AHR EXPO ISSUE

APPLIANCE & HVAC REPORT

Reaching Design Engineers at the OEM Level

January/February 2020 VOLUME 2 ➢ NUMBER 1



Creating More Efficient Commercial HVAC Enclosures

See Page 23

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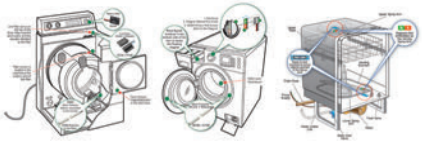
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Welcome to 2020



We published our first issue of ***The Appliance & HVAC Report*** and were encouraged by the reaction of our readers and advertisers. Everyone said it looked great, with one exception: One client said we need to make the type darker, so we enhanced it by 20 percent. Can't say we don't listen, John Bishop!

I'm also happy to note every response said the content was excellent. That is what we are striving for.

What surprised us the most, however, is companies coming to us asking to reach our design engineering audience via eblasts. As of this writing, we have done more than a dozen, averaging about one per week. (We don't want to do them more frequently because we don't want to bombard and exhaust our audience.)

On the lighter side of the appliance world: Wouldn't you know it? Our washing machine broke down recently, so we bought a new one. And that didn't work, so we returned it and bought still another. So far, so good on this unit. But what are the odds that the owner of a new brand for this industry not only has a breakdown of his washer, but then the one he bought to replace it fails too? Fortunately, my significant other has the patience of Job; she does the laundry, and I schlep it up two flights of stairs.

Those of us in the industry consider power tools to be appliances. So, it caught my eye when I saw an ad in a Binghamton, New York newspaper discussing trade adjustment eligibility for workers who were hurt by imports of competitive products. Pennies on the dollar for the recipients, but everything helps, right?

And on another appliance-related note: I live in the Cleveland, Ohio area (don't hold it against me), and we have the Cleveland Browns. Big things were expected this season and they didn't happen. As of this writing, it again looks like we won't make the playoffs. Believe it or not, the Browns not only have never won a Super Bowl, they have never played in one. Not many teams can say that.

So, in anticipation of this season, Budweiser came up with a promotion, offering fridges with Bud Light stocked in them for long-suffering Cleveland fans. "This Bud's (and refrigerator) for you" should be their ad slogan, based on an old one they previously used.

OK, back to business. We have ten white papers in this issue, authored by the following: 3M, Electrolux and The Chemquest Group, Littelfuse, Nye Lubricants, Portage Electric Products, Protolabs, Rosenberg GmbH, Sectigo, Southco and Vitrek. And that's not a typo you're seeing: Littelfuse spells it with the "e" before the "L".

Also, for those going to the AHR show February 3 through 5, 2020 in Orlando, Florida, we are exhibiting. Stop by and say hello. We will be at booth 9547. In attendance will be my associate, Mike Venezia, and myself.

Thanks for your support and attention. Best wishes this year. Don't be afraid to send us input via our site ***www.appliancehvacreport.com***. You can also email me at brad@appliancehvacreport.com. And remember, you can find our digital edition on our website, along with archived eblasts.

Ciao, shalom, and goodbye—until our March/April issue that is.

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Derating For Real World Conditions

Allowing for desired safety margins when selecting components of an electrical circuit requires close attention to how each component will react to real world conditions, both ambient and circuit-related.

BY PORTAGE ELECTRIC PRODUCTS

Conductive-type thermal controls provide for the safe operation of an electrical circuit while allowing for complexities of circuit design. These devices incorporate a bimetallic element into the circuit so that the thermal control reacts to both changes in current and ambient temperature, enabling the device to open (break) at a pre-set temperature. Since conductive controls carry circuit current they add another degree of protection beyond the ability to react to changes in ambient temperature. However, this added level of protection must be accounted for when applying conductive-type controls into your application. The resistance value (resistivity) of the bimetal element causes heat build-up that can lead to opening the circuit at lower temperatures. In other words, the device is operating at a lower temperature rating than expected. This derating effect must be acknowledged and accounted for in every design application. However, it provides an extra, often critically-important, margin of safety by getting circuits off-line before there is a dangerous build-up of heat.

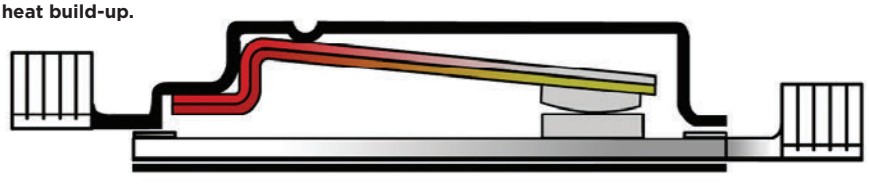
Resistivity of Bimetallic Elements

Resistivity is a measure of how strongly a material opposes the flow of electric current. A low resistivity material, such as silver, readily allows the flow of current in an electrical circuit. A material with higher resistance, such as nickel, impedes the flow of current in the circuit generating heat in the process.

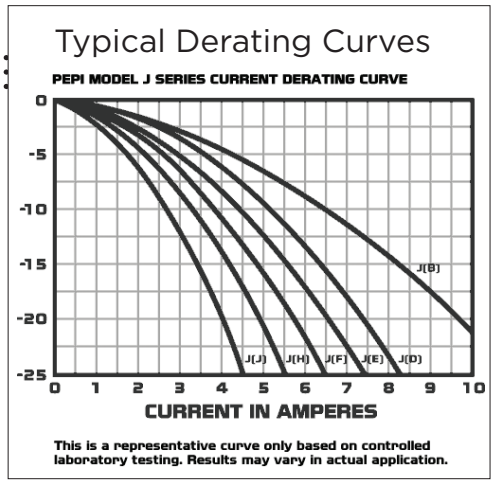
One of the functional attractions of conductive-type bimetallic controls is the ability to match the sensitivity of the bimetallic element to the functional needs of the application. There are a wide variety of bimetallic elements that can be used in conductive-type controls when incorporated into an electrical circuit. By altering the sensitivity of the bimetallic element, a designer can make the device either more or less sensitive to current flowing through the circuit and ambient temperatures surrounding the device. The sensitivity of the bimetal is actually a measurement of the resistance different metals exhibit to current flowing through them. The more sensitive the element, the higher its resistivity. This is similar to the higher water pressures that build up in smaller diameter hoses as opposed to larger diameter hoses.

This resistivity causes a self-heating effect in the bimetal element, known as I^2R effect. Basically, the I^2R effect is the amount of heat generated due to power losses when current flows through the bimetal. The measurement of this lost power indicates how freely or how impeded current flows through the various types of bimetal. Low resistivity elements experience lower I^2R heat effect. High resistivity elements exhibit more I^2R effect. This self-heating characteristic plays a prominent role in derating the performance of a thermal control and is especially useful when thermal controls are utilized in inductive load applications.

The design objective is to anticipate heat build-up in a circuit and shut it down quickly and before catastrophic failure can occur. This is made easier by derating which anticipates how a device will behave in conditions closer to those in the real world.



The higher the resistivity of the bimetal the greater the heat build-up.



What is Derating?

Current derating is a term used to describe the self-heating effect of a thermal control based on the amount of current flowing through the device. Derating is a measurement for current-carrying devices to react (open) at a temperature lower than its preset operating temperature. This is due to the I^2R effect or internal heating of the bimetallic element. The amount of deration for each type of device is expressed in derating curves that provide general guidelines to define anticipated functionality under various electrical loads. In this manner, derating increases the margin of safety between design limits for applications that are subject to unanticipated increases in electrical loads.

Starting Points vs. Operational Characteristics

All manufacturers of reliable thermal controls have had their products evaluated by one or more world-wide safety approvals agencies to standards based on the specific needs of the end application. These evaluations permit manufacturers to provide contact ratings expressing the maximum allowable voltage and current that it can carry, or pass through the device. When the load flowing through a circuit exceeds the rating of the thermal control tasked with protecting the circuit, it will open to prevent a catastrophic failure. However, for certain application types, the stated ratings do not take into account real world operating conditions.

It is important to note that both ratings and anticipated deratings are derived from lab testing under controlled test conditions. True real world effects from actual loads, ambient temperatures, cooling mechanisms and placement of the device can only be measured in actual application testing.

Using Derating to Your Advantage

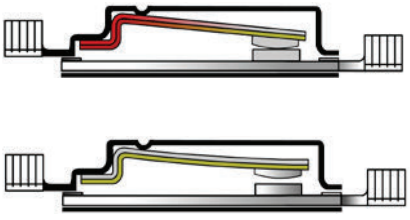
The ability to utilize the effects of derating to help anticipate real world fault conditions helps product designers maintain a margin of safety. Consider a typical sump pump motor carrying an inductive load. In inductive load applications, there is a high potential for the current to increase sharply…even faster than the temperature. This can occurn if a sump pump would lose its prime and the normal resistance is removed as water stops flowing through the pump. All of a sudden the motor speeds up and heat builds up fast. By placing a thermal control in the circuit, it can anticipate rapid heat-build up and get the circuit off-line even before ambient temperatures become hot enough to trip the device. You can observe the same phenomenon by placing your hand over the suction hose of a vacuum cleaner and listen to the increase of the speed of the motor.

The window between a product's normal operating state (steady state) and full load current, (safe maximum limits) is the area where a product designer can utilize the derating effects of thermal controls to plan for safe operating performance. Once the operation of an application surpasses that window it must be taken off line as quickly as possible. The key is to have a current carrying device in the circuit that senses increases to the electrical load even before there is an unsafe increase in temperature of the application.

Low Resistance vs. High Resistance Bimetals

As mentioned previously, an advantage of bimetallic devices is their ability to match their performance with application needs. Some applications, such as battery packs, require less sensitive devices that allow current to flow virtually unimpeded. Lower resistance devices do not exhibit the I^2R self-heating effect and present a truer relationship between the fixed set point of thermal control and the actual temperature of the battery pack it is protecting. In an application like a battery pack, a thermal control with higher resistivity would actually draw more power out of the battery causing the battery to discharge at a faster rate than what would be considered optimum.

Thermal controls with higher resistivity are required whenever it is desirable to pick up changes in the electrical load, most often prior to a build-up of heat in the application. As mentioned previously, these conductive devices actually combine the performance of a temperature sensitive device with that of a circuit breaker to anticipate problems and get motors off-line quicker than a device operating solely on changes in ambient temperature. In some applications, it is critical to have a device which interrupts the electrical circuit far sooner than a non-current sensitive device would function based strictly on increases in the ambient temperature. Without this anticipation of the thermal control, some materials used in the application could degrade, or even worse, fail.



The more sensitive the bimetal, the more quickly the circuit will be opened

Selecting the Right Bimetal for Any Application

Selecting the right bimetal materials is a critical factor in determining how a thermal control will perform in your application. It is essential that thermal control manufacturers offer design engineers a choice between different bimetallic elements to enhance performance of the thermal control under certain application conditions, especially when providing optimum operating performance and safety considerations for inductive type loads.

Conductive type devices derate as loads build. Understanding this tendency to derate can be helpful to the design engineer because it provides a surer view of the safety window that extends from the steady state to full load current.

However, the design engineer must always remember that both ratings and expected deratings for different bimetals and thermal control devices are done under laboratory environments with no-load conditions.

This is where Portage Electric's unique ability to work as a design partner comes into play. We are an engineering-oriented company with nearly a half-century of experience working with virtually any bimetallic combination and can recommend the right device and bimetallic element to use for any application. However, after selecting the device most likely to match your application needs, you must also test on your application to make sure it is the correct device for your particular application. ●

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Axial and backward curved radial EC fans

Using Modbus Controls For EC Fans to Reduce HVAC Energy Consumption

BY VINCENZO NUZZI

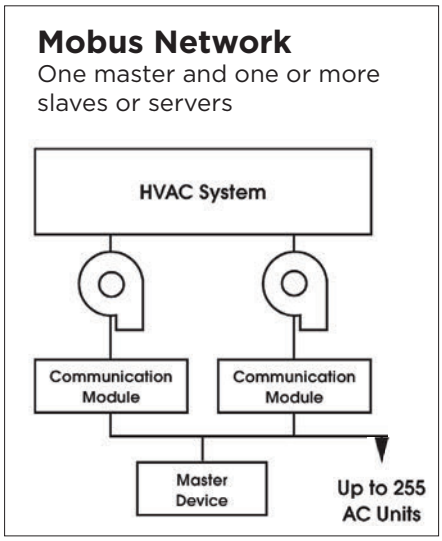
Controlling energy cost without sacrificing comfort in mid-size to large commercial buildings has always been a challenge. With energy costs soaring, the challenge has taken on a new urgency.

Fans are the primary consumers of electricity in HVAC equipment, and, as a category of products, are among the largest energy users in the world. In fact, a recent article in ASHRAE Journal stated that 23% of all energy usage worldwide is for the operation of fans. Given this fact, the need for greater efficiency in HVAC fan operations is obvious.

Greater efficiency is also within reach. In this article, we focus on how to use existing Modbus protocol system management technology with ''smart'' electronically commutated (EC) fans to optimize fan performance while reducing energy consumption.

Several advanced OEM fan manufacturers who are suppliers to the HVAC industry are now offering EC fans with built-in Modbus communications capabilities. This eliminates the need for separate fan control modules and greatly simplifies networking equipment across large zones.

Additionally, Modbus communication interface software developed specifically for fan operations is now readily available, simplifying the process even further. It is not unusual for fan manufacturers to provide their own Modbus driver software at no cost for use with their Modbus capable fans.



Why Modbus?

Modbus is one of the de facto standard communications protocols. It was first introduced in the late 1970s to communicate with programmable logic controllers (PLCs). Originally used in factory automation and process controls, it was later adopted into building management systems. Today Modbus is used worldwide in office buildings, airports, schools, hotels, hospitals and other commercial, industrial and institutional facilities.

Modbus allows for communication between about 250 devices connected within the same network, depending on the Modbus variation being employed. While Modbus is a type of master/slave (or client/server) protocol it allows the master device and all the slave or server devices to be controlled individually.

A typical Modbus network has one master and one or more slaves or servers. Each slave has a unique 8-bit device address or unit ID number. Commands sent from the master device contain the address for the particular slave device for which the message is intended. Only the intended device will act on the command, even though other devices might receive it. This is the aspect of the protocol that provides for individual communication with all networked devices.

While each server fan has its own ID number, and reacts only to messages sent to that ID, the system operator can also "broadcast" commands to all operating fan units. This is often accomplished by assigning broadcast messages an ID of zero (0). Broadcast messages are acted upon by all server fans simultaneously, as long as they are properly received.

A facilities manager or system operator can remotely control the connected devices, including scheduling, start/stop commands, change of operation mode and change of settings. Building or plant operations can be continually optimized using data transferred from the connected devices, such as status messages, alarms and energy usage meters.

Open Source/Open Networks

There are several types of Modbus. The most common is Modbus RTU, which operates on a RS-485 network. RTU stands for Remote Terminal Unit. Modbus is open source technology. Protocol specifications are available from www.modbus-ida.org at no cost.

It is a favorite of systems integrators and automation contractors as a way to integrate different types of devices from different sources into a single network.

Because of this easy accessibility and because it is a simple, reliable, adaptable technology, Modbus is now used for a wide range of applications, from HVAC, to water and waste water management, to oil and gas processing, to manufacturing automation.

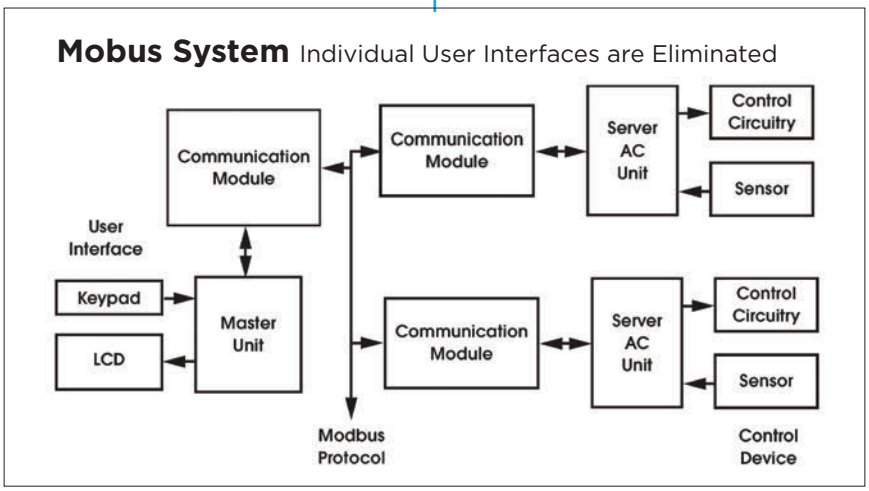
Important elements of HVAC control are common functions for Modbus, such as I/O interface, AC/DC drive control and monitoring or sensor input capabilities.

Well-defined functions make HVAC implementation easier, and fan manufacturers now routinely provide their own proprietary Modbus interface software that simplifies the process even further. Used in combination with "smart" EC fans that feature built-in communication capability, no additional hardware such as a control unit or a frequency inverter is needed upstream. As a result, equipment cost is reduced, as well.

