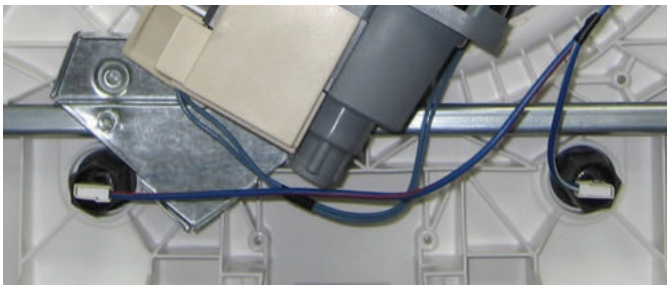


Figure 6: **Closed Back Terminals in use on dishwasher produced by major appliance manufacturer.**

process. There are UL specifications for permissible levels of heat rise over specific gauge wires and terminals. We test to make sure all terminals are well within acceptable levels of compliance. In this test the full amperage power has been increased on cycle to 2 full hours an approximately 170% increase over the standard specification of 45 minutes.

Part of the UL 749 Standard involves measuring temperature rise across terminals and components. Our laboratory's Farnell Power Supply provided the test boards with precisely metered current as required by UL for specific wire gauge applications. The boards were stabilized for 2 hours before beginning each test. Measurements were taken during full powered segments at the end of the 2 hour power on cycles. The ambient temperature of the lab was established, documented and maintained throughout the testing process. The temperatures of the terminals were measured using the Keithley 2750 DMM and a K-type thermocouple applied directly to the valley of the "F" crimp. The final temperature rise numbers easily comply with UL specifications as shown in Test Tables 5 - 8. ●

TABLE 5
DF-225 18 AWG T-RISE TEST RESULTS

Test Current	14 Amps	**Total Rise (F°)**	38.7 ° F
Ambient Temp. (F°)	75.7 ° F	**UL-749 acceptable T-Rise (F°)**	95.0 ° F
Terminal Temp. (F°)	114.4 ° F	**DF-225 18 AWG in compliance by 58.1 °F**	

TABLE 6
DF-225 22 AWG T-RISE TEST RESULTS

Test Current	6 Amps	**Total Rise (F°)**	9.5 ° F
Ambient Temp. (F°)	75.1 ° F	**UL-749 acceptable T-Rise (F°)**	95.0 ° F
Terminal Temp. (F°)	84.6 ° F	**DF-225 22 AWG in compliance by 85.5 °F**	

TABLE 7
DF-224 18 AWG T-RISE TEST RESULTS

Test Current	14 Amps	**Total Rise (F°)**	28.1 ° F
Ambient Temp. (F°)	74.9 ° F	**UL-749 acceptable T-Rise (F°)**	95.0 ° F
Terminal Temp. (F°)	103.0 ° F	**DF-224 16 in compliance by 66.9 °F**	

TABLE 8
DF-224 14 AWG T-RISE TEST RESULTS

Test Current	30 Amps	**Total Rise (F°)**	68.9 ° F
Ambient Temp. (F°)	73.6 ° F	**UL-749 acceptable T-Rise (F°)**	95.0 ° F
Terminal Temp. (F°)	142.6 ° F	**DF-224 14 in compliance by 26.1 °F**	



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



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PART 2
How Ceramics and Glass Contribute to the $4.17T Residential Building Market

BY APRIL GOCHA & LISA MCDONALD

Insulation Keeps Us Comfortable

Each year, cities around the globe continue to set new records for hottest and coldest days on record. These temperature extremes and increasing urbanization are expected to drive growth in sales of new and upgraded heating and air conditioning systems, especially in Europe. The number of European households that buy and install a new air conditioning system is expected to increase by an average of 4.3% per year through 2040.[17]

Ceramic components can be found in both forced-air furnaces, the most common system in the U.S. (58% of heating systems in newly completed single-family houses in 2018), and heat pumps (40% of heating systems), which act as both furnace and air conditioner.15 For instance, modern gas furnaces commonly contain a silicon carbide or silicon nitride hot surface ignitor.

The U.S. Department of Energy estimates that about half of a home's energy use is spent heating and cooling spaces, while 18% is spent heating water, indicating these systems and proper insulation of these systems have a significant role to play in residential energy savings.[18]

In fact, modeling studies show that electricity consumption could have been reduced by 37 terawatt-hours per year in the U.S. just by increasing insulation to 2012 IECC levels in all existing single-family homes in 2013, representing a total 3.4% reduction in annual electricity consumption.[19]

Demand for insulation of all types is predicted to rise in the U.S. through 2021, influenced by increasing demand for energy efficiency and by states increasingly adopting IECC mandates.[20]

Although there are various types of insulation materials, fibrous mineral insulation, which includes fiberglass and mineral wool, represents the largest portion of the U.S. insulation industry. This is a significant industry—insulation manufacturing is a $13.9 billion industry in the U.S. and generates more than 500,000 total jobs, including manufacture, distribution, and installation of insulation.18

In residential homes, insulation is most common in the exterior walls and the attic or roof area, where most heat escapes. Home Innovation's 2019 Annual Builder Practices Survey of home builders indicates that fiberglass insulation (batt and blown) comprises 71% of insulation in new single-family homes built in 2018 (including floors, walls, and roofs).[21] Fiberglass insulation consists of loosely bonded thin glass fibers separated by pockets of air.

"The focus of manufacturing for insulation materials continues to be driven by efforts to lower environmental impacts and decrease embodied energy," says Saint-Gobain's Lucas Hamilton.

One way for insulation manufacturers to lower their environmental impact is by using recycled content. Most fiberglass manufacturers in the U.S. spin glass fibers from 40%–60% recycled glass content,[22] which both diverts a material waste stream from landfills and offers additional energy savings during insulation manufacturing.

Including recycled glass in the melt reduces the energy requirements to manufacture fiberglass. "From a manufacturing standpoint, it's easier to melt already formed glass than it is to melt raw materials going into the glass," says Matthew Gawryla, insulation R&D leader at Owens Corning.

Recycling diverts a considerable amount of materials away from landfills. A 2018 survey from the North American Insulation Manufacturers Association indicates that U.S. manufacturers recycled 2.2 billion

pounds of glass into insulation.[23]

Mineral wool, which consists of ceramic instead of glass fibers, contains recycled slag from steel mills. Mineral wool has a higher density than fiberglass, which translates to higher R-values and greater insulating performance. Plus, it has the added benefit of acoustic insulation as well as higher temperature resistance than fiberglass.

More expensive than fiberglass insulation, mineral wool is used primarily in commercial building applications. However, mineral wool does seem to be gaining some popularity in the insulation market in general.[24]

''Owens Corning has invested significantly in the mineral wool area of the market because it's a growing segment, especially as used in exterior continuous insulation,'' Gawryla says. ''There is a desire in the market for high-temperature, noncombustible materials, a lot in commercial buildings but also somewhat in residential buildings.''

Another trend in the insulation industry is a move toward mixed materials. ''The combined thermal, moisture, and air resistance properties of the insulation are so varied that we tend to mix and match different materials on a job based on climate, building usage, and where in the envelope the material is being deployed,'' Hamilton says. ''What you're beginning to see is a lot of mixing and matching various insulation products in order to control moisture.''

Windows: Portals to the Outdoors

While the ultimate goal of a home is to separate inside space and outside environment, windows provide a portal between these two worlds—they allow light into homes and provide a view to the outdoors.

''Most of the innovation has been to the value add of the base glass. The formulation of the glass we see in everyday windows hasn't really changed—it's the same types of raw components and same system for getting to that glass, which is the float process,'' according to Julia Schimmelpenningh, industry technical manager of architectural customer applications and service lab manager at Eastman Chemical Co. (Kingsport, Tenn.). ''What has happened is the innovation of what we're doing to that glass, adding color or putting coatings or specific surfaces on the glass.''

Those coatings allow the glass to achieve functions such as improved protection and resistance to breakage, for example, or aesthetic appeal. But perhaps the most important function of glass coatings has been to improve energy efficiency.

Modern windows have dramatically boosted their efficiency with low-emissivity (low-e) coatings. These thin silver or tin oxide coatings, applied during the float process or sputtered onto the glass, offer additional energy efficiency savings by blocking long-wavelength heat radiation yet allowing short-wavelength light to pass through.

Most modern windows in residential homes also are double glazed, meaning they contain two panes of glass separated by a small air space, which improves the window's insulation ability. Window R-values are usually further boosted by filling the space with a lower conductivity gas such as argon.