Single User Interface

Unlike conventional separate units that serve one relatively small zone, a networked HVAC system that is designed to maintain comfortable air conditioning in medium to large areas must use multiple units working together as a "team".

In a conventional scenario, each individual air conditioning unit each has its own user interface and



control device. The user interface, usually a wall mounted thermostat, includes a display device and buttons or switches, which comprise the operational interface. The control device might include a temperature sensor and control circuitry.

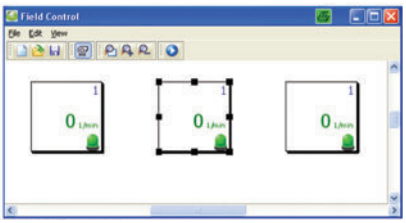
Individual user interfaces are eliminated with Modbus controls. In a Modbus system, a single master or client device using a low-level communication network (such as Modbus RTU) with a common interface, can control all units with the highest efficiency and reduced energy consumption.

Simple Six-Step Process

1) The first step in attaining optimal HVAC performance with lower energy usage is proper fan product selection. For the purpose of controlling and reducing energy consumption across a large networked HVAC system, standardizing on one fan manufacturer and one software solution will simplify the process and improve the results. Creating a system made up entirely of products from one manufacturer will eliminate interface problems.

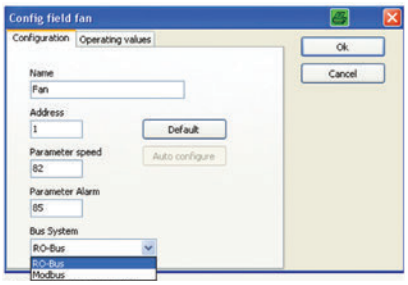
Selection criteria should include product quality, performance, efficiency and product range (size and configuration). Fans must be electronically commutated to allow for 100% variable speed control. (EC fans have other benefits, as well. Controlled by maintenance-free electronic circuitry, they run cooler and quieter with longer service life.) Fans should have built-in Modbus communication capabilities to facilitate connections. No special connectors or tools should be needed for communication wiring. The availability of pre-configured Modbus driver interface software should be an important consideration.

2) The client and all server devices must be linked together in a communication network. Modbus RTU is a serial network and must be physically connected using the appropriate RS-485 interface. Since most PCs do not support RS-485, plug-in converters for RS-232 and USB to RS-485 are available from several sources, including fan manufacturers. The fan must be connected to the network and also to the power supply.



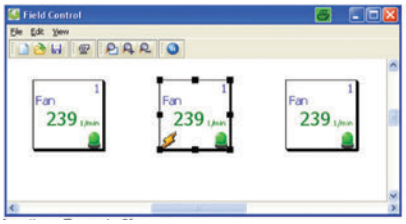
Example 1

3) The fan must be added to the software driver. (See example 1: choose the fan icon in the tool bar; click on each fan symbol to add the associated fan to the system)



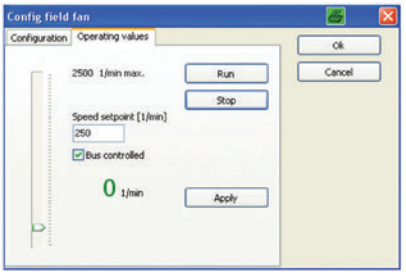
Example 2

4) Configure each fan's parameters. (See example 2: double click on the appropriate fan symbol to open the configuration window. Add fan address and name. Select the appropriate bus system. Set fan parameters.)



Example 3

5) Run a system check/initialization. (See example 3: system check provides visualization that each server fan is communicating with the control system. The lightning bolt shows actual communication with each fan serially. The system is operable after initialization.)



6) Set controls for each fan. (See example 4: Open the configuration window and click on the operating values tab. Here you will find all the necessary tools to set or adjust the fans' operating controls.)

Once Step 6 is complete, the system operator or building manager is in control of each fan individually and the facility as a whole from his or her computer. Each fan unit will operate to its own settings in its particular area. Sensors connected to each operating fan unit will maintain control settings and can record relevant data. Fan operations can be precisely monitored and managed individually and as a system.

Vendor Software or Your Own?

In the example above, the final four steps in the control process were completed through a Modbus interface provided by a fan manufacturer. Given its availability, its cost (usually there is none) and the fact it is already configured to easily control fan operations, vendor software is often a good choice.

Interface software from fan OEMs sometimes includes ''extras'', too, that in-house programmers might not have the time or the expertise to include. For example, Rosenberg's ECParam software allows operators to visualize the current state of any selected fan. It provides animated graphing of the

curves of the speed, setpoint and sensor signal. This is visualization is useful for operators to see how a fan is reacting to external influence if pressure, airflow or temperature controls are used. The reported values can also be stored in a file for diagnostic purposes.

As discussed, however, Modbus is a simple, well-established protocol that can be configured to almost any type of process control automation. If your HVAC application requires control of devices other than fans – valves or pumps, for example – a custom solution might be more useful.

Depending on the scope of your needs, other communication protocols may also be appropriate. Although more complex than Modbus, both BACnet and LonWorks are commonly used in building automation.

LON is a trademark, which stands for Local Operating Network. LonWorks is a building automation protocol created by Eclelon Corporation in 1989. It is a peerto-peer network, meaning there is no single master on the network. Control devices are free to communicate directly with each other, avoiding some of the problems that can occur if a single master fails.

BACnet stands for Building Automation and Control Network. It was officially unveiled by ASHRAE in 1996, and has been approved as ISO standard 16454-5. It is also becoming a standard in the European Union. It is a peer-to-peer network, like LonWorks. As its name implies, this protocol focuses on building automation applications.

Conclusion

The advantages of Modbus controls for large HVAC systems are significant. Individual HVAC units controlled separately by individual user interfaces (wallmounted thermostats) are unsuitable for large areas. At the same time, large conventional master/slave systems are also extremely inefficient and create buildings that are always too hot or too cold, sometimes on the same day!

Creating more comfortable indoor environments for commerce and industry while at the same time reducing energy costs, Modbus controls for HVAC fans represent a real solution for problems noted above.

The unique client/server architecture of the Modbus protocol allows a wide range of control options for large HVAC systems. Through one interface, building managers and system operators can monitor and control many separate devices, each supported by its own sensors and control circuitry.

Leading fan manufacturers are now providing advanced EC fans with built-in Modbus communication capabilities and Modbus interface software. With energy costs at record highs, the promise of energy savings and increased comfort should fuel the drive to Modbus.

In short, it has never been easier, or smarter, to connect HVAC fans in a Modbus network and control their operations for improved energy consumption management.



Vincenzo Nuzzi *is an engineer with Rosenberg GmbH. www. rosenberg-gmbh.com*

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Qualifying an XYZ Robotic Adhesive Application for Freezer Assembly

BY TIM JONES AND AGGIE LOTZ

Electrolux is a global manufacturer of major appliances with well-known brand names such as Electrolux, AEG, Anova, Frigidaire, Westinghouse and Zanussi. The company's St. Cloud, MN, Manufacturing and Quality Assurance (QA) departments had identified a loss in productivity and inconsistent quality in its freezers. As a result, an internal team involving seven Electrolux departments in St. Cloud set out to upgrade from an outdated XY-applied hot-melt pressure-sensitive adhesive (HMPSA) to a fully automated XYZ application process.

At issue was a seemingly underperforming HMPSA. The Manufacturing department's stopgap of reinforcing the HMPSA with large quantities of 2-inch-wide masking tape, which also required more labor hours, was driving up production costs. Equally important was the issue that the plant's target for the number of freezers assembled per shift was not being met. An internal consensus was reached: the stopgap had to be replaced.

Representatives from Electrolux's Manufacturing, Quality Assurance (QA), Manufacturing Engineering, Maintenance, Electrical, Materials Engineering, and Purchasing departments regularly forged solutions through ad-hoc teams to improve plant operations. In this case, the company's Purchasing department reiterated that Manufacturing's stopgap was exceeding its bill of materials for the freezer application's masking tape and labor. QA identified vibration noises in the freezer's air duct subassembly, resulting in a higher-than-average service call rate (SCR) in the field. The Manufacturing Engineering, Maintenance, and Electrical departments wanted to update unreliable, outdated adhesive application equipment and operating software to mitigate escalating maintenance costs.

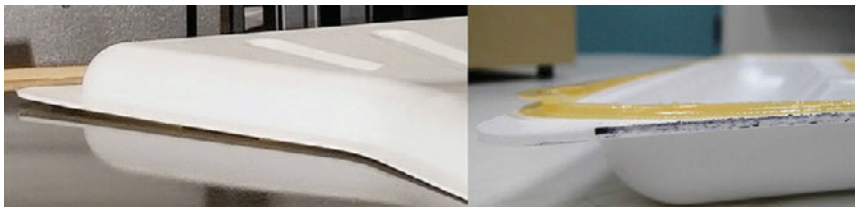
Having identified these multiple objectives, the department representatives deployed an ad-hoc development team to address the HMPSA application and the SCR vibration noise. The team's first order of business was to establish benchmarks.

Attachment Process

Attaching the air duct to its liner involved the same HMPSA/masking tape-reinforced application regardless of the freezer's size (e.g., 13, 17, 19, or 21 cu ft), although the air duct and liner dimensions increase proportionally with freezer size. The larger air ducts and liners manufactured for 19-21 cu ft freezers required more HMPSA and tape.

The upright liner was constructed of coil-coated steel. The air duct substrate was a high-impact polystyrene (HIPS) constructed from an extruded sheet that Electrolux

Warped air ducts result in unacceptable adhesive pull-away.



Acceptable adhesive press-out on an air duct.



Acceptable adhesive bead pattern on the perimeter (left) vs. unacceptable (right).



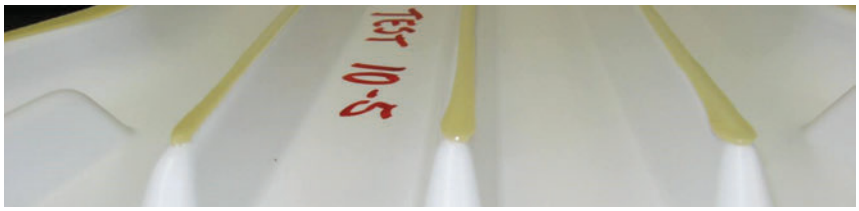
thermoformed to specification for physical dimensions that properly regulated airflow.

The attachment method used by Electrolux for the previous 20 years required an XY hot-melt applicator to dispense the HMPSA on a specific area of the reverse side of the liner. After dispensing the adhesive, the liner part advanced on the assembly line approximately 5 feet to the next process area, where workers placed the air duct precisely on the liner's adhesive joint. Workers then taped the perimeter of the air duct to the backside of the liner to secure it. Without masking tape, the parts would not remain attached when advancing through the pre-heat foaming operations. Figures 1-4 illustrate some of the issues related to adhesive application in this area.

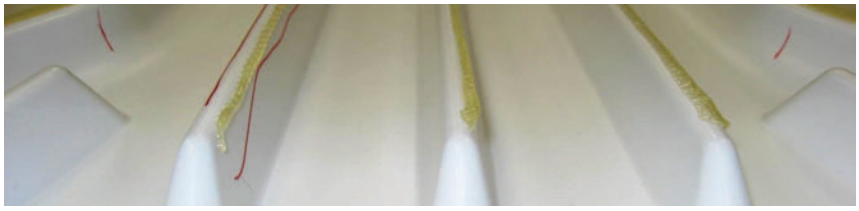
From there, the air duct would advance through a few more stations, where the liner would be rotated to expose its interior for attaching plastic breakers to the liner. A worker would drop the liner into the cavity of the upright shell, and then fit the breakers to the shell. This step resulted in an open cavity between the two parts.

The assembled shell and liner then advanced to a preheated forced-air oven (temperatures ranging between 115-135°F) for approximately 2 minutes. Preheating ensures the urethane foam migrates to the nooks and crannies of the cavity (between the liner and the shell) for uniform foam density distribution. Next, the high-pressure urethane foam would be injected into the cabinet (i.e., the preheated shell and liner with air duct), filling the cavity within 6-7 sec. The "foamed" cabinet would remain undisturbed in the cure oven for 4-5 minutes to ensure that the urethane foam was completely cured.

This step-by-step attachment process was originally designed without masking tape. However, Electrolux's HMPSA often became unstable following preheating and prior to curing, resulting in a bond break. Tests revealed it couldn't withstand the 135°F process temperature for 2 minutes. Manufacturing resorted to using 2-inch masking tape to avoid a HMPSA failure (i.e., detachment of the air duct from the liner) following preheating.



Acceptable placement of adhesive on air duct center ribs.



Unacceptable placement of adhesive on air duct center ribs.

SCR Noise Mitigation

Separately, a vibrating noise inside one freezer model had been detected. The air, which is cooled by the evaporator located behind the



Tests were conducted on 6 adhesive samples.

Table 1
Adhesion Test Data

HIPS Sheet	Extruded Sheet Wt.	Extruded Sheet Wt. Plus Adhesive Wt.	Adhesive (g/lbs)	Open Time	120˚F Heat Exposure	130˚F Heat Exposure	140˚F Heat Exposure	150˚F Heat Exposure	160˚F Heat Exposure
Sample 1 (350˚F)	1,490.43	1,498.29	7.86 / 0.0173	10-15 sec	Fail at ~ 23 min	---	---	---	---
Sample 2 (350˚F)	1,483.73	1,498.64	14.91 / 0.0328	10-15 sec	Fail at ~ 29 min	---	---	---	---
Sample 3 (350˚F)	1,485.12	1,505.68	20.56 / 0.0453	10-15 sec	Pass	Fail at ~ 14 min	---	---	---
Sample 4 (360˚F)	1,480.09	1,487.05	6.96 / 0.0153	10-15 sec	Pass	Fail at ~ 12 min	---	---	---
Sample 5 (360˚F)	1,481.30	1,494.71	13.41 / 0.0295	10-15 sec	Pass	Fail at ~ 18 min	---	---	---
Sample 6 (360˚F)	1,369.43	1,392.99	23.56 / 0.0519	10-15 sec	Pass	Pass	Pass	Pass	Pass
Sample 4 (370˚F)	1,377.18	1,388.76	11.58 / 0.0255	10-15 sec	Pass	Fail at ~ 19 min	---	---	---
Sample 5 (370˚F)	1,517.71	1,531.66	13.95 / 0.0307	10-15 sec	Pass	Pass	Pass	Fail at ~ 7 min	---
Sample 6 (370˚F)	1,365.22	1,394.84	29.62 / 0.0652	10-15 sec	Pass	Pass	Pass	Pass	Pass

freezer compartment, is blown by the freezer's evaporator fan unit and passes through the air duct to the freezer compartment. The evaporator cover has a few plastic ribs that allow air to flow through discharge holes located on the fan louver. Vibration occurred with contact between the plastic ribs and the exterior coil-coated steel liner.

Having knowledge of the internal evaluation that was underway and the pending HMPSA substitution, QA realized they could kill two birds with one stone: Why not muffle the vibrating noise with an adhesive?

Engineering a Solution

The central issue that Electrolux's Engineering and Quality departments faced was how to facilitate process control by delivering precise (repeatable) adhesive dispensing results in the air duct-liner attachment (to eliminate the need for reinforcement with masking tape) while concurrently applying adhesive to the plastic ribs for SCR noise reduction. The team believed a new XYZ robotic adhesive application was the answer, but there were many details to work out and variables to test. Manufacturing, Manufacturing Engineering, and Quality collaborated on the optimization method to meet the required 23-second cycle rate. Manufacturing Engineering evaluated a few different robots for a two-step process. The robotic arm would pick up the air duct and articulate it (XYZ movement) under the hot-melt adhesive nozzle to apply adhesive to the perimeter of the air duct. Following this operation, the air duct was immediately articulated under the next three glue guns to apply adhesive to the center ribs. The goal was to not exceed the 10-second open time of the adhesive before placing and pressing the air duct onto the back of the liner.

The team recognized that the real challenge would be selecting an adhesive with the desired pressure-sensitive characteristics (mainly tack) and with higher viscosity. High viscosities mitigate excessive running of the adhesive to the edges of the bonded joints; in this application, the adhesive flow shouldn't extend beyond the edges of the air duct. The desired thickness was indicated for longer heat retention (slower setup) and for proper wetting out to the pre-painted liner.

Laboratory Testing

Six different adhesive samples were tested (see Table 1 and Figure 5). The successful selection was predicated on Electrolux's laboratory protocol using a pre-painted steel panel and a handheld hot-melt adhesive dispenser. The adhesive supplier provided the correct application temperature, and Electrolux's Purchasing department specified the required amount of adhesive to properly regulate cost, which was by no means a trivial calculation.

Testing was then performed on the dispensing of various adhesive bead sizes ranging from 1/16-3/16 inch. Given that a smaller adhesive bead size carries fewer calories of heat, the smaller bead size was quickly ruled out. Testing involved timing the dispensing to obtain full coverage, with desired thickness and rigidity over the perimeter. Concurrently, the bead size was tested to facilitate proper wetting on the ribs to ensure bonding to the plastic and adherence to the polyester backer coating of the pre-painted steel. A specifically



The heat stability testing frame for the hot chamber. The plastic panel went into the oven inverted, hanging upside down on the pre-painted steel.

regulated adhesive temperature was required to provide the proper amount of open time (for mating of the air duct to the liner back) and best wet-out to the two substrates.