''The U.S. window market today represents a remarkable transformation to products that use about 50% of the energy that was typical of early 1980s products, but windows still account for about 4 Q [quadrillion BTU] of energy use at an annual cost of $40B,'' according to an article from Lawrence Berkeley National Laboratory.[25]

While the technology exists to significantly improve the energy efficiency of windows even further—and even take a dynamic leap forward (see sidebar, Rooms with a view)—the challenge is making these products at volume and competitive cost.

One such technology is triple glazing, in which windows contain an additional layer of glass (or, alternatively, a membrane) to further improve insulation by providing two air spaces compared to one with double glazing (Figure 4). Triple glazing is not new, but previous iterations of these windows were bulky, heavy, and expensive.

However, a few key recent events in other markets have now converged to allow manufacturers to further refine tripling glazing technology, making these systems more compact and efficient. First, the rise of smartphones and flatscreen TVs expanded the production sizes and reduced the cost of fabricating large, thin panels of glass. Second, replacement of halogen lamps with LEDs dramatically reduced the demand and thus price of krypton gas, which is used to fill the air space in triple glazed units.[26]

Now, thin triple glazing units can be manufactured at more competitive prices with a 1-mm thin pane of glass in between a standard double-glazed unit, with krypton gas filling the now-divided air space (Figure 5).

U.S. window manufacturers Alpen and Andersen are working with Berkeley Lab to develop these window technologies, and it seems these technologies may be coming to the market soon, although they are still more expensive than standard double glazing.

''We have spent some significant time investigating more automated lines capable of making thin-glass units,'' Brad Begin, Alpen CEO, says in a Building Green article from early 2019.[26] ''I am actively working through a capital plan and in further discussions with potential capital sources to fund the plan.''

Another option to reduce thermal

conduction and convection in windows is to nearly eliminate these parameters—by eliminating all air between the glass.

This idea is the concept behind vacuum glazing, a technology that, similar to triple glazing, has been around for decades. "But how we produce it, the sizes we produce it in, and the efficiency in production of materials are all changing," Schimmelpenningh says.

With vacuum glazed units, however, the seal remains a challenge. "Because the vacuum between the glazing tends to pull the panes of glass together, tiny glass or ceramic spacers are also needed in a grid pattern to hold the glass apart—a technical and aesthetic complication," according to a Building Green article.[27]

The spacing, materials, and design of these spacers are significant considerations beyond aesthetics, as these parameters impact the performance of the resulting window unit as well. However, if technological barriers can be removed, vacuum insulated glazing offers the ability to produce windows that are thin and low weight with much higher energy performance.

"New vacuum insulated glass from Guardian Glass (made in the U.S.) and VIG Technologies (made in China) are poised to make serious inroads into the high-performance glazing market in the US. They are not cheap, but if their long-term thermal performance can be verified, they may very well be worth the cost," according to a recent Building Green article.[28]

Surfaces: Covered With Choices

Floors, ceilings, walls—a house is filled with surfaces waiting to be covered. Many materials fulfill this purpose, from carpets, cement, tile, and wood on the floor to paint, paper, tile, and wood paneling on the walls.

In the late 1980s, U.S. Census Bureau data showed ceramic tile consumption at just over 1 billion ft² per year.[29] Thirty years later, consumption reached 3.11 billion ft² in the U.S. in 2018.[30] That growth reflects just a 1.5% increase over 2017 numbers, as figures for ceramic tile consumption over the past decade clearly demonstrate that the industry is still recovering from the recession.

In the future, demand for decorative tile is expected to increase 2.4% annually through 2023, with the fastest growth for porcelain tile due to its durability, performance, and aesthetics.[31]

Part of that slower growth can be attributed to a transformation in the resilient flooring market lately due to rising popularity of multilayer flooring, which includes new hybrid materials such as wood-plastic composite and solid polymer core (SPC) flooring.[32] These alternative materials offer durability, comfort, low cost, and ease of installation.

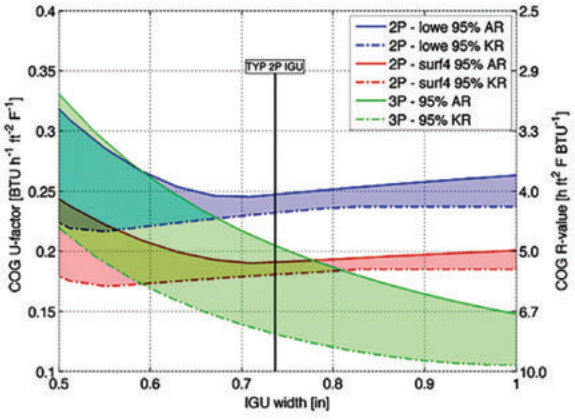
"[SPC is] a very stable product—it's warm to the touch and it's much cheaper to install than ceramic tile, so it's definitely cannibalizing ceramic tile sales," says Paul Raiche, president and CEO of Ceratec, a ceramic tile manufacturing company (Quebec City, Canada). "Ceramic tile has to innovate because it's moving around in the value chain right now."

Part of that innovation is enabled by advancements in the equipment used to manufacture ceramic tiles, which has allowed tile sizes to get much bigger, Raiche says. Technological advancements in production lines allowed manufacturing of larger thin porcelain tiles, along with changes to improve the durability and reduce the weight of these larger formats.

As a testament of the growing popularity of larger format tiles, Italian porcelain tile company Iris Ceramica opened the first large-format thin porcelain tile panel production line in the U.S. in 2018 with its plant in Crossville, Tenn.

"This $70 million investment enhanced the production capacity of the company's sole U.S. tile manufacturing plant by 20%, adding

Figure 4: Thermal performance of double glazing (2P) compared to triple glazing (3P) windows at various insulating glass unit (IGU) thickness and filled with argon (AR) or krypton (KR). Blue represents most windows currently on the market. Red represents windows with an additional low-E coating on the inside surface, indicating modest performance gains. Green indicates significant potential energy savings with triple-glazed units.



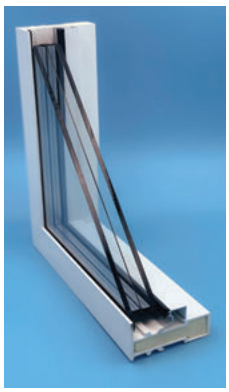


Figure 5: Cross section of a triple-glazed window unit, showing a thin panel of glass that separates the standard air space in a double-glazed unit.

manufacturing capabilities for 120'' x 60'' panels, as well as large-format panels with 6-mm thicknesses,'' according to a Freedonia article.[33]

The ceramic tile market still has a firm grip on walls, Raiche says. ''What is not necessarily changing is feature wall products and backsplashes. What goes on the wall has become more important, as small shapes, geometric shapes, and very decorative materials coming out of ceramic tile factories are being used for walls.''

Innovation in thin glazes to create new finishes and textures allowed tile manufactures to create looks such as wood grains at the kiln, offering the ability to produce tiles in more shapes, sizes, textures, patterns, and finishes than ever before.

Essential Sanitaryware

In the U.S., demand for all plumbing fixtures (which includes bathtubs, showers, sinks, toilets, hot tubs, spas, bidets, and drinking fountains) is expected to grow at a 5.0% CAGR through 2021 to reach an estimated market size of $7.6 billion.[34]

While these fixtures are now available in a variety of materials, ceramics still dominate many of the markets. For certain ceramic materials, sanitaryware accounts for a significant proportion of their end-use applications—for example, sanitaryware consumes 15% of ball clay use.[35] Sanitaryware includes vitreous china (which leads the market), traditional fireclay, and fine fireclay.

''The fine fireclay is more popular in Europe because it gives you the opportunity to have really large formats, big dimensions,'' says Felipe Mejia, ceramic engineer manager at Mansfield Plumbing Products. ''The fine fireclay offers lower shrinkage rate and more dimensional stability, but it's also harder to make or to produce [compared to traditional porcelain or washbasins],'' which drives up the cost.

While various ceramics are used in washbasins (Figure 6), porcelain continues to be the preferred option for toilets. ''It is a relatively cheap material, reliable, it lasts for many years, it doesn't break easy unless you let something drop on top of it,'' Mejia says.

The manufacturing process for toilets has remained relatively unchanged over the years. Innovations instead have focused on toilet functionalities, such as water consumption. ''There is a trend always to go toward a lower consumption of water every time you flush,'' Mejia says. ''Old toilets can use two, three, four times more water than the current toilets that we have on the market. So you can save the environment but at the same time you can save some money if you remodel and switch to the newest versions of the toilet.''



Figure 7: Lixil's Aquaceramic super-hydrophilic ceramic is engineered to use water to lift oils and substances off the surface, offering the ability to wash away potential stains with a flush.