The most effective method for obtaining the recommended calories of heat for this application involved experimenting on an extruded sheet of plastic that was approximately the same weight as the air duct. Various bead sizes and amounts of adhesive were tested with various temperature characteristics.

The dissimilar substrates (plastic and pre-painted steel panels) were pressure tested to ensure accuracy and uniformity of the degree of pressure the application required. As shown in Figure 6, the plastic panel went into the oven inverted, hanging upside down on the pre-painted steel, to validate the oven temperature target, with a testing range of between 125-145°F (and up to 160°F as an experimental control). Multiple tests verified that when the correct amount of adhesive was applied, the bond between the two parts met production requirements.

The laboratory test involved a manual application of adhesive to the substrates; therefore, the next phase of testing involved validating the 23-second cycle time. In that timeframe, the robot had to grip and lift the plastic air duct, then position it beneath the hot-melt glue gun, applying adhesive around the perimeter of the air duct and then applying the beads to the ribs for noise control. The final process step was to invert the air duct in 10 seconds or less and place it on the liner, holding a constant degree of pressure on the two substrates for 2-3 seconds.

Testing on the Plant Floor?

When the laboratory testing results were satisfactory, the testing had to be performed in the production area. Because the new robot hadn't yet arrived, the crew used the available hot-melt application equipment to test the adhesive formulation. Attaching the hot-melt gun to the in-house XY manipulator, the team performed testing to validate the amount of adhesive needed in manufacturing. That process proved successful without using masking tape; however, dispensing the adhesive in the correct location proved challenging with the XY manipulator. Nevertheless, the process at this stage looked promising for the adhesive selection.

When the team cut out the back side of the liner to check for urethane foam leakage, a failure was detected. Eventually, the bead size, temperature, and amount of adhesive were validated. The required 23-second cycle was met, and the urethane foam leakage was resolved.

XYZ Robot Applicator Installation and Testing

Now the capital expense of the XYZ robot could be approved by Manufacturing with confidence. The testing had to be repeated on the new XYZ robot, including the timing sequence, bead sizes, and 23-second cycle time. The last step involved fully programming and integrating the XYZ robot according to the application parameters into the assembly operation. Smoothing out the cycle times, bead size, and all the corresponding adjustments took Manufacturing Engineering a few weeks to complete, with Quality overseeing the rib adhesive application for noise reduction.



To meet the required cycle time, Manufacturing Engineering increased the adhesive temperature once again to speed up flow of the adhesive through the hot-melt gun.

Finally, a run-off test was conducted with a short production run on 120 air ducts and pre-painted liners (all freezer sizes were represented). The result was successful in full production mode following several adjustments to the program and several rib realignments that involved weekends, lunch breaks, and the third shift for nearly a month. Syncing the 10-second XYZ robotic adhesive application around the perimeter of the air duct, followed by applying adhesive to the plastic ribs, was memorable (mating the bonded substrates must occur quickly to prevent contamination of the bond surface). Dialing in the targeted amount of adhesive to meet cost requirements was equally laborious.

Ultimately, every automation goal was met, including the elimination of the masking tape reinforcement (and lost productivity) and reduced labor resulting from the attachment of the air ducts to the liners. The vibrating noise was mitigated, reducing the SCR in the field.

Upstream Production Anomalies

In real-world manufacturing, Murphy's Law dictates that even a streamlined operation will occasionally fail. This process was no exception: a part would be missed or damaged upstream of the adhesive application, causing the line to stop. The solution involved programming the software to go into QA mode if, after 30 seconds, the adhesive was not dispensed. This mode entailed dispensing the adhesive into a Teflon-coated pan for testing the adhesive temperature. If the adhesive temperature was too hot, the adhesive was dispensed several more times into the pan and then discarded in order to purge the overheated material and to reset the temperature.

Purchasing cited its concern that the QA mode added cost to the process (i.e., excessive adhesive was used). Manufacturing and Manufacturing Engineering reviewed the frequency of deploying the QA mode and its added cost, eventually concluding that there wasn't a less-costly alternative. The QA mode was therefore adopted over Purchasing's objections.

Additional unexpected manufacturing anomalies were troubleshooted from time to time, but nothing proved too difficult to resolve. The ad-hoc team had replaced an outdated, inefficient 20-year piece of machinery. Electricians in the Maintenance Department had fewer maintenance issues and less downtime; they were satisfied with the improved reliability outcome.

Testing for Success

Electrolux was able to determine its adhesive selection requirements through extensive testing—first in the laboratory, then on the production floor, and finally in a third round of testing that was performed on new XYZ robotic adhesive application equipment that had to be financially justified prior to approval of the capital expense and equipment integration. Not unexpectedly, the three testing environments produced variations in the testing results. Production involved bonding dissimilar substrates, mitigating a vibrating noise to which consumers objected, and eliminating masking tape as a reinforcement to a seemingly underperforming HMPSA. In reality, the HMPSA simply couldn't withstand the process temperature that reached beyond the limit it was formulated for.

OEM value chain participants involved with different applications can learn plenty from this situation. ChemQuest's Technology Institute has observed and measured the remarkable effect temperature and humidity has had in manufacturing facilities on adhesive chemistries and substrates. For example, temperature and humidity affect surface energy (polar and dispersive components), liquid viscosity, surface tension of the liquid, application dynamics, and curing dynamics. Application testing of adhesive products and substrates in an environment that simulates a wide range of environmental conditions can help to narrow down the proper performance window and aid in the development of new materials and formulations that perform more robustly over larger application ranges.

Adhesives formulators should be proactive and access testing protocols and real-world manufacturing environments that accurately simulate their end customers' factory conditions. The same resources are available to end users that need them. ●



***Tim Jones**, a materials engineer for forty years with Electrolux Major Appliances, retired in April 2018. Mr. Jones was involved in qualifying new materials (coatings, adhesives, sealants, urethane foam) and new application equipment to satisfy Electrolux internal requirements, while working with vendors seeking qualifications for U.S.-based appliance and part materials.*



***Aggie Lotz** is vice president of the international strategic management consulting firm The ChemQuest Group and The ChemQuest Technology Institute, which provides technical resources with exclusive focus in specialty chemicals markets.*

For more information from either author, call (412) 781-1320 or email alotz@chemquest.com, or visit www.chemquest.com. Electrolux can be found online at www.electroluxappliances.com.

Owens Corning is pleased to announce 2030 sustainability goals that are its most comprehensive and ambitious to date. These goals represent the company's third set of long-term goals and are designed to expand the company's business impact through sustainability, continuing its commitment to incorporate material environmental, social and economic initiatives into its global practices and operations.

"These goals advance our business priorities by pushing us to discover increasingly more sustainable solutions, which is becoming more important to our customers and other key stakeholders," Chief Executive Officer Brian Chambers said. "Our employees are energized by the challenge to use their creativity and dedication to achieve these ambitious goals."

Chief Sustainability Officer Frank O'Brien-Bernini added, "The scope and ambition of our sustainability goals have evolved over the years, from an initial focus on reducing our environmental footprint, to our current 2030 aspirations to double the positive impact of our products, halve the negative impact of our operations, eliminate injuries, improve the quality of life for our employees and their families, advance inclusion and diversity, and have a positive impact on our communities."

A few examples of Owens Corning's 2030 sustainability goals include:

- **Reducing greenhouse gas emissions** by 50%, in line with guidance to hold global warming to 1.5 degrees Celsius. This goal was approved by the Science Based Target Initiative.
- **Sourcing 100% renewable electricity** to reduce product embodied carbon.
- **Maximizing product sustainability,** including circular economy strategies for reduced consumption of virgin materials and increased end-of-life reuse and recycling.
- **Building and supporting inclusive and diverse teams** that reflect the communities in which we live, work, and serve.

Owens Corning ranked No. 1 on ***Corporate Responsibility Magazine's*** 100 Best Corporate Citizens list for 2019 and recently became the first U.S. industrial company to issue a green bond. It was also just named Industry Leader for the DJSI World Building Products group, for the seventh straight year.



Scheugenpflug AG will be part of the **Swedish Atlas Copco Group** in the future. The specialist for adhesive bonding, dispensing and potting technology will operate as an independent company within Atlas Copco's "Industrial Assembly Solutions" (IAS) division. Atlas Copco currently employs approximately 37,000 people and supports customers in over 180 countries.





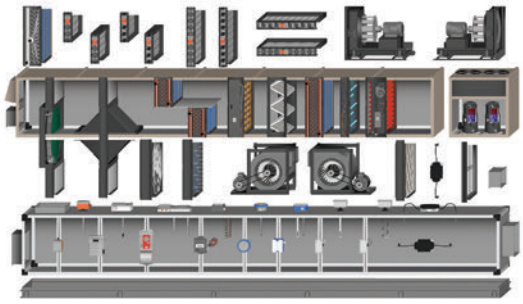
SSW Holding Company, LLC announced the promotion of Mark Gritton to Chief Executive Officer of the company. In addition to assuming the leadership of SSW as CEO, Gritton, a 25-year company veteran, will continue to serve in his current position of President.

Gritton has succeeded Paul Kara, who served as SSW's CEO since 2000. Kara will continue to serve as Chairman of SSW. "It has been a privilege to serve as the CEO of SSW and I am extremely proud of what our company has accomplished together," said Kara. "I know Mark is committed to lead our exceptionally talented team and I look forward to his continued success."

Norwegian Airfilters announces they will exhibit at AHR Expo. They are a Norwegian manufacturer of all types of airfilters on the American market. Norway has some of the worlds most strict requirements for airfilters quality, and the company offers this quality on the American market. Their selection of filters goes from MERV 4 to MERV 16 and include Z-linefilters, Minipleatfilters, Bagfilters and Compactfilters. We also have a good selection of carbon filters in all classes. They promise delivery within 48 hours from their factory.



Goodway Technologies newest high-performing industrial descaling system the GDS-100 is a portable, clean-in-place pump system ideal for large and small descaling cleaning applications. Remove limescale, calcium and mineral deposits, rust and other contaminants from HVAC and process manufacturing equipment. The presence of scale and deposits can act as an insulation barrier on heat transfer surfaces which impact the actual loss of heat transfer and operational efficiencies. Common cleaning applications include boilers, chillers, condensers, shell & tube and plate type heat exchangers, and vacuum pumps and any other water operated piece of equipment. The high flow capability of this unit at 96 GPM, was designed with gasketed & brazed plate heat exchangers as well as large condenser barrel cleanings in mind.



QA Graphics has created a module for its newly released BAS Vector Symbol Library. This tool is an extension update for the existing Vector Symbol Library, and it will easily substitute Tridium's N4 graphics file. The module will effortlessly integrate within the software, allowing N4 users to implement QA Graphics' Vector Symbol Library, and it's free of charge to those who purchase the Vector Symbol Library. In addition, QA Graphics is also offering companies a free test module to try within their Niagara system beforehand.



Rosenberg's ECOFIT® brand backward-curved motorized impellers deliver low-noise and highly efficient air movement. Applications include uninterruptible power supply (UPS), variable frequency drive (VFD), rectifiers and inverters. They are also used in domestic air conditioning, low-power industrial heaters and cowl ventilation.

The innovative blade design of our standard fans ensures noise is kept to a minimum. Their compact size makes them a perfect fit in a broad variety of equipment.



Climate by Design International (CDI) announces that they will be showing the Dry Climate Desiccant Dehumidification Series at the 2020 AHR.

The Dry Climate is a compact pre-engineered desiccant dehumidifier with stainless steel construction that performs in a variety of commercial and industrial applications including Bulk Product Handling – Pneumatic Conveying and Silo Blanketing, Archival Storage, Food Processing, Seed Storage, Spiral Freezer and Cold Storage. Dry Climate has multiple supply voltage options and a continuous modulating reactivation heaters to maintain peak efficiency. It is available with BMS communication, filter monitoring, VFD control, electric or gas reactivation heaters, cooling options, and more.



Dwyer Instruments announces the release of the Temperature Transmitter, Model TBU-00. Dwyer's customizable and versatile Model TBU-00 can be utilized to monitor temperature in process applications where a 4 to 20 mA signal is required, such as: food processing equipment, boiler equipment, refrigeration equipment, and brewing equipment. The TBU-00 is able to accept thermocouples, Pt100 or Pt1000 RTDs, thermistors, or a 0 to 50 mV voltage signal. This universal input reduces inventory, while remaining highly accurate and user friendly for simple to sophisticated measurement applications. The integral micro-USB port combines with free downloadable software in order to facilitate easy configuration and calibration of temperature ranges in a lab or in the field. Utilizing the easy-to-use configuration software, users are able to select the measurement range, input type, and output configuration, which can be set to direct 4 to 20 mA or reverse 20 to 4 mA. The standard head mount housing fits the requirements of various applications and allows for an expedited installation. When the TBU-00 needs to be used in harsh environments, the optional A-709 aluminum enclosure is NEMA 4X rated to offer added protection.

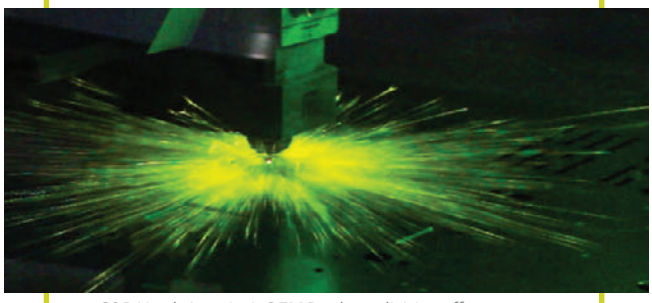


Nordson ASYMTEK, a Nordson company, recently announced that it has celebrated 20 years of supplying fluid dispensing equipment to Demant A/S, a manufacturer of hearing aid brands that include Oticon, Bernafon, and Sonic. During this history, Nordson reports that its technologies have enabled Demant to design smaller and more capable hearing aids. The first Nordson ASYMTEK dispensing systems were shipped to Demant in 1999 for a dam-and-fill application for hearing aid electronics. Over the years, more systems were added to jet underfill and surface mount adhesive and to dispense solder paste using a variety of Nordson ASYMTEK's valve technologies. Approximately 20 dispensing systems have been shipped to Demant facilities, with the majority still in operation.



SpeedClean, LLC launched the CoilJet® CJ-125 Coil Cleaner. a portable HVAC coil cleaning system ideal for cleaning evaporator coils and condenser coil in locations where water and power may be inaccessible, such as rooftops and attics. The CJ-125 is designed for portability by including separate water and chemical tanks and a long-life rechargeable battery. Expertly clean condenser and evaporator coils no matter where the location may be. The CJ-125 delivers a powerful spray of water and cleaning chemical from the included tanks to wash even the dirtiest coils, without damaging sensitive fins.

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WELDING • PAINTING
ELECTRICAL ASSEMBLY
AND MORE

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Johnson Controls International plc has named **Tomas Brannemo** vice president and president, Building Solutions Europe, Middle East, Africa, and Latin America (EMEALA. Brannemo will serve as an officer of the company and oversee Johnson Controls Building Technologies & Solutions operations across EMEALA.

Brannemo succeeds Jeff Williams, who was recently appointed vice president and president, Global Products, Building Technologies & Solutions.

FABRISONIC
Solid State Additive Manufacturer of Metals

Fabrisonic recently had the pleasure of hosting the crew from **Made in America** to talk about metal 3D printing. These journalists travel the country and document the dynamic of American manufacturing, from industrial luggage at Pelican to metal 3D printing at Fabrisonic. All of the diverse manufacturing companies have one thing in common, they all make their products here in the USA.

During their stay, we talked about many of the factors that make Fabrisonic's 3D printing process unique:

- **Low Temperature Welding** – Ultrasonic welding happens near room temperature with no changes in microstructure or metal temper
- **Hybrid Approach** – All Fabrisonic systems have both an additive stage and a subtractive stage meaning all surfaces, internal and external, have CNC quality surface finish and accuracy.
- **Dissimilar Metals** – The solid-state nature of UAM allows all Fabrisonic systems to weld dissimilar metals within a single part without adverse metallurgical reactions.
- **Embedding Electronics** – The hybrid approach coupled with the low temperature welding allows SonicLayer systems the ability to embed electronics or sensors anywhere in solid metal parts
- **Common Feedstocks** – UAM systems utilize commercially available metal foils



Shurtape Technologies has officially broken ground on a new distribution center in Catawba, N.C. Expected to open in the spring of 2020, the facility will offer 205,000 sq. ft. of high-bay storage, with the capability of expanding to 1 million sq. ft., including space for light manufacturing operations. The new facility will support the company's retail and industrial distribution requirements in the Southeastern U.S.

More than 30 team members currently employed at Shurtape's distribution center in Catawba will transfer to the new facility. The company expects to add 100 new positions over the next four years to support continued business growth.

Shurtape expects to invest over $31 million in the project, which is being facilitated, in part, by a Job Development Investment Grant (JDIG) that was approved by the state's Economic Investment Committee.



PennEngineering has announced the launch of the new **microPEM® ClampDisk™ Press-on Fastener**. Designed as a unique alternative in assemblies for the automotive electronics and consumer electronics markets, the ClampDisk™ micro fastener delivers a fast, simple way to achieve sheet-to-sheet clamped attachment while replacing the use of standard screws, nuts, and adhesives.