Other innovations in toilet technology include coatings that make the bowl easier to clean and more stain resistant. For example, Lixil (Tokyo, Japan) engineered a super-hydrophilic ceramic surface, called AquaCeramic, that uses water to lift oils and substances off the surface (Figure 7).

According a Lixil article,[36] ''The more problematic issue of hard water stains, which are caused by silica in the rinse water chemically combining with hydroxyl groups on the surface of the ceramic, has also been solved. AquaCeramic reinvents toilet materials by using a structure that does not expose hydroxyl groups, meaning that hard water stains are unable to build up and the ceramic surface remains flat and smooth.''

Although the company is not willing to share additional details about the AquaCeramic formulation or process, a Lixil press release indicates the company also developed a new glazing technique for the finish that ''integrates a special substance to resist



Figure 6: A worker at Mansfield Plumbing loads a batch of slip cast washbasins on the transportation cart. Ceramic engineer manager Felipe Mejia says the sanitaryware industry is looking to automate the more labor-intensive steps of the manufacturing process.



Figure 8: A porcelain enamel Lustron house still stands in Albany, N.Y. From 1948–1950, the Lustron Corporation used an assembly line in a former warplane manufacturing factory in Columbus, Ohio, to manufacture porcelain enamel houses as a quick and low-cost solution to the post-World War II housing crisis.

waste and hard-water stains at the molecular level,'' which it says makes the finish last for 100 years.[37] Watch a video of AquaCeramic in action at youtu.be/D9MSr-nfGQM.

Now We Are Cooking

Not many materials can claim they provide a sanitary, corrosion-resistant, easy-to-clean, extremely durable, heat-resistant, color-stable, and environmentally friendly finish—yet porcelain enamel can. Perhaps that is why it once coated entire homes (see Figure 8).

Porcelain enamel is primarily limited in modern kitchen appliances to the oven and stove, where it can be found on the top surfaces of burner cooktops, inside the oven cavity and door, and under the cooktop. Porcelain enamel covers cookware too, with an inert, antimicrobial, and long-lasting finish. Porcelain enamel's durable finish also can still be found on the tops and spinner baskets of some laundry appliances as well as hot water tank liners.

Plastic has replaced porcelain enamel in many appliances because it is quicker, easier, and cheaper to manufacture. ''You can injection mold an entire dishwasher cavity, which takes minutes, and it's done. You don't have to coat it, and you don't need any particular labor input to fabricate it—it's just a cheaper way to go,'' says Cullen Hackler, executive vice president of the Porcelain Enamel Institute (Norcross, Ga.).

Color is an important consideration in the porcelain enamel industry. Higher-end appliance models often use porcelain enamel finishes to provide color on the exterior of units, although more affordable units today are likely painted or plastic instead. ''One of the biggest drivers in the market is demand for new and different colors to make a product stand out,'' says Charles Baldwin, R&D manager of porcelain enamels at Ferro Corp. (Cleveland, Ohio).

Because of those reasons, applications for porcelain enamel in modern homes are growing and can be increasingly found as finishes on grills, woodburning stoves, and outdoor fireplaces.

Porcelain enamel can be found in the bathroom as well, as a finish for plumbingware such as sinks, bathtubs, and shower trays. Plumbingware actually comprises the largest market for porcelain enamel today, followed by storage water heaters, and then major appliances, Hackler says. That order is reversed from 20 years ago.

In addition to competition from other materials, a significant current challenge for the porcelain enamel industry, perhaps surprisingly, is batteries.

Surging demand for lithium-ion batteries to power the modern world created significant supply and demand imbalances for raw materials lithium and cobalt—materials also important in porcelain enamel manufacturing—resulting in inflated market prices.

''Lithium in porcelain enamel is the most effective glass modifier flux for lowering the melting point of enamel while maintaining a dense glass structure that provides high corrosion resistance and high electrical resistivity for electrostatic application,'' Baldwin says.

But replacing these raw materials in porcelain enamel is not a matter of simply swapping a new material in, Baldwin explains. ''Other changes need to be made to glass formers and glass modifiers to obtain enamel with similar properties.''

The porcelain enamel industry continues to innovate with new formulations, however. Baldwin says one of the trends Ferro sees is the emergence of alternatives to self-cleaning pyrolytic ovens, once a great selling feature for these appliances. Eliminating the high heat and fumes associated with these cycles is both an energy and health consideration, so more appliances are turning to steam and water cleaning cycles instead.