Ideal for micro/targeted applications in automotive electronics and consumer electronics assemblies:

- First micro fastener of its kind on the market at this size/shape
- Installs onto a pin or cast post
- Used for sheet-to-sheet attachment
- Part provides a clamping load from the flexing of its downward facing flanges located along part's perimeter
- Can be used to replace a number of welded screw, nut, or adhesive assemblies
- Can be easily removed with a sharp-edged tool
- Compatible with multiple materials
- Rapid, easy installation – axial installation force
- Tamper-resistant design



Southco's new **High Pressure Sealed E3 VISE ACTION® Compression Latch** is sealed to IP69K to prevent liquid ingress and is DIN EN1672-2 compliant, making it an ideal solution for applications where hygiene and cleanliness is essential. With its robust stainless steel construction, the High Pressure Sealed E3 resists harsh environments and chemicals typically used in food processing machinery and medical equipment applications.

The High Pressure Sealed E3 provides the same quick, secure closure as the standard E3 series, and delivers robust, vibration-resistant fastening. Additionally, the High Pressure Sealed E3 features the same panel hole prep as the standard series for easy retrofit and is available in a variety of grip lengths to provide optimal door closure.



Vitrek, the leader in high-voltage test and measurement equipment, introduces the **PA920** Series Ultra High Accuracy Power Analyzer.

The multi-channel PA920 offers unprecedented 0.024% power measurement accuracy for all channels (1-4 channel cards available per unit), innovative VPA architecture, 100 full precision readings per second and measurement bandwidths sufficient to handle 5 MHz signals — all at a cost far lower than less capable, competitive models. The unit's intuitive touchscreen operation — with built-in data history, scope mode and waveform zoom — allows users to explore many aspects of power measurement in greater detail than traditional power analyzers.

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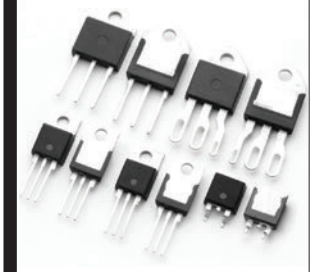
The **Behlman VPXtra® 1000CD5-IQI COTS** power supply is a VITA 62.0 6U VPX power module that delivers 1050W of DC power via two outputs. Includes intelligence features aligned with the SOSA technical standard. Rugged, highly reliable, conduction cooled, switch mode unit built for military and high-end industrial applications.

The 1000W +12V main output can be paralleled with the main output of other VPXtra® 1000CD5-IQI power supplies for higher power; both main and auxiliary outputs may be paralleled for redundancy. The VPXtra® 1000CD5-IQI operates IAW MIL-STD-704E, and contains a VITA 46.11 IPMC for integration into chassis with system management. VPXtra® 1000CD5-IQI power supply has no minimum load requirement and has overvoltage and short circuit protection as well as over-current and thermal protection. The power supply is designed to support the rigors of mission-critical airborne, shipboard, vehicle and mobile systems. The VPXtra®1000CD5-IQI has many other features: efficiency of 90% typical, conduction cooled at card edge, conformal coating on PCB, remote sensing on main output, load sharing on main output, and redundancy on all outputs.

The Behlman VPXtra® series offers 20 diverse DC-to-DC, AC-to-DC and hold-up units that can be configured for a wide range of high-end industrial and military airborne, shipboard, ground and mobile applications – without the cost of full-custom development.



Marketair Inc. introduces the **Disconnect Standby Switch** (DSS), the industry's only electrical disconnect box with an easily accessible standby port/switch to enable a portable generator to power any residential or light commercial heat pump condensers during power outages. The DSS differs from common condenser electrical disconnect boxes, because it features a three-position toggle that switches from "on" (house power), to "off," and "standby" (generator positions).



Littelfuse, Inc. introduces an additional five series of high-temperature **Alternistor TRIAC switching thyristors.** The thyristors are designed for use as semiconductor switches in appliances and equipment powered by line AC voltages up to 250VRMS.



Cincinnati Test Systems updates the previous generation of TracerMate with **TracerMate II**. The TracerMate II can perform a high-resolution pressure decay test followed by leak location on the same test station. Reduces the costs associated with extra test stations and part handling. This replaces the dunk tank and soapy water approach on the production line or in the repair bay with a reliable and automated dry method that eliminates operator subjectivity.



Nye Lubricants recently introduced a new dielectric grease for electrical connectors and electronic circuits. **Rheotemp 769G** is a polyurea-thickened, medium-viscosity grease that has been fortified with polytetrafluoroethylene (PTFE) to lubricate and protect electrical contacts. The synthetic hydrocarbon lubricant also offers protection against fretting corrosion, which is caused by low-amplitude vibrations that expose metal surfaces to oxidation and can result in connectivity issues.

In addition, the grease features reduced insertion force to help ease the mating of connectors during the assembly of cars and other electronic equipment.

With water-washout resistance and a service temperature range of 347 degrees to minus 40 degrees F, the dielectric grease can help protect electrical connectors from moisture, vibration and other corrosive environmental conditions. It also has been formulated to respond to the increased demand for advanced automotive drive-assistance systems while extending component life and improving reliability.



Creating More Efficient Commercial HVAC Enclosures

With Advanced Access Technology

BY TODD SCHWANGER



Southco's 96 Hinge series allows a large HVAC door to be "lifted off" its frame quickly and easily, without the need for separate tools.

Commercial heating, ventilation and air-conditioning (HVAC) systems are some of the most expensive and critical engineered systems used in buildings today. Building owners, developers and their tenants are demanding more cost-effective and cost-efficient equipment performance while ensuring comfortable environmental conditions as each season changes.

HVAC systems are becoming smarter and more integrated to help maximize long-term performance and value. Building owners and facility managers are constantly on the lookout for new tools that can more effectively reduce repair costs, minimize downtime and keep the operating environment in their buildings in optimum condition.

In turn, HVAC equipment manufacturers have been improving HVAC enclosure designs to be more energy efficient. These enclosures are not perfectly sealed boxes, however. They include doors and removable panels that are often quite large and which require maintenance and repair access, and other activities. HVAC manufacturers and enclosure designers are installing thicker doors and panels with more insulation to help improve thermal efficiency and prevent heat from transferring through the door, enabling the unit to handle the heating/cooling load while tightly controlling the HVAC system's energy demands.

As the designs and physical construction of these doors have changed, there is a need for new latching and hinging technology that can improve access to these enclosures and help HVAC equipment suppliers satisfy their end-use customers.

Engineering HVAC energy efficiency

Just as our modern world depends on complex systems such as data centers, cell phone towers and switching equipment, our built environment depends on high-performance HVAC units, the majority of which need to operate efficiently 24/7. Commercial HVAC units keep our workplaces, retailers, hospitals, schools, travel terminals and a myriad of other locations comfortable and supplied with fresh air whenever in use.

These systems share several other characteristics: They use expensive, high-technology equipment that heat and/or cool vast volumes of air to precisely controlled temperatures and then move that air continuously, making them major energy consumers. According to the U.S. Department of Energy's studies of commercial buildings, HVAC equipment typically accounts for 39% of a building's energy usage1.

For building owners and facilities managers focused on controlling costs, improving margins and keeping tenants happy, maximizing the energy efficiency of their HVAC systems is a key imperative. That means they will be looking to HVAC system suppliers who are improving the efficiency of their systems.

HVAC units are installed within enclosed, climate-controlled spaces as well as outside the building, often on rooftops. Major HVAC manufacturers typically design and fabricate their own enclosures; however, there is a second tier of enclosure manufacturers that make multiple components and supply them to HVAC manufacturers. Both types of manufacturers have begun to redesign their enclosures, focusing on improving the efficiency of the enclosure by improving the level of insulation.

Improving enclosure access door designs

Enclosure access doors are one of the key areas where leakage can develop, so the industry is updating access door technology to reduce energy loss from two kinds of leakage: infiltration and exfiltration. Infiltration is leakage of unconditioned air into the HVAC unit from outside the enclosure. Exfiltration is leakage of air, typically conditioned air, from inside the unit through the casing to the outside. Both types of leakage increase the amount of energy required to supply conditioned air to the space.

Enclosure access doors are using thicker panels with improved insulation to reduce heat transfer through the door itself. Newer generation access doors are typically double-walled and insulated, with the total thickness of the door usually ranging from 50 to 75 millimeters.

Now, some access doors have thicknesses up to 100 millimeters. These double-panel doors are typically constructed of two separate panels with a thick layer of foam insulation in between. Depending on the door size, they typically weigh between 35 to 50 pounds.

Some doors are just standard panels that open to allow access to control equipment; others are full, man-sized doors that enable personnel to enter the enclosure. There are even some very large panels, designed to be removable, that facilitate access to large pieces of equipment inside. Using thicker access doors with more insulation in these applications promotes a high perception of quality and creates important competitive value for HVAC system providers.

Securing larger doors

For any door to work, it needs a secure latching system and sturdy, reliable hinges. Larger, heavier enclosure doors need more robust latching and access control solutions. If not properly equipped, doors can become weak points in the enclosure envelope.

Regardless of size, the door still needs to close securely to create a near-airtight seal to prevent leakage. Insulated doors typically have a layer of closed-cell foam material or a compressible rubber bulb applied around the door opening which functions as a gasket to create a secure seal. While standard latching mechanisms were used to secure older enclosures with single sheet metal doors, newer double-skin doors require a different type of latching solution capable of securing a door panel between 25-75 millimeters and up to 100 millimeters thick.

The most appropriate solution for this is a compression latch, which holds a panel or cover closed with a cam and, at the same time, compresses a gasket around the inside of the door to seal it. A key challenge in selecting these latches is an unavoidable fact: The latch handle has to penetrate the door, creating a hole through the insulated wall.

One way to reduce the possible heat loss is to select latches with handles with a minimal design footprint to reduce the size of the hole that must go through the panel. Another design consideration is thermal conductivity connectivity, and choosing latches that incorporate non-metallic insulating components can help to provide a thermal break. There are a number of component manufacturers currently investigating these solutions.

While a compression latch is the right solution for a double-walled door panel with insulation, improper installation of the latch could squeeze the insulation too much, damaging the foam and creating a void that could reduce the insulating factor. There are specialty cam latches designed to avoid this problem that can be firmly attached to the door without squeezing the foam insulation when closed.

In some cases, these doors have very large dimensions, so a single latch may not be sufficient to fully secure the door. Multipoint latching systems — which allow multiple latch points at the top, bottom and middle of the door to be controlled by one actuator — can provide a simplified access solution for oversized doors.

When selecting a cam or compression latching solution for any enclosure door, it is important to take the following design requirements into consideration:

• Environment. With the majority of HVAC equipment located outside, enclosure OEMs must ensure that their equipment meets environmental protection and durability requirements. Enclosure OEMs can maintain compliance by incorporating latches that are tested to UL, NEMA or IP standards.

• Safety. The interior of HVAC enclosures containing fans blowing air into and out of the equipment can generate a high level of pressure that can be harmful to maintenance technicians if they open the door quickly. There are latching systems that, when first actuated, allow the



The smooth operation of Southco's E3 VISE ACTION® Compression Latch series aligns the cam behind the frame and draws it up tight with a single continuous half-turn motion, which can prevent air leakage or vent hot air from the enclosure interior.

air to be slowly released, so that the high pressure building inside the enclosure does not force the door open too quickly. . The operator can then actuate the latch a second time to safely access the enclosure.

• Ease of use. A simple opening is an important ergonomic characteristic, especially to maintenance technicians servicing large facilities such as warehouses, production facilities, hospitals, business parks and other multibuilding locations. Being able to access the enclosure door with simple tools creates a positive user experience and creates an overall impression of quality and value for the entire HVAC system.

Intuitive enclosure access

Like latches, hinges are an essential access component in the overall design of the HVAC enclosure, but they go beyond simply joining the panel to the frame. While relatively simple in terms of functionality, the technical capabilities of the latest hinge technology provide design engineers with new options for enhancing the performance of and interaction with panel doors.

It's often the case that when maintenance technicians open an enclosure door, they want it to stay open while they access and work on a control panel or perform equipment maintenance. Rather than attach an external secondary door stay to prop it open, detent hinges allow a door to open to a preset angle and click into position.



Fixed-position detent hinges, like Southco's C6 series, allow a door to open to a preset angle and click into position for easy access, versus having to attach an external secondary door stay to prop the door open.

Constant torque hinges fulfill the same function with a greater range of possibility, providing smooth opening operation and infinite positioning of the door, opening as far as a technician desires, and remaining in position until pushed close. These hinges allow for intuitive movement of the door, holding it at any point throughout the full range of motion when stopped and with the amount of effort required to move the door just enough to respond to deliberate motion.

In addition to opening, in certain HVAC systems, large doors may also need to be easily removed to accommodate the replacement or upgrade of large equipment. There is a range of removable hinges available that have been engineered for very simple removal without the need for separate tools, allowing a door to be "lifted off" its frame. As with the latching solutions and hinges previously mentioned, HVAC equipment OEMs and enclosure suppliers should select hinges that comply with standards for external use environments and provide durability and long operating life when exposed to the elements.

Selecting the right components

HVAC enclosure designers need to select the appropriate latching and hinging solutions that will satisfy two basic functional requirements: easy opening and secure closing.

Component selection should be based on a door's dimensions, thickness and weight. This includes choosing the proper number of hinges for the door's size and determining whether a standard latch with just one latching point or a multiple latch configuration is required.

It's also important to work with a component supplier whose products are certified to comply with leading industry standards, such as IP65 and NEMA4. Since the majority of enclosures are outdoors, these certifications ensure that the products will withstand the weathering and corrosion that comes with exposure to the elements.

When choosing a high-volume supplier of latching and hinging solutions, HVAC designers should evaluate the strength of a vendor's supply chain. The best suppliers are typically equipped with a strong supply chain and ample product available to meet production requirements. They will also be able to supply expert support and advice on the best latching and hinging technology to use on specific enclosure designs — especially those with insulated doors that call for access solutions engineered specifically for those applications.

As HVAC OEMs continue to improve the design and energy efficiency of their enclosure systems, selecting the appropriate latching and hinging solutions to complete those designs can help achieve the overall efficiency, energy savings and improved performance that the latest generation of HVAC systems are engineered to provide. ●



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Sectigo's IoT Manager locks down appliances and protects them against cyberattack

When Refrigerators Are Attacked

How Cyber Criminals Infect Appliances, and How Manufacturers Can Stop Them

BY ALAN GRAU

Homes and businesses worldwide are vulnerable to attacks from cyber thieves and other bad actors – and not just through their computer networks. The embedded electronics inside appliances present an easy path of entry. It's already been happening. According to Business Insider and Proofpoint, one of the first refrigerator incidents occurred in late 2013 when a refrigerator-based botnet was used to attack businesses.

Some of these attacks, such as infecting appliances with botnet malware, don't really have much effect upon a family's security and safety. In fact, if a "smart" refrigerator gets infected by a bot, the homeowner might not even notice anything wrong.

However, connected-appliance based cyberattacks are not limited to just refrigerators – and they are rarely one-off incidents. Almost any type of appliance can be hacked and used to host a botnet that could attack the web. According to Wired Magazine, a botnet of compromised water heaters, space heaters, air conditioners and other big power consuming home appliances, could suddenly turn on simultaneously, creating an immense power draw that could cripple the country's power grid.

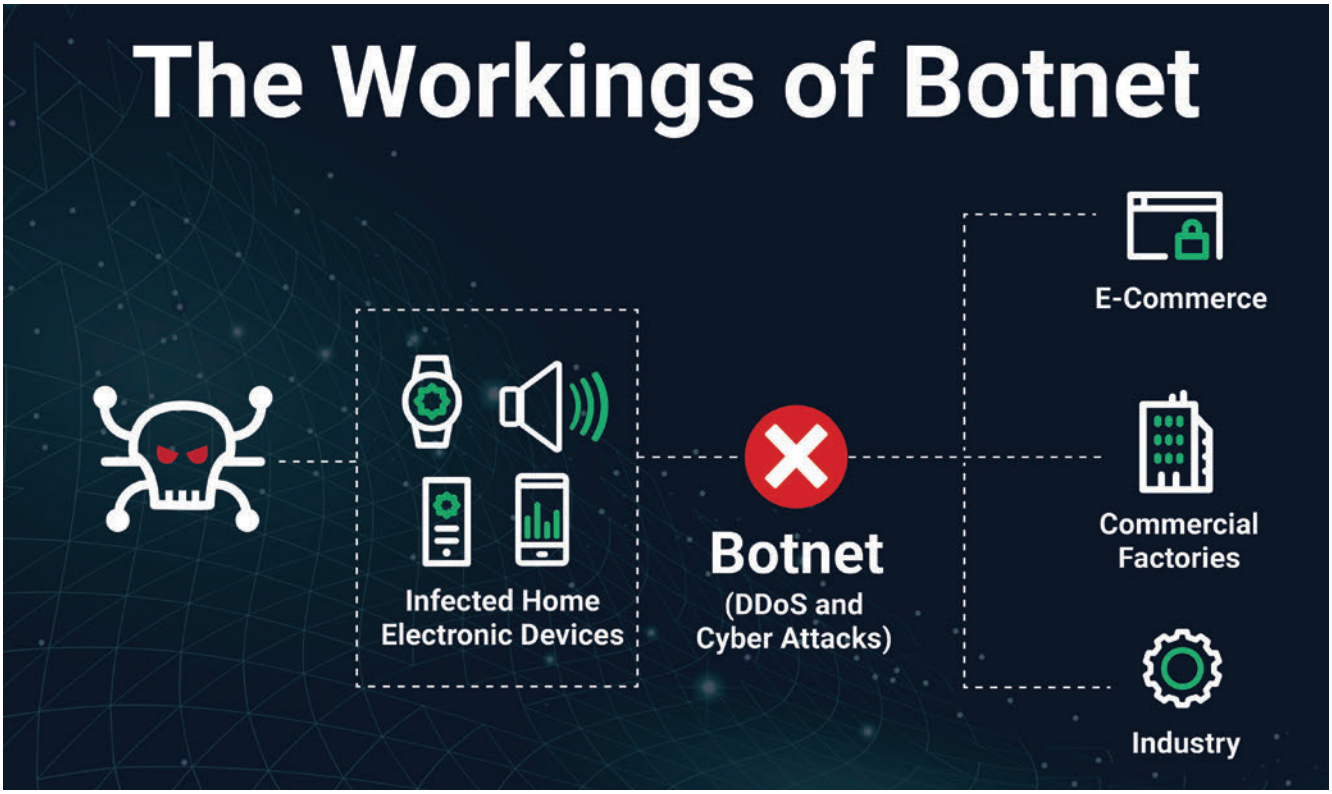
A bot, quite simply, is an infected computer. Many cyberattacks, like the Mirai Malware and the Dyn attacks, infect a network of computers, including "smart" connected devices such as home appliances, security cameras, baby monitors, air conditioning/heating controls, televisions, etc., and turn them all into compromised servers. These compromised servers then act as nodes in an attack and together create a botnet. They can participate in a variety of coordinated attacks, infecting other devices and expanding the network of bots, or participating in Denial of Service attacks.

Without any apparent symptoms or notice, a criminally enhanced refrigerator could be generating and sending out thousands of attacks every minute. In addition to the homeowner or business manager never realizing what is going on, these attacks may be unstoppable until the machine itself is disconnected from its web connection.

Additionally, the infected refrigerator could spread malware from the kitchen to the home's "smart" TVs, to the home's computer networks, to other smart devices in the home, and even to connected smart phones. Every target could be transformed into malicious bots that distribute millions of infected spam messages and cyber-attacks.

So how do we combat this threat?

Unfortunately, end users really have no power to fix this problem. There is probably no way for a homeowner, office manager – or even



A bad actor or cyber criminal can send infected messages to a home or business network that targets various appliances or machines. Once infected, that machine is under the control of the bad actor and can be used to send out thousands of infected messages to new targets worldwide. The botnets can also send out millions of dummy messages to a single target – overwhelming it and putting it out of service.

an experienced refrigerator repair person – to talk to a refrigerator's electronics. No way to get into the appliance's software and middleware to identify and kill an infection. However, if the homeowner suspects an infection, they could disconnect the refrigerator from the its internet connection to make it "dumb" again.

It is up to device manufacturers to protect against these attacks.

So how do manufacturers combat this type of attack? How can they ensure that appliances in homes and offices do not get infected to cause mayhem?

Security starts in the design process for the refrigerator itself, as well as for the appliances' various electronic components and control surfaces. Most appliance manufacturers get their control sub-assemblies from a wide network of smaller manufacturers, sometimes with a worldwide supply chain. These suppliers need to make sure that the chips and sub-assemblies they use are secure from hacks.

Two important security practices can be utilized by appliance makers:

- **Embedded Firewall** with blacklist and whitelist support – Protect appliances and edge devices from attacks by building firewall technology directly into the appliance. An embedded firewall can review incoming messages from the web or over the home network and, via a built in, and regularly updated blacklist, reject any that are not previously approved.
- **Secure Remote Updates** and Alerts – Validate that the firmware inside the device is authenticated and unmodified before permitting installation of any new firmware updates. Updates ensure the incoming software components have not been modified and are authenticated software downloads modules from the appliance manufacturer.

Most consumer and device manufacturers have heard about the potential for attacks on smart devices like door locks, baby monitors, and home thermostats, but this risk awareness needs to expand to types of connected systems – including appliances. An infected refrigerator sending out malware is not just a funny story. These systems have been attacked and used to spread malware. Ensuring the security of these devices is necessary to protect home network, slow the spread of malware and even protect credit card numbers or other personal data stored in smart home devices. ●



***Alan Grau** has 25 years of experience in telecommunications and the embedded software marketplace. He is VP of IoT, Embedded Solutions IoT at Sectigo, the world's largest commercial Certificate Authority and provider of purpose-built, automated PKI solutions.*

Sectigo provides award-winning, purpose-built and automated PKI management solutions to secure websites, connected devices, applications, and digital identities. As the largest commercial Certificate Authority, trusted by enterprises globally for more than 20 years, and more than 100 million SSL certificates issued in over 200 countries, Sectigo has the proven performance and experience to meet the growing needs of securing today's digital landscape. For more information, visit ***www.sectigo.com***.



IMPROVING
The Safety & Reliability of
ELECTRICAL CONTACTS
For Household Appliances

By Nicole St. Pierre

Appliance manufacturers are challenged to deliver innovation and value to everyday household products. Some areas of innovation focus on customer experience, low water/energy usage, smaller size, personalization, and shorter cycle times. Value is often delivered in the design, function, quality, durability, and reliability of a product. Appliance lubrication can enable innovation without sacrificing the value customers expect.

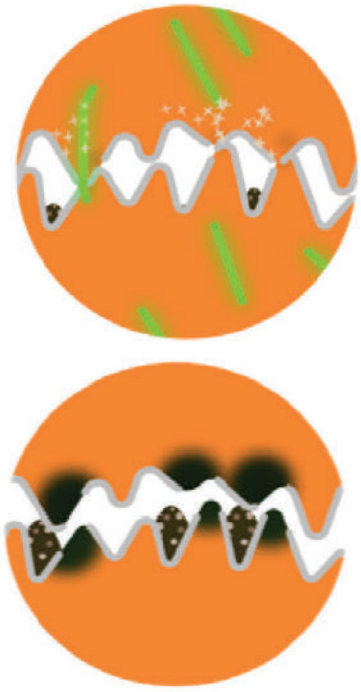
In the appliance industry there are many applications besides gear boxes that can benefit from lubrication. Electrical contacts, sensors, and connectors are in appliances like refrigerators, dehumidifiers, dryers, dishwashers, ovens, and washing machines. Any water intrusion into these electrical components can not only jeopardize performance but could lead to more serious operation concerns such as short circuits which could pose a potential fire hazard.

Vibration, moisture, corrosion, extreme temperatures, and demanding load-carrying requirements are all common causes of component failure in household appliances. A small amount of lubricant can create a barrier that protects components from the environment, wear, and ultimately, product failure. When electrical components fail, it creates serious problems for OEMs including poor customer experience, increased warranty costs, and safety concerns. Oven temperature sensors and connections on control panels of dishwashers and washing machines which control water temperature, set water volume, and wash time are a few examples where an instantaneous short circuit or a communication network fault due to signal loss can have serious consequences for consumers. Something seemingly as small as connector reliability could mean the difference between safe operation and costly recalls for the manufacturer.

Dielectric Grease

There are many misconceptions about the use of dielectric grease on electrical connections. People mistakenly conclude that dielectric grease should never be used on electrical connections because the word dielectric refers to an electrically insulating material. This conclusion is based on a misunderstanding of how dielectric grease works. Dielectric grease has several key properties that make it desirable specifically for use on electrical connections, especially in applications that see moisture like refrigerators, dishwashers, and washing machines. First, although the dielectric grease is non-conductive, it still allows the microscopic asperities

Figure 1
Asperity contact completes current flow between connectors.



Wear debris and oxides form, separating asperities, creating an open circuit.

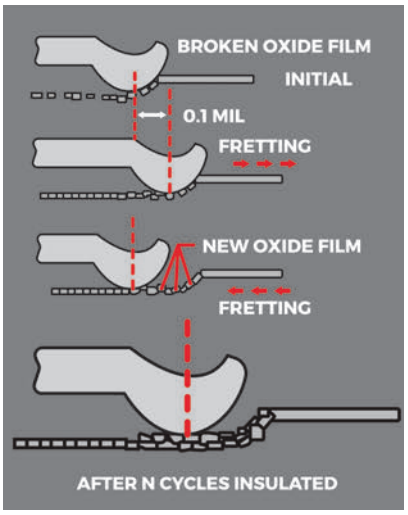
of the contact surface to transfer signal and power, while filling in the valleys of the contact surface, where oxides and wear debris can form (Figure 1). Second, by sealing the system from the surrounding environment, dielectric grease prevents the intrusion of moisture, dirt, dust, and other environmental debris from entering which could lead to corrosion. A buildup of corrosion on the contact surface results in resistance increase and eventual signal loss for the component. Third, the grease reduces physical wear between the connecting surfaces as they undergo micromotions and fretting wear due to vibrations from the running appliance. This reduction in wear helps to preserve the layered coatings on the contacts/connectors which are designed to prevent oxidation and minimize resistance. Lastly, the dielectric properties become important in multi-pin connectors eliminating the possibility of water creating a short between pins.

It is important to know that not all greases are suitable for electrical connectors and contacts. Silicone greases are often sold as dielectric greases. There are concerns with the silicone as it can migrate and get into electrical components which have been linked to relay failures in the past. Silicone has a very low surface tension (21 dyne/cm) which means it readily will spread out on surfaces which affects the ability of other materials to wet out the surface. Other grease chemistries like hydrocarbon-based greases have a higher surface tension (30 dyne/cm) which means they don't spread as easily and can't displace the silicone oil from the surface. Even if the silicone oil was to be wiped from the surface there will be problems adhering other materials to that surface. Not all silicone greases are fortified to offer protection against copper corrosion or to have good water resistance. Most silicone greases are thickened with silica and depending whether a hydrophilic or hydrophobic silica is used will have significantly different capabilities in resistance to water. Testing needs to be performed to know the grease's limitations before using it in components.

Fretting Corrosion

One of the most common reasons for electronic connector failure is fretting corrosion (Figure 2) which differs from galvanic corrosion. Fretting corrosion/wear in electrical connectors and contacts is the result of micromotion caused by vibration and/or thermal expansion due to heating/cooling cycles. These micromovements result in wear down through the metal coatings into the base material (generally copper) that

Figure 2
Unlubricated Contact



becomes oxidized. The inclusion of a copper passivator in the dielectric grease will protect the base material from oxidizing. As this oxide layer builds up and increases on the base material, the oxide film acts as an insulator between the contacts creating an open circuit which then results in voltage drop across the terminal leading to either signal loss or a power failure. The loss of continuity across the connectors/contacts can be catastrophic and potentially result in component failure. In one instance of a recall, millions of dehumidifiers were recalled after causing smoke and fire damage to people's homes. This issue was caused by vibration within the dehumidifier which led to excessive wear on the electrical contact and millions of dollars of claims against the manufacturer. There have been similar recalls involving dryers and washing machines where vibrations caused wear on electrical contacts that led to overheating of the units and posed a potential fire hazard. Using the proper dielectric grease fortified with additives to prevent failures due to fretting corrosion, wear, or corrosion is key to improving component reliability, ensuring safe operation, and avoiding recalls.

Water Intrusion

Water intrusion can jeopardize the performance of electronic components and electrical connections as it leads to galvanic corrosion on the metal surface. Galvanic corrosion occurs when metal components come in contact with moisture. Metals are unstable under normal atmospheric conditions which allow them to be converted into their oxide form. When corrosion starts on the surface of an electrical contact, insulative oxides form on the surface which ultimately results in increased resistance and signal loss leading to component failure.

There have been several recalls by top appliance manufactures due to water intrusion into electrical connections that caused corrosion on contacts in refrigerators and dishwashers. There have also been several recalls for corrosion on contacts in refrigerators which resulted in intermittent interruption of ice production and melting of ice in the bin. Another recall was issued after dishwashers began to overheat due to the formation of corrosion on the electrical component which posed the potential to cause fires. Using the proper dielectric grease in electrical contacts will prevent corrosion from occurring and create an environmental barrier to keep moisture out which will increase component reliability, extend life of the component, reduce safety concerns, and reduce warranty costs.

Test Methods

Not all dielectric greases have the ability of preventing corrosion or water intrusion. Testing needs to be performed to know the grease's limitations before it is selected for an application. Nye's dielectric grease product line was carefully developed to protect against corrosion and to have good water resistance which is backed by extensive validation testing.

Table 1
Images of Passing Tin-Copper and Nickel-Brass Panels after 720 hours exposure SAE J2334



Tin Plated Copper Coupons (Rheotemp™769G)



Nickel Plated Brass Coupons (NyoGel®760G)

The SAE J2334 method is a common corrosion test used for tin-copper or nickel-brass contacts. This cyclic corrosion test replicates accelerated exposure conditions and relies on three segments the humid, the spray application, and the dry stage. These stages provide an accurate simulation of typical operating conditions for applications such as dishwashers and refrigerators. The wet and the dry part of the cycle mimic natural cyclic conditions while the spray application introduces the corrosive solution. Each cycle totals 24 hours where the first segment is a 6-hour humid stage at 50°C, 100% relative humidity (RH) followed by a 15-minute salt application stage at 25°C and finally a drying stage at 60°C, 50% RH for 17.75 hours. A thin layer of grease is applied per the test method specification to coupons before being placed in the test chamber. The automotive industry has found that 80 cycles correlates to 5 years in the field for their applications. The appliance industry could also utilize this testing to identify a correlation for specific applications of interest. See images in Tables 1 and 2 for passing and failing results on tin-copper and nickel-brass coupons used in the testing of dielectric greases. When looking at the failed coupons in Table 2 notice the range in color and degree of corrosion severity.

When performing corrosion tests, it is important to obtain data on both the upper and base metal coatings of the component to evaluate a grease's ability to protect the copper underplating that is traditionally used in electrical contacts and connectors. Nye performs copper corrosion testing per ASTM D-4048 at 100°C for 24 hours. The ratings cover a scale ranging from slight tarnish (1A/1B), moderate tarnish (2A-2E), dark tarnish (3A/3B), and corrosion (4A-4C). The results seen in Figure 3 represents a dielectric grease that did not protect the copper surface from corrosion and

Table 2
Images of Failing Tin-Copper and Nickel-Brass Panels after 720 hours exposure SAE J2334



Tin Plated Copper Coupons (Competitive PAO/Li Soap)



Nickel Plated Brass Coupons (Competitive PAO/Li Soap)



Figure 3
Dielectric grease that did not protect the copper surface from corrosion



Figure 4
Dielectric grease that was properly fortified to protect the copper surface from corrosion

is normally what one would see for a 3B result in the copper corrosion test that equates to dark tarnish described in the test method. The results seen in Figure 4, represent a dielectric grease that was properly fortified to protect the copper surface from corrosion and is typically what one would see for a 1A and 1B results on the corrosion scale. A dielectric grease that doesn't offer protection against copper corrosion puts electrical contacts and connectors at risk for failure which can result in component malfunctions for customers and product recalls for manufacturers.

Greases have different water resistance capabilities depending on the thickener chemistry utilized in the formulation. ASTM D-1264, is a typical water washout test used to determine a greases' resistance to water. In this test, a bearing is filled with a prescribed amount of grease and is inserted into a housing with specified clearances and rotated at 600 rpm while water, controlled at 79 +/- 1°C, is sprayed on the bearing at a rate of 5 ml/second. After, the system is dried to remove water from testing components and the amount of grease remaining is recorded. The data in Table 3 shows the water washout characteristics of commonly used dielectric greases.

As previously mentioned, fretting corrosion can be detrimental to an electrical system. Nye Lubricants developed a custom fretting test rig to simulate fretting conditions. To test for fretting protection, 2.8 mm APEX tin copper connectors were used with testing conditions of 100 µm stroke amplitude and 10 hertz frequency until a failure (100 mΩ increase in resistance over the baseline initial readings) occurred. When looking at electrical contacts or connectors if the upper metal coating has worn through to the base material as seen in Image 6, this indicates that the component is experiencing a wear problem making it susceptible to oxidation which ultimately will lead to signal loss and component failure. Image 5 represents a connector

Table 3
Water washout characteristics of commonly used dielectric greases

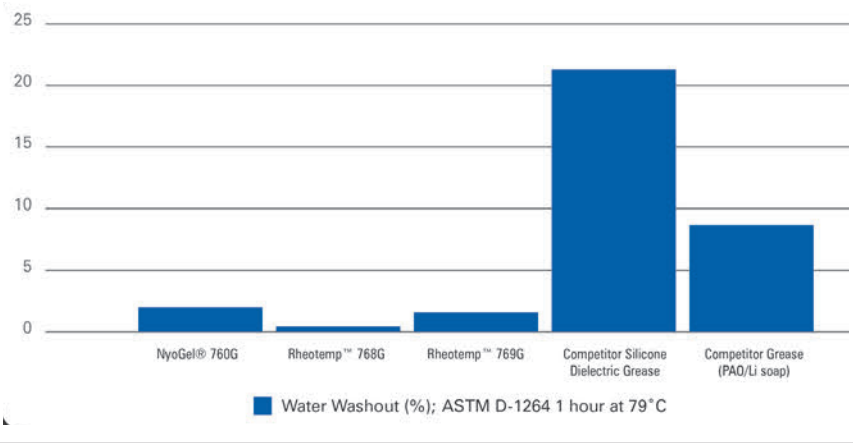




Figure 5
Upper metal coating worn through to base material indicates wear problem



Figure 6
Lubricated connector with dielectric grease additive that prevents fretting wear, preserving the layered coatings

that was lubricated with one of Nye's dielectric greases which contained an additive package that prevents fretting wear preserving the layered coatings on the contact to ensure the integrity of the electrical contact.