Ferro's hydrophilic AquaRealEase enamel product provides new functionality for such appliances. ''In a low-temperature oven lined with AquaRealEase, tough soils like baked-on strawberry pie spills wipe clean with a damp cloth after soaking or exposure to steam from water heated at just 190°F for one hour,'' according to a Ferro press release.[38]

When it comes to cleaning cooktops, however, nothing beats a smooth or flat cooktop. Often referred to as glass cooktops, that material is actually a glass-ceramic.

''One of the very interesting things about glass-ceramic that makes it a unique material compared to glass or other materials is its near-zero coefficient of thermal expansion,'' Karen Elder, product manager of glass-ceramics at Schott North America (Louisville, Ky.), explains. That means it does not react to rapid changes in temperature or large temperature differentials without shattering, warping, or deforming, making it ideal for applications such as cooktops and fireplaces.

One big innovation in glass-ceramic cooktops is induction cooktops, Elder says, which are currently much more popular in Europe than in the U.S. Induction cooktops do not use radiant heating elements to generate thermal energy but rather use an electromagnetic field to induce currents, which heat pots made of metals such as stainless steel and cast iron. Induction cooking generates far less waste heat than radiant heating elements, making it a much more energy efficient process.

However, the lack of traditional

heating elements comes with a caveat—because there is no open flame or red-hot heating element, it can be difficult to visually determine if the induction cooktop burner is on.

One solution is to incorporate lights into induction cooktops. ''We're moving into new formulations that allow different colors of light to come through the cooktop, which opens up design opportunities for our customers to integrate things like white light,'' Elder says.

Schott's glass-ceramic provides better light transmission through the material so that lights can be integrated underneath the cooktop—when the lights are off, the cooktop appears uniformly monochromatic; when on, the lights provide a visual cue that a burner is active (Figure 9).

Plus, the lack of heating elements in induction cooktops also opens up new abilities to integrate additional electronics, such as liquid-crystal displays, into cooktops to further bring technology into the kitchen.

Other uses for glass-ceramic include innovations such as grills and toasters equipped with clear glass-ceramic windows. ''We are always tweaking [the glass-ceramic] recipe and seeing what we can do to enhance it,'' Elder says.

What will the homes of tomorrow look like?

Future Home

''If you look at current trends, I think you're going to see smaller homes where you have multifunctional materials, and therefore you don't need big spaces,'' says Eastman Chemical's Julia Schimmelpenningh. ''But those materials are going to have to do more, they're going to continue to evolve to be multifunctional.''

One of the ways that materials are doing more is through integration of technology. Technology allow us to connect with our homes through the Internet of Things (IoT) and smart technologies in unprecedented ways, allowing integration and crosstalk across diverse platforms.

''The kitchen is one of the places where there's so much activity happening in the house, and it's definitely where there's a gap—there can be more efficient ways to use that time in the kitchen,'' says Schott's Karen Elder.

Innovations in materials such as transparent glass-ceramic options for cooktops are enabling these advances by integrating displays into cooking surfaces, for example, and providing connected multimedia experiences such as the ability to interact with a recipe while actively cooking. These advancements further blur the lines of technology within the home by integrating them ever more seamlessly.

In addition to connecting us to our homes, technology brings improved energy efficiency in buildings. By incorporating sensors, actuators, and microchips to automate processes such as heating and cooling, ventilation, lighting, and security, smart homes offer additional opportunities for houses to improve energy efficiency. ''With companies such as Hitachi, IBM, Cisco investing in this technology, the demand for the smart buildings is expected to rise and generate a global revenue of $8.5 billion by 2020,'' according to the BCC report.[3]

Future homes will continue adapting to the changing environment as well, especially as severe weather patterns continue to challenge a warming world. ''Materials will continue to evolve to be increasingly impact resistant to endure stronger and more frequent storms,'' says Saint-Gobain's Lucas Hamilton.

For example, laminated glazing dramatically increased the safety of building glass especially in hurricane-prone areas, allowing the material to more effectively protect against windborne debris.

In many cases, ceramic and glass materials already offer superior solutions over alternative building materials. For example, brick is one of the strongest exterior cladding materials available for homes.

NBRC's tests with walls built from various exterior cladding materials show that, when faced with a 9-lb wooden 2x4 ''missile'' traveling at about 50 mph, brick is the only material that can withstand the abuse.