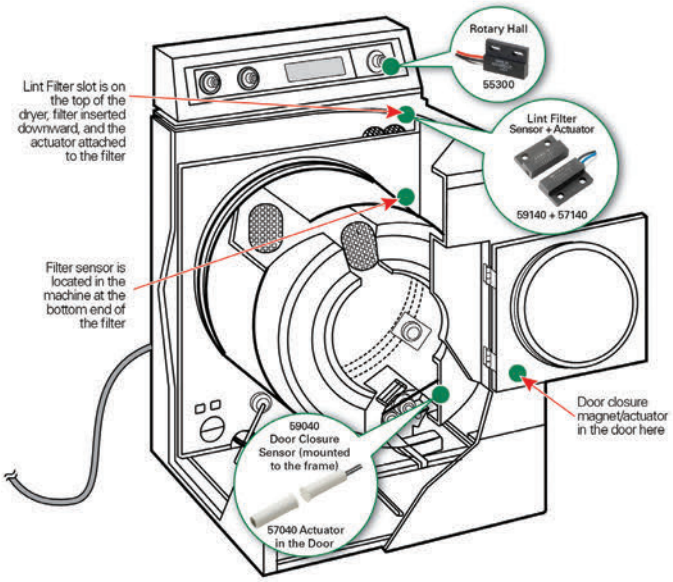
Improve Connector Life

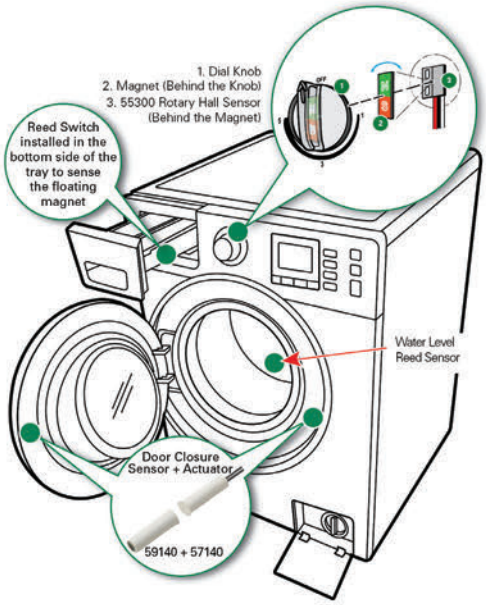
Applying a properly fortified dielectric grease during production ensures a solid connection for the life of the electronic contact which will help avoid costly warranty claims, avoid recalls, reduce safety risks, and improve component reliability. As connectors, electrical contacts, and electrical systems evolve and become more sensitive to resistance changes, dielectric lubricants must also progress to keep up with the demanding needs of these applications

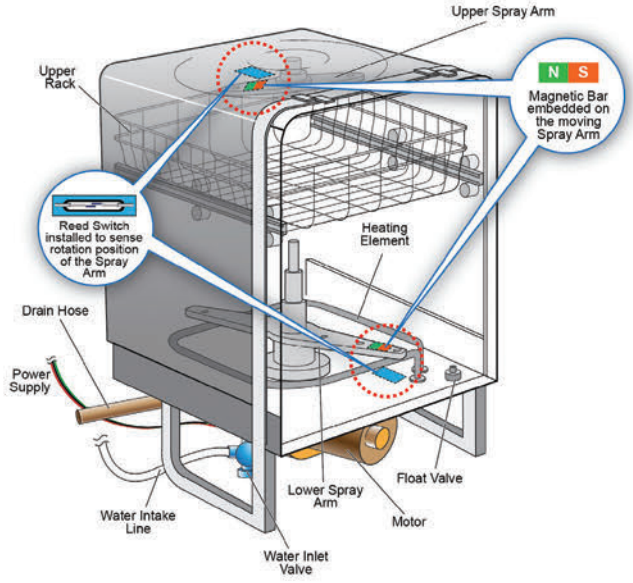
Nye's dielectric grease product line was carefully developed to protect against corrosion, have low water washout, reduce fretting wear, achieve excellent thermal stability, and seal the connector/contact from environmental factors to keep out water, dirt, and other elements that can lead to power failure. ●



Nicole St. Pierre *has been with Nye for 20 years. She focuses on growing Nye's research and development capabilities www.nyelubricants.com/connectors*







EIGHT CONSIDERATIONS

When Purchasing Custom Sensors For Your Next Appliance Design

BY RYAN SHEAHEN

For many purchasing professionals, sensors are just another type of component. Among these buyers, the choice of vendors is often based heavily on price and delivery. For the more discriminating buyer, however, a variety of other factors need to be weighed in the purchasing decision, many of which don't necessarily appear on the invoice.

Here are some questions that purchasing managers need to ask themselves and the engineers who specify components before placing an order.

Are the vendor and manufacturer the same organization?

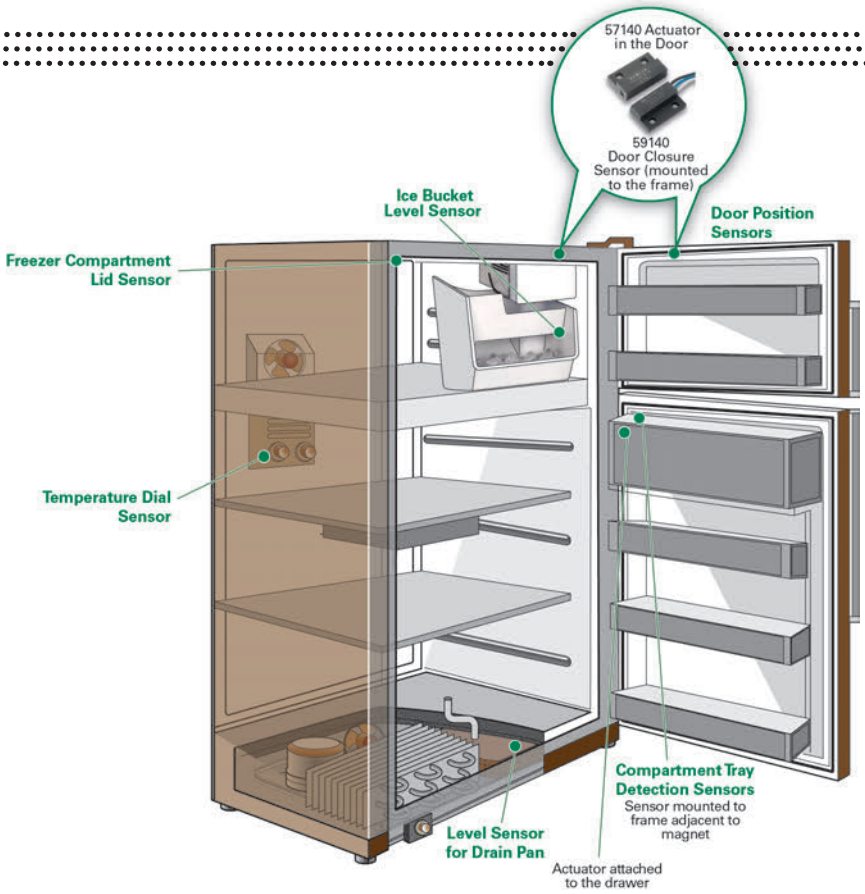
Not surprisingly, many organizations that sell a specific type of sensor don't actually manufacture the discrete component itself. A manufacturer will always have more control over the quality of the sensor sold than a buyer/reseller simply because the manufacturer has the ability to investigate the root cause of a quality problem. A buyer/reseller can only report a problem, not fix it. The manufacturer also has greater control than a buyer/reseller in terms of increasing production capacity to meet increased demand for a specific sensor.

Does the vendor offer a broad range of sensors that address the majority of your sensing requirements, both now and in the future?

Some manufacturers specialize in only a single type of sensor (Hall effect, magnetic, reed switches/sensors, temperature, etc.). However, sensor manufacturers that produce multiple sensor types are far more likely to have a broader range of up-to-date sensor R&D capabilities and the design personnel necessary to develop new or custom products.

What other kinds of components does a specific sensor supplier offer?

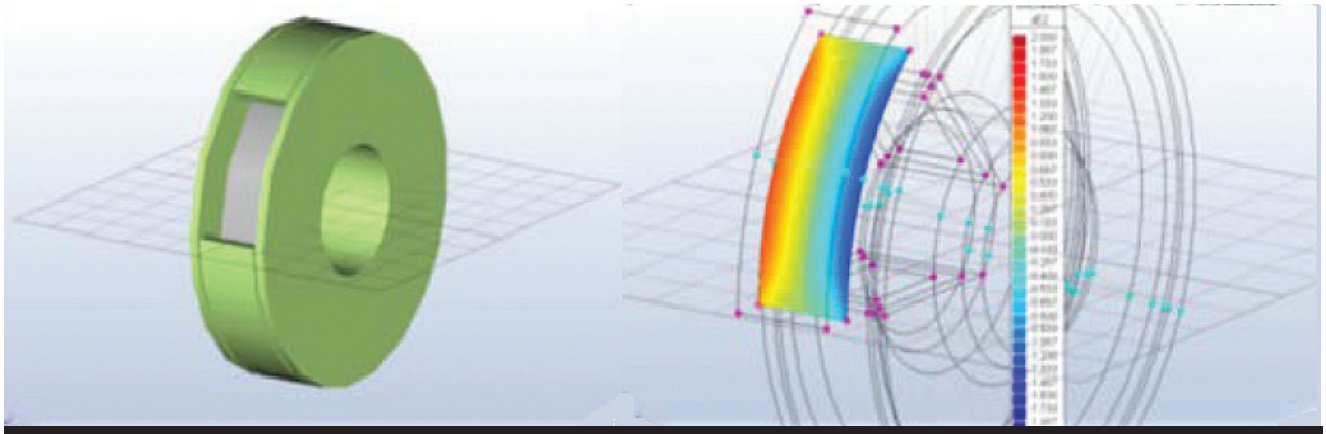
It's important to look beyond the specific sensor you are purchasing today to the rest of the supplier's component portfolio. For example, the appliances your company is manufacturing probably also require other electronic components like TVS diodes and arrays, GDTs, thyristors, varistors, fuses, switches, semiconductors, etc. Choosing a vendor capable of supplying a significant percentage of your company's purchased parts requirements would allow paring down the number of vendors you work with, which is always advantageous. Similarly, suppliers that can offer a broad portfolio are also likely to be able to offer you higher volume purchasing discounts than a vendor that only supplies a handful of parts.



In addition, a vendor with extensive portfolio range and a leading position in diverse markets gives customers an opportunity to offer new technologies, products and solutions to problems. The knowledge and experience the vendor develops gets passed along



Littelfuse custom sensor designers employ 3D CAD design tools to create a new design or modify existing standard product packages, such as adding connectors or changing wire size or length, as well as offering special reed sensitivities.

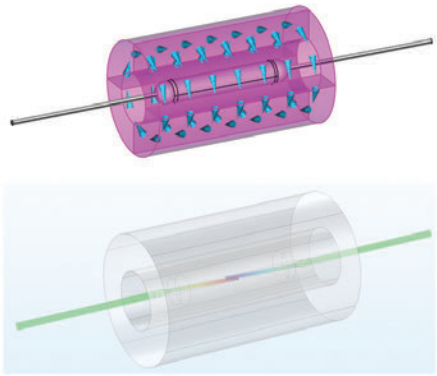


Littelfuse magnetic sensor developers use magnetic sensor simulation tools to gain a thorough understanding of a sensor's magnetic operating environment and project sensor performance under the full range of operating conditions. Simulation work like this makes it possible to consider design, manufacturing, performance, and environmental parameters and tolerances during the initial phases of a design. Using magnetic simulation often allows a variety of magnet and sensor configurations to be studied and analyzed in a much shorter time period than trying to physically assemble and test sensors.

to its customers so they can tackle complicated new projects.

Does the sensor supplier offer applications assistance to the engineers who specify sensors at your company?

Expert applications assistance provided by a sensor supplier can help your engineers make better specifying decisions faster and determine the optimal sensor for the job the first time. When engineers encounter a problem with a new sensor design, vendor applications personnel can help engineers determine if they are installing/using the sensor properly or if the part is simply unsuited for the application.



Magnetic sensor developers at Littelfuse also use multiphysics simulation packages to predict the mechanical deflection of reed blades from the magnetic field source, such as coils or permanent magnets. This allows for quick design of reed sensors for various customer projects with minimum material cost.

Does the supplier offer custom engineering and development capabilities to its customers?

If your company is a leader in innovative design, it might not be possible to find a standard sensor that suits a new application's requirements precisely. However, manufacturers with in-house customization capabilities can often modify one of their standard products relatively quickly and cost-effectively, such as by adding connectors or changing the wire gauge or length, offering various levels of sensitivity, custom lead forming and bending or modifications to bare reed switches.

If a minor modification isn't sufficient and the job would require a more significant design development project, look for sensor manufacturers with engineering capabilities like these:

- 3D CAD mechanical design services (Figure 2)
- Electronic circuitry design
- Magnetic simulation support analyzing feasibility of the design options (Figures 3 and 4)
- 3D mapping of magnetic actuation of the sensor
- Rapid prototyping and quick-turn concept parts including 3D printed parts
- Reliability/validation testing options

Once engineering is complete, producing these custom designs requires a broad range of manufacturing capabilities, including plastic assembly (injection molding, ultrasonic welding, heat staking), encapsulation (over-molding, potting), wire hardness and termination, assembly, tape & reel packaging, circuit board assembly and testing, and final testing.

Often, if the manufacturer can count on producing the customized sensor in sufficient quantities over an extended period, these types of design assistance and modifications can be factored into the product pricing.

Can the sensor supplier guarantee sufficient capacity to handle the largest orders reliably?

Unlike sensor manufacturers, who have both the resources and the motivation to invest in capacity expansion to meet demand and

keep delivery lead times reasonable, buyer/resellers are at the mercy of their own suppliers. That can make a critical difference when demand for a specific sensor surges quickly.

For magnetic sensors, does the sensor supplier also provide the magnetic actuator?

It is always recommended that the sensor supplier review the magnetic actuator that the customer selects. Together, the sensor and actuator form a "magnetic circuit" that must work together within the application. Don't attempt to buy a sensor from one supplier and an actuator from another one, without at least reviewing your choice of actuator with the sensor supplier.

Is the sensor manufacturer involved in industrial standards development efforts?

Unlike buyer/resellers, sensor manufacturers often encourage their personnel to contribute to the development of new industry standards for safety and performance through organizations like UL and ATEX. Not only does this help suppliers stay on the leading edge of new technical developments, but they can help direct the next generation of sensor designs.

Conclusion

Pricing and delivery will always be important factors in purchasing decisions, but a more comprehensive perspective on supplier selection can often save more money and reduce buying headaches in the longer term.



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Making Sense of Sensors

A HALL EFFECT DEVICE is a semiconductor-based integrated circuit with Hall plates that respond to magnetic fields. Additional circuitry is required for power supply and signal conditioning, temperature compensation and EMC/ESD protection. Hall effect devices provide digital or analog output signals that are used for proximity and continuous rotary or linear positioning. Unlike a reed switch, a Hall effect device contains active circuitry, so it draws a small amount of current at all times.

REED SWITCHES have two ferromagnetic blades (reeds) hermetically sealed within a tubular glass envelope. The contacts on each reed blade have a thin layer of precious metal deposited on them. The glass envelope is filled with nitrogen gas to eliminate oxygen and prevent contact oxidation. Reed switches can be activated by either a permanent magnet or an electromagnet. The reed switch and magnetic field combination is referred to as the "magnetic circuit." The relative stiffness of the reed blades and the small gap and overlap between the two contacts controls the switch's sensitivity, that is, the amount of magnetic field required to actuate the contact into an open or closed mode. Unlike an integrated circuit, a reed switch requires no power to operate, which makes it a very popular choice for battery-powered applications.

Although a reed switch can easily be mounted on circuit boards, for mechanical system applications like a door security sensor, greater protection is essential. **REED SENSORS** are reed switches packaged inside a housing to simplify mounting/connection and enhance environmental protection. Reed sensors offer protection from mechanical stress by shielding the reed switch's glass envelope.

A REED RELAY combines a reed switch with a copper coil. Like other relays, this provides galvanic isolation between the coil input and the controlled contact(s). However, because of the reed switch's small size and magnetic efficiency, the power required to drive the coil is lower than for most other relay types. Other advantages include high insulation resistance, low contact resistance and long contact life. Reed relays are used in many applications, including automotive, test equipment, security, medical and process control equipment.