''When we hit a typical particle board wall, it goes through the wall. When we hit vinyl siding, it goes through the wall. When we hit EFIS [exterior insulation finishing system, a stucco-like finish], it goes through the wall,'' says Sanders, director of NBRC. ''When we hit brick, we tend to destroy the missile.'' A video of NBRC's test is available at youtu.be/fDk0QKEc02Q.

Brick also boasts excellent thermal performance as well, which is an important consideration in some parts of the U.S. in light of growing frequency of devastating wildfires. ''Having that ceramic material on the outside of your house could buy you extra time,'' Sanders adds.

Entire homes constructed out of concrete offer a still more extreme solution to protect inhabitants from severe environmental conditions, including fire and debris.[39]

Ultimately, these diverse evolutions in the construction industry and more broadly in the world may point



Figure 9: Schott's glass-ceramic cooktop can incorporate lights underneath the cooktop, opening up interesting new possibilities for technology in the kitchen.

to serious changes ahead for many building products—but they also represent significant opportunities.

''As the complexity of these systems increases, so does the methodology, the science, the innovation—all that is able to come into these systems more and more,'' Schimmelpenningh says. ''So the opportunities for innovation increase with the complexity.''

That is good news for the materials that make these building products, as innovation is something the materials do exceedingly well. As preferences continue to demand products that do more, materials will rise to the challenge—pushing for higher performance, becoming more multifunctional, and improving in many other ways.

Ceramic and glass materials have been and will continue to be a significant part of this equation because they provide a unique combination of durability, reliability, performance, and beauty to the structures we inhabit.

''The combination of safety, lifespan, and thermal performance, when you look at the whole, makes ceramic materials really a no brainer,'' says Sanders. ''They are so far superior to everything else.'' ●

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Rooms With a View—Dynamic Window Glazing

Dynamic glazing, often called smart glass, is another big area of development in windows. These advances include coatings on the glass or integrated technologies that can reversibly control glass tint to adjust how much light passes through.

By variably adjusting solar heat gain through the glass, these technologies allow differential control during different climates—using less tint to allow more solar energy to pass through the glass during colder climates, warming the building inside; and using darker tint to reflect more solar radiation when the outside climate is hotter, keeping the building inside cooler.

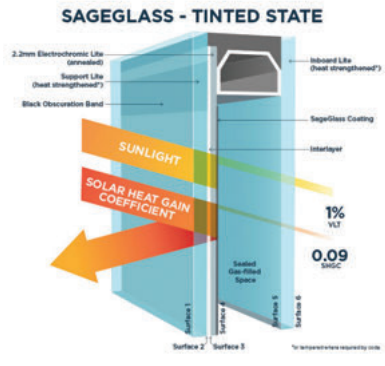
Dynamic glazing attempts to balance conflicting desires of wanting a view yet also needing to reduce solar energy gain through the windows, which can account for up to about 30% of heat loss in homes.[a]

"How can we provide comfort for the occupants, in the most energy efficient manner possible? That's what dynamic glazing does" says Julia Schimmelpenningh, industry technical manager of architectural customer applications and service lab manager at Eastman Chemical Co. (Kingsport, Tenn.).

There are several variations of dynamic glazing, including electrochromic glazing, which controls glass tint with an electrical current; photochromic glazing, which adjusts based on light; and thermochromic glazing, which adjusts based on temperature.

SageGlass, for instance, is Saint-Gobain's (Malvern, Pa.) electrochromic glass, which is already on the market for commercial applications.

The float glass is sputtered with five metal oxide layers that give SageGlass electrochromic abilities. Applying a low voltage to the glass causes ions to migrate among these ceramic layers, initiating a solid-state change that darkens the glass. The process is reversible, allowing glass to darker and lighten on demand to tint levels of 1%–60%.[b]



SageGlass's high-volume manufacturing plant in Faribault, Minn., is the largest electrochromic glazing plant in the world, capable of churning out millions of square feet of dynamic glass annually in a 324,000 ft² LEED-certified facility, which opened in 2012.

Still other developing window technologies go one step further than tailored energy control and also add energy harvesting to their abilities. Similar to roofs, building incorporated photovoltaics are another future direction for windows that directly integrate solar cells or energy harvesting technologies onto the glass.

While countless types of these technologies have been developed in prototypes or small scales, most all are currently cost-prohibitive or face manufacturing or commercial-scale barriers.

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