THERMISTORS are thermally sensitive resistors that exhibit a large, predictable and precise change in electrical resistance when subjected to a corresponding change in body temperature. Negative Temperature Coefficient (NTC) thermistors exhibit a decrease in electrical resistance when subjected to an increase in body temperature and Positive Temperature Coefficient (PTC) thermistors exhibit an increase in electrical resistance when subjected to an increase in body temperature. Their highly predictable characteristics and excellent long-term stability make thermistors ideal for temperature measurement and control applications.

PLATINUM RESISTANCE TEMPERATURE DETECTORS (Pt-RTDs) are temperature sensors with a positive, predictable and nearly linear change in resistance when subjected to a corresponding change in their body temperature. Platinum RTDs will maintain a significant and uniform rate of range of resistance vs. temperature over an extended operating temperature range, which is ideal for digital measurement and control applications.



Seeking improvements in the manufacturing process and to increase the thermal efficiency in refrigerators, the appliance industries extensively used aluminum tapes to replace mechanical fasteners to attach tubes inside refrigerators. In many cases however, there are not many studies clearly showing the benefits of using tapes and having many tape options may cause doubts as to which one to choose. Nowadays there are several types of tapes, including options that can be applied automatically, without tearing the aluminum foil, leading to more efficiency in the production line.

The Benefits of Aluminum Foil Tapes in Refrigeration Systems

BY BARBARA DE CASTRO NUNES & BRUNA MEDICI AMORIM BONON

The operation logics of the main current cooling systems can be understood by studying the operation system of a common household refrigerator, also known as a mechanical steam compression system (Figure 1). In the refrigeration cycle, there are six basic components: refrigerant gas, compressor, condensers, evaporators (inside the freezer), capillary tube and polyurethane foam [1].

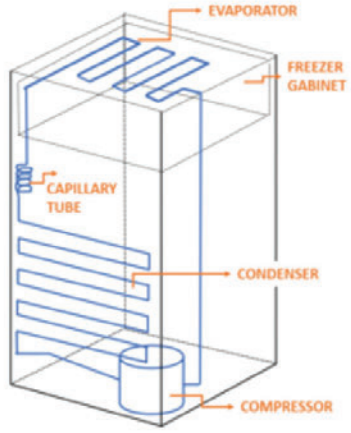
Two types of condensers are commonly used in small-to-medium sized domestic refrigerators. In the first type, condenser tubes with welded wires (which act as fins) are located outside the cabinet, known as external condenser. In the second type the condenser tubes are attached to the inner surface of the outer wall and are not visible from outside, known as a ''skin condenser''.

The tubes (aluminum or copper tubes) are a fundamental part of the refrigeration system. In wall-and-tube type condensers the heat transfer takes place from the refrigerant to the tube, from where it is rejected to ambient through convection and radiation.

It is very important to ensure that the tubes are in contact with the wall of the refrigerator before injecting the polyurethane (PU) so that it will not be able to enter between the tube and the wall, which would result in failure of the heat exchange system, because in this case the PU would isolate the serpentines.

In the past, the tube fastening was achieved by using metal clamps (Figure 2), welded to the refrigerator walls. This attachment process was

Figure 1: Refrigeration System
How the six components interact



1. The refrigerant gas is a substance which, circulating within a closed circuit, is capable of removing heat from an environment while vaporizing at low pressure

2. The compressor pulls the refrigerant gas (low pressure) and compresses it towards the wire tube condenser (high pressure and high temperature).

3. Through the condenser and its fins, the refrigerant gas at high temperature coming from the compressor, perform a thermal exchange with the external environment, releasing the heat absorbed in the evaporator and in the compression process.

4. After exiting the condenser, the gas reaches the capillary tube , which is a small diameter copper tube. Its function is to lower pressure and temperature of the refrigerant gas.

5. The gas then enters the fin tube evaporator where heat is absorbed from the surface of the tube, resulting in the transformation of subcooled liquid into saturated low pressure vapor. This effect results in lowering the temperature of the internal environment of the refrigerator.

6. After the assembly of the system, liquid polyurethane is injected, which expands forming polyurethane foam. This foam is the thermal insulation of the system.

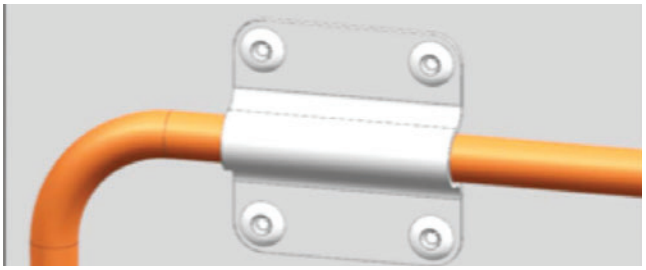


Figure 2: Mechanical fastening of the tube



Figure 3: Tube attachment using aluminum tapes

slow, required skilled labor to perform the welds and many times needed an extra finishing work to remove marks on the walls of the refrigerator caused by welding. Another point to consider is that this system could leave voids between the tube and the wall of the refrigerator. This could reduce thermal exchange and increase the risk of the polyurethane mistakenly isolating the tube-wall system.

Focusing on the improvement of efficiency of the cooling system, many industries have been seeking new solutions. Therefore, the aluminum tapes were developed and have been used to attach tubes (Figure 3). The tape's purpose is to replace the welded clamps, which works as a fin, optimizing the thermal transfer while covering 100% of the tube avoiding PU to enter between the tube and refrigerator wall.

The open literature is very scarce regarding the influence of tapes on the evaporator and condenser fastening systems for domestic refrigerators. It is common to find studies, such as Bansal and Chin (2002), presenting a complete analysis of the design aspects of skin condensers for domestic refrigerators, where they considered the heat transfer inside the tubes, through the tubes walls and through the wall of the refrigerator. However, the effect of aluminum tape on heat transfer was not evaluated or studied.

Nevertheless, new studies started to look at the tape more carefully to understand its impact on the system. Gupta and Gopal (2008) show that the aluminum tape used to bond the condenser tube to the outer refrigerator wall plays a significant role in the heat transfer from the condenser to the environment. They have developed a mathematical model to measure the thermal transfer of a skin condenser which includes the important effect of aluminum tape.

Aluminum Tapes

3M has a wide portfolio of aluminum tapes for the appliance market. The main difference between them is the aluminum backing thickness and the type of adhesive used. This type of tape involves different technological platforms such as adhesives, films, lamination and thermal conductivity properties.

It is known that there is a direct relation between the aluminum thickness of the tape and the heat conduction, while the adhesive performance impacts the initial tack and also to the durability of the bonding. Some of the 3M tapes for tube attachment in refrigerators are expressed in Table 1 [6].

Tape application has always been a manual process, however, there is a need to increase automated systems in refrigerator manufacturing processes to increase productivity and minimize waste.

Conventional aluminum tapes are not suitable for automated application, because the thin aluminum foil tears when tensioned. With the increasing

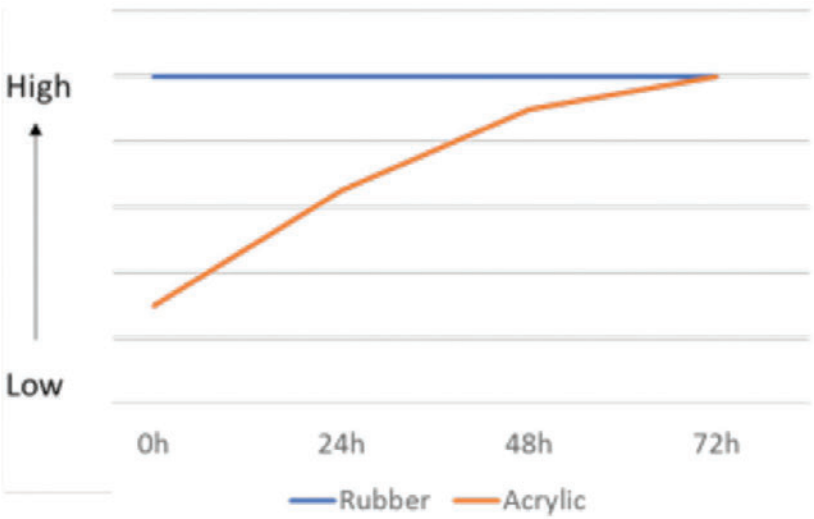
Table 1: 3M Aluminum Tapes For Refrigerator Tube Bonding

Product Code	Aluminum Thickness	Total Tape Thickness	Adhesive
419	0.035 mm	0.070 mm	Rubber
423	0.050 mm	0.085 mm	Acrylic
425	0.070 mm	0.116 mm	Acrylic
438	0.127 mm	0.182 mm	Acrylic

Table 2: 3M Aluminum Foil Reinforced Tapes For Refrigerator Tube Bonding

Product Code	Aluminum Thickness	Total Tape Thickness	Adhesive	Reinforced Backing
1470	0.035 mm	0.110 mm	Rubber	Polypropylene
1452	0.025 mm	0.120 mm	Acrylic	Polypropylene

Figure 4: General Adhesion Profile
For Rubber and Acrylic adhesives over time
(after tape has been applied in substrate)



demand for automatic processes, 3M has developed aluminum tapes with polymer backing, which allow their application to be fully automated. These tapes are also available in long rolls up to 400 m, reducing set-up time and increasing productivity. These tapes are presented in Table 2.

The first relevant feature of a metal tape is that the adhesive needs to be a PSA (Pressure Sensitive Adhesive:. Dahlquist criterion - energy storage modulus G '<3x105 Pa) [7]. These adhesives do not require activation factors like water, heat or solvents; however they are activated by pressure during the application.

As shown in Table 1, it is possible to use adhesives with rubber-based or acrylic-based formulations, among others. The choice of the type of adhesive is related to the characteristics required for the application, once each adhesive has unique characteristics, such as initial or final adhesion, durability, stability, UV resistance, etc. [5]. If a high tack is required, it is recommended to use a rubber based adhesive with a tackifier in its composition.

However, it is worth mentioning that rubber-based formulations have less durability when compared to acrylic ones, since rubber polymer chains have double bonds susceptible to degradation by factors such as heat, light and oxygen. On the other hand, rubber formulations have a lower cost and may be a good option in cases where the application will be temporary. Finally, it can be noted that acrylic adhesives have low initial adhesion but increases over time, while rubber base adhesives have a high initial adhesion that remains over time[5] (Figure 4)

Aluminum tapes and their contribution to thermal conductivity in refrigerators

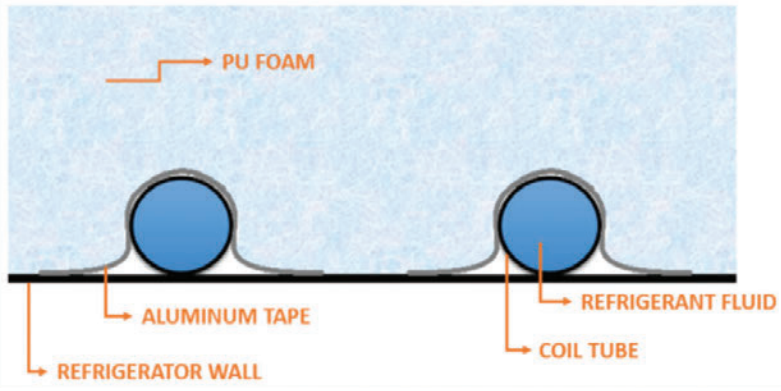
Usually in the refrigeration market, metal foil tapes are used to attach tubes, channels or coils expanding the area of thermal exchange. In the case of application in coils, the increase of the thermal efficiency is due to the system working as a secondary evaporator.

It is important to take some specific cares during the application of aluminum tape to tubes and cooling boxes to ensure that they are free of contaminants such as dust, oils, and lubricants that could decrease tape adhesion. In addition, it is necessary to check if the refrigerator box has paint that could act as an insulator decreasing the thermal conduction thus affecting the system performance.

For a better understanding, let us consider in our analysis Figure 5 which shows the transversal view of a capillary tube fixed to a wall with an aluminum tape.

In the study by Gupta and Gopal (2008), the model considers that the aluminum tape acts as a fin and the thermal insulation made by the

Figure 5: Transversal View
showing the application of the aluminum tape over the refrigerant tube



polyurethane foam is 100% efficient in the system, with no heat transfer in the foam [4].

Normally, the aluminum tapes used to attach the tubes to the cooling boxes have acrylic adhesive and have a thermal contact resistance of magnitude 7 x 10-5 m^2 K / W. For the most part, when compared to the system's thermal resistances, such as heat transfer in the condenser tube (R ~ 10-3 m^2 K / W) and heat transfer in ambient air (R ~ 10-1 m^2 K / W), resistance of the adhesive tape can be disregarded [4].

In this analysis, we will consider the operating system of a condenser (heat exchange with the external environment). In this case, the refrigerant fluid, passing through the capillary tube is hot. The heat flow will then be as follows: heat will flow from the fluid to the adhesive tape, and in the sequence the heat will be transmitted to the wall of the refrigerator box, which in turn will dissipate it to the external environment. In this way, the heat will be removed from the system.

An important note to point out is that the thickness of the aluminum on the backing of the tape (or other metal) directly influences the rate of heat exchange in the system.

To demonstrate this property, an experiment was conducted in 3M Brazil's laboratory where a sample with aluminum foil of 25μ (1452), two samples with aluminum foil of 35μ (1470 and 419) and a sample of tape with only plastic backing, without metallic parts (5063PE) were subjected to a heat transfer process. In order to identify the differences in temperature, a temperature-sensitive film was used, where the hottest zones are highlighted with green and blue colors.

In Figure 6 we can see that the blue regions are where the temperatures are the highest. In this way, we can observe that the tapes with aluminum foil of higher thickness presented higher temperatures in this test (tapes 419 and 1470). It is also important to note that there was practically no heat spreading where the 5063PE tape was used.

In general, aluminum foil tapes can greatly contribute to the performance of thermal exchange systems and tests are required to determine the best tape thickness and width for each system.

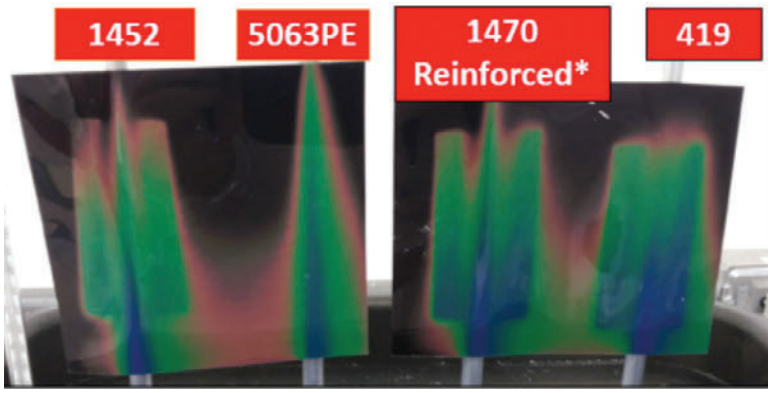
Conclusion

There are benefits in using aluminum tapes in refrigeration systems, for the fixation of evaporator and condenser coils, where the tape acts as a fin and improves the thermal efficiency of the system. The thickness and width of the tape are factors to be considered in the assembly, as they have direct impact on the performance of the refrigerator.

Another important role of aluminum tape is to prevent the insulation material (usually polyurethane foam) from sticking between the coils and the wall of the cooler box during the injection process of the polyurethane foam, which results in a deficiency in the system.

Today there are several options of metal foil tapes, with different types of adhesives, backings and metal thicknesses. Even in automated systems, aluminum tapes can be used due to the new tape structures with reinforced backing. ●

Figure 6: Scheme
Demonstrating the performance in transmitting the heat of the 3M portfolio tapes



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Sheet metal is one of the most versatile materials and processes in the world today. Designers and engineers develop components as small as washers and as large as entire roofs.

Designing for Sheet Metal Fabrication

BY JAMIE WHITE

Sheet metal is one of the most versatile materials in the manufacturing industry. It's made from steel, aluminum, brass, copper, tin, nickel, titanium, or precious metals. It ranges in thickness from wispy leaf through light foil to heavy plate. It takes a variety of forms: plain flat sheets, embossed, etched, ribbed, corrugated, and perforated. And its uses expand across many different industries including transportation, aerospace, appliance manufacturing, consumer electronics, industrial furniture, machinery, and more.

Why Sheet Metal?

Depending on the application, sheet metal offers advantages, not just over non-metal alternatives but over other types of metal fabrication as well. Compared to machining, it generally has a significantly lower material cost.

Rather than starting with a block of material, much of which will be machined away, sheet metal lets you buy what you need and use what you need. The remainder of a metal sheet is still usable, while swarf—the shavings removed in machining—must be recycled.

As with many modern fabrication techniques, sheet metal manufacturing can be automated and parts produced directly from CAD models. The technology uses a variety of materials and a range of processes for shaping finished components and products. Perhaps most important, in a world of mass production, sheet metal fabrication is highly scalable. While setup for the first piece can be costly, the price per piece drops quickly as the volume increases. This is, of course, true of many processes, but cost-per-piece for sheet metal generally drops more steeply than for a subtractive process like machining.

How is Sheet Metal Being Used?

Sheet metal is cut, stamped, punched, sheared, formed, bent, welded, rolled, riveted, drilled, tapped, and machined. Hardware can be inserted into sheet metal components. The components can be brushed, plated, anodized, powder coated, spray painted, silk screened, or otherwise marked. And, of course, parts can be riveted, screwed, or welded into complex assemblies.

Like most other technologies today, sheet metal fabrication is evolving. Materials, equipment, and tooling have become more specialized than ever before. To take full advantage of sheet metal, it is critical that you leverage the correct supplier and method of manufacturing for your parts and their application. Along these lines, this white paper explores key components of sheet metal fabrication:

A punch press is especially effective for cutting relatively simpler parts that would otherwise be cut with a laser or waterjet.



- Materials
- Manufacturing processes
- Design considerations
- Finishing options

What Technologies and Techniques are used to Shape Metal Parts?

Sheet metal, by definition, starts out flat but can be shaped in many different ways to meet many different requirements. While this paper focuses on the technologies that shape sheet metal by bending it along a single axis, a variety of techniques exist for shaping the material into multi-axis forms that are not made up of flat planes or bent along a single axis. These include hot and cold forming techniques of deep drawing, hydroforming, spinning, and stamping. These are the kind of processes that create the body panels for modern vehicles, complex formed objects like metal sinks, and aluminum beverage cans. In many cases these techniques are iterative, shaping the metal by repeating the process several times to change the shape of the metal in increments.

Cold-forming processes addressed here are: **Cutting**

- ***Shearing*** was long the primary way to cut sheet steel but has now been replaced by faster, more precise methods.
- ***A punch press*** can be used to punch and die sets to cut metal. This is particularly effective for cutting relatively simpler parts than would be cut with a laser or waterjet. Because it can operate at hundreds of strokes per minute, a punch press can make suitable parts quickly. Punching can also be used to make holes or other cutouts in parts. Combining punch and laser cutting allows the creation of a complex flat pattern with size-limited stamped features.
- ***CNC laser cutting*** works with jets of oxygen, nitrogen, helium, or carbon dioxide to burn away metal and produce a clean, finished edge. The speed of this process differs with the thickness of the metal, but the cut can be quite complex and, at tolerances of +/- 0.005 in. or better, is quite precise. And because there is no contact, the tool does not wear out the way a mechanical cutter does. Two types of lasers are used in sheet metal fabrication. Fiber-optic laser are used for thinner and more reflective materials to deliver precise cuts. Multi-gas or CO_2 lasers are more powerful and suitable for thicker gauges.
- ***Photochemical machining*** is a process of controlled etching using CAD-generated stencils to leave a pattern that is chemically activated to remove unwanted metal.

Bending

Most metals can be bent along a straight axis using a variety of presses. The shapes of bends can range from gentle curves, like those along the vertical axis of a steel can, to sharp corners at angles above, below, or right at 90 degrees. Press brakes are used to create these relatively sharp bends. Rolling and forming methods produce open or closed single-axis curves in a continuous bending operation.

Hemming

This involves rolling the edge of a metal shape to provide a smoother, stronger edge. Hems can be open, leaving an air space within the bend, or closed, in which the folded metal is pressed tight against itself. Curling produces a rounded edge to a piece of metal, also called a barrel hem. This can be used to simply eliminate the sharp edge or to serve a specific operational function as in the case of a door hinge where it holds the pin around which the hinge rotates.

What Types of Sheet Metal Are There?

Varied metals and metal alloys can be formed into sheets and used to fabricate sheet metal parts. The choice of materials depends on the requirements of the application, and factors in material selection include formability, weldability, corrosion resistance, strength, weight, and cost. Popular sheet metal materials include:

Stainless Steel

Two families of stainless steel—standard and spring-like—are used in sheet metal fabrication.

- ***Standard stainless*** can be non-magnetic—any of the 300 series steels—and is the most commonly used type of stainless. It does not require hot work or other stress relief during manufacturing. Grade 316 is the most corrosion-resistant of the stainless steel grades and maintains its

Caliper measurements for bend accuracy are part of the entire sheet metal quality process.



strength at high temperatures. Grade 304 is the most widely used and, while it is somewhat less corrosion-resistant, offers good formability and weldability.

• ***Standard type magnetic stainless*** for sheet metal fabrication is the 400 series. Grade 410 offers less corrosion resistance but is heat treatable. Grade 430 is an inexpensive alternative to the other stainless steel options and is used in applications where corrosion resistance is not a major requirement such as brush-finished appliance surfaces. Because these materials tend toward elastic—rather than plastic—deformation, they must be over bent to achieve final form.

• ***Spring-like steels*** will work-harden quickly and must be heated to relieve stresses when being formed. Grades include 301, 17-4, 1095, and 1075. Spring-like stainless typically requires specialized equipment and processes and must be significantly over bent to achieve final form.

Cold rolled steel (CRS). The process of cold rolling steel is used to smooth the finish of hot rolled steel as well as to hold a tighter tolerance when forming. CRS is available in 1008 and 1018 alloys.

Pre-plated steel

This sheet metal material is either hot-dip galvanized steel or galvanealed steel, which is galvanized and then annealed.

Aluminum

A moderately priced material, aluminum has a range of characteristics across several grades to meet application requirements. Grade 1100 offers relatively low strength but is chemical and weather resistant, and weldable and ductile, allowing deep drawing. Grade 3003 is stronger and formable, weldable, corrosion-resistant, and affordable. Grade 5052 is significantly stronger while still formable, weldable, and corrosion-resistant. Grade 6061 is a structural alloy that is corrosion-resistant and strong, but not formable. It is weldable, though it sacrifices some strength when welded.

Copper/Brass

Designers and engineers who want a "red" metal typically choose electrolytically tough pitch (ETP) copper, either C110 or C101. In less frequent cases, cartridge brass is used as an alternative.

Design Considerations for Sheet Metal Fabrication?

Sheet metal fabrication is a non-additive, non-subtractive process. It begins with flat material and, by definition, maintains constant material thickness throughout a part. In some cases, areas of a part can be selectively thickened by welding multiple metal sheets together, but this is a costly and uncommon practice.

Designing for sheet metal fabrication has its own criteria, which differ from those of other production processes. The more that's known early in the design phases about a part's features and functions, the sooner a manufacturable design will finalized. If, however a design has problematic features, a manufacturing supplier should be able to point those out and suggest ways of addressing them. In some cases, the supplier may even have design analysis software that can quickly highlight issues for design improvement. Some design consideration:

• Sheet metal fabrication is most economical when it uses configurations of "universal" tools rather than part-specific tooling. If a single part becomes too complex, consider welding or riveting together parts that can be made using universal tools.

• Because bends stretch the metal, features must stand away from bends to avoid distortion. A useful convention is 4T—four times the material thickness.

• A press brake creates a bend by pressing sheet metal into a die with a linear punch, so design does not allow the creation of closed geometry.

• Sheet metal tolerances are far more generous than machining or 3D printing tolerances. Factors affecting tolerances include material thickness, machines used, and number of steps in part production. Suppliers will typically provide detailed information on tolerances.

• A uniform bend radius such as 0.030 in. (industry standard) should be used across a single part to reduce the number of machine setups and accelerate production.

• Where possible, maintain a standard distance of four times the material thickness from bend to edge. This will eliminate the need to remove excess material required to make the bend.

• Welding thin materials can lead to cracking or warping. Other assembly methods are preferable.

• When using PEM hardware, always consider the minimum requirements of the manufacturer for installation locations and material thickness.

How to Finish Sheet Metal Parts?

Sheet metal can be finished in several ways and for different reasons. There are finishes that protect vulnerable materials from rust or corrosion and others that are applied for aesthetic reasons. In some cases finishing serves both purposes. Some treatments are simply alterations to the metal surface itself; others consist of another material or process that is applied to the metal. Finishing treatments include:

• ***Sand blasting***, which consists of shooting jets of abrasive material at the metal to roughen and clean the surface. Sandblasting is typically used on stainless and carbon steel and is often used as a preliminary step before painting to remove impurities and improve adhesion.

• ***Brushing*** is similar to sandblasting in function, but uses abrasive brushes to clean and score the metal surface. It can serve as a final finish on materials like aluminum and stainless steel and is commonly used as an appliance finish.

• ***Polishing*** yields a glossy surface and is used on metals like stainless steel, aluminum, and copper. It can serve as the final finish or as preparation for other finishing processes such as plating. It is generally unsuitable for metals that are to be painted because it does not enhance adhesion.

• ***Powder coating electrostatically*** applies a dry powder—typically a thermoplastic or thermoset polymer—to the metal surface and then cures it with heat. The process results in surface that is more durable than conventional paint but may not have paint's aesthetic qualities.

• ***Plating*** can be done electrolytically or electroless for a various purposes. It can inhibit corrosion, improve solderability, harden a surface, prevent wear, reduce friction, or aid paint adhesion. Plating processes for sheet metal include:

– ***Passivation***, a cleaning process that prevents corrosion in stainless steels by removing free irons from the surface of the material

– ***Chromate coating***, a conductive coating used on aluminum to protect against corrosion.

– ***Anodizing***, an electrochemical process used on aluminum and other non-ferrous metals that provides insulation and prevents corrosion

– ***Zinc***, a self-sacrificing anti-corrosion coating (applied by galvanizing or galvanealing) for steels and is often combined with a Chromate coating over the zinc

– ***Nickel***, often a cosmetic coating and can serve as a substrate for plating processes that cannot adhere to a given metal

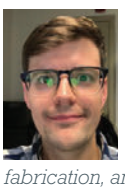
– ***Tin***, a solderable, conductive coating

Final Thoughts on Choosing Sheet Metal Fabrication?

Deciding to use—or simply consider—sheet metal for an application is the first step in a process. The process begins, of course, with function, which in turn dictates design. Choosing a material and gauge are critical steps that involve balancing factors like strength, weight, and cost. This is not a simple process, but it can be streamlined with the use of CAD models and finite element analysis (FEA) tools. The real test, however, is prototyping.

While today's engineering tools are powerful, it is only when you can see and handle a part that it's known whether the design meets expectations. Is it strong enough? Light enough? Does it look, feel, and balance the way it should? Does it impinge on other components? Even relatively simple components benefit from a real-world tryout before committing to hundreds or thousands of parts. In some cases, it may take several prototype iterations to get the sheet metal part right, in which case the speed with which parts are produced and tested becomes a major factor in speed to market.

But even once a design has been created, prototyped, and tested, there can be many options for turning small quantities of prototypes into low-volume, end-use production parts. The same part can often be produced by several different methods at different costs. Choosing would be easy if all metal shops offered the same range of capabilities. Unfortunately they don't, so it makes sense to seek quotes from multiple suppliers as each will bring its own expertise and capabilities. ●



Jamie White *is the associate product manager for sheet metal at Protolabs. White has more than 5 years of experience in rapid prototyping, sheet metal fabrication, and digital manufacturing. www.protolabs.com*

Vitrek's V7X Hipot Tester is well-suited to the requirements of electrical safety production testing.





Vitrek's 964i offers automated multi-conductor, multi-point hipot testing.

Picking the Right Hipot Tester for the Job

BY KEVIN CLARK, VITREK INC.

Hipot testers offer a range of capabilities starting with dielectric withstand and insulation resistance testing but also, in many instances, providing accurate low-resistance measurements and low-resistance/high-current outputs to test ground resistance and ground bond integrity. Selecting the right one for your application will ultimately save both time and expense in performing these essential tests.

Product Safety Certification

Before getting into the individual functions, it is important to point out that hipot testing is a generic term. Actual testing will require meeting different specifications, depending upon where in the world the product will be sold and used. The details of what constitutes a certified product is dependent upon a daunting number (hundreds) of safety standards and the region of the world where the device will be sold and used. Standards setting organizations include: EN / IEC (European), UL (US), CSA (Canada, CCC (China), JEIDA / MITI (Japan)

Manufacturers must submit samples of their products to recognized certification agencies. Nationally Recognized Certification Laboratories (NRTLs) include UL, VDE, FM, ETL and others. The agency certification process is conducted to confirm compliance with the relevant standard(s).

It is vitally important that your selection of hipot tester is capable of being set up to perform testing to meet the relevant standards.

Periodic inspection and calibration of test equipment is a standard requirement to maintain NRTL certification. Agency inspection will include check of hipot instrument calibration certification. This "cal cert" is typically required on an annual basis. (UL and other NRTLs require compliance certification with ISO17025.) Another common requirement prescribed by most NRTLs is a daily functional test of the hipot equipment.

Dielectric Withstand – Hipot

The basic hipot test applies a high voltage from the conductors to the chassis of the device-under-test (DUT). This test is often referred to as "dielectric" or "voltage" withstand. Its purpose is to confirm that the insulation and isolation of the non-conducting surfaces from the operating voltage is sufficient to avoid a shock hazard. The typical specification for this test is: 2 x (normal operating voltage) + 1000V.

Both AC and DC hipot tests are possible and, in general, the test should use the same type of voltage as it would be during normal operation. However, if a DC hipot test is used on an AC circuit, the hipot voltage should be two times the peak (2 x 1.4 x RMS) + 1000V.

Depending on the applicable standard, units pass this test if either:

- The leakage current measured is less than the maximum allowable current.
- No breakdown occurs, i.e., no sudden and uncontrolled flow of current.

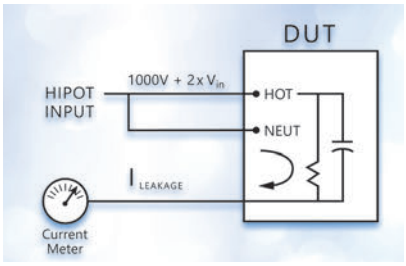
For double-insulated products, higher voltages will often be specified in the test standard. In addition, this class of device typically requires special fixturing to connect the non-conductive outer shell to a conductive element.

Defects that are often detected with the hipot test include contamination (dirt, debris) and lack of proper spacing (creepage and clearance) of components. Creepage is measured across surfaces, clearance is the

The Vitrek 952i is representative of the highest performance hipot testers featuring up to 40A ground bond capability and 4-wire tera-ohm insulation resistance measurement capability.



air gap between components. Contamination would likely cause an unacceptable level of leakage current. Clearance problems could result in breakdown.



Hipot is applied to both conductors and leakage is measured in return circuit through the ground connection

Desirable Dielectric Withstand Test Features: **Adjustable maximum output voltage**

- 5KV is adequate for many applications
- Higher voltages (up to 30KV) may be required
- AC and DC outputs
- Excellent regulation – both line and load
- Controllable ramp rates, dwell times and discharge features
- Phase angle measurement of leakage current – capacitive coupling detection
- Some standards allow for in-phase and quadrature current to be measured separately. Leakage current due to capacitive coupling may not be a safety concern

Min/max pass/fail current limits

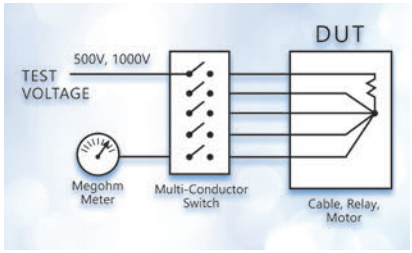
- Separate limits during ramp

Programmable multichannel testing

Insulation Resistance

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

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



Voltage is applied to one conductor at a time while adjacent conductors are bundled. Resistance is calculated based on leakage current.

Desirable Insulation Resistance Test Features :

- Wide range of selectable test voltages
- Accurate/repeatable high-resistance measurement
- Programmable high-voltage switching accessory
- Multichannel programmable testing
- "Pass" on steady and Increasing voltage

Ground Continuity

Where ground continuity measures the resistance of the safety ground connection, the ground bond test assures the integrity of the connection. Using the same test setup, a high current is passed through the circuit. If the ground bond is solid, the current passes without a change in resistance. If weak, the resistive heating of the current would induce a failure of the bond.

Desirable Ground Bond Test Features:

- Accurate high current source
- Programmable test currents and test times
- Plug adaptor accessory to speed testing
- 4-wire milliohm meter - providing a Kelvin connection for highly accurate low resistance measurements.

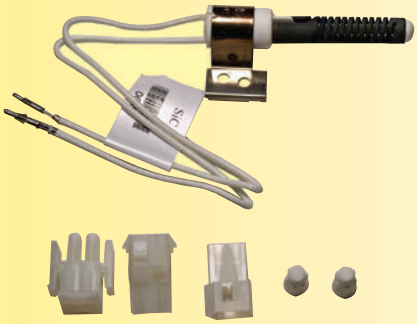
Conclusion

Electrical safety testing is a universal requirement for electrical and electronic equipment. Testing to the specific regional requirements can be a daunting task that is simplified by the programmable features and functionality of advanced hipot testers. Reviewing the desirable features of testers, based on the actual testing requirements, can and will result in more efficient and reliable testing. ●

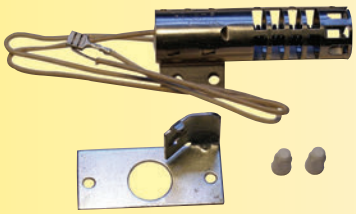
For more information visit **www.vitrek.com**

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