# APPLIANCE & HVAC REPORT

Reaching Design Engineers at the OEM Level

January 2021

VOLUME 3 ➢ NUMBER 1

**9 FEATURES COVERING**

ECOFRIENDLY
DISINFECTION
FORCE
MOTORS
PSAs
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STANDARDS
TUBING
TRENDS

## NEWS BEAT

**PEOPLE**
**COMPANY NEWS**
**TRADE SHOWS**

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# Welcome to 2021



Lets hope and pray 2021 its better than 2020. Hard to believe it could be worse.

This is the first of our four quarterly issues. Each issue will come out the first month of each, normally within the first week or two of the month.

As with many events worldwide the 2021 AHR show was cancelled. Scheduled for Chicago, it is bypassing the Windy City next year and will be in Las Vegas in 2022.

This leads to my question...do we need an annual AHR? Would every other year work for exhibitors and attendees alike?

Don't get me wrong...I have been to probably more than 100 in my rather checkered career. And for the most part I liked going to them, as there is no better way to meet with many people at one time.

But we are living in a different time with new technologies and new ways of reaching others. Zoom calls are now in vogue...so simple to use. And free. Plus email, texting and cell phones all make connecting easier than before. Its less expensive and less physically demanding.

The exhibitors pay the bills. And their decisions, or lack thereof, regarding moving the show to bi-annual will carry the day.

As I have mentioned previously, in ***The New York Times*** Sunday editions, there is now a Home section. Why? Because we are all home more than ever before. And as part of this section, they recently included the following products in the appliance/HVAC industry, shown in "The New Essentials":

Best Blender: Oster Versa Pro Series
Best Ice Cream Machine: Whynter ICM-201SB
Best Cold Brew Maker: OXO Good Grips Cold Brew Coffee Maker
Best Fan: Vornado 630 Medium Air Circulator
Best Window AC Unit: LG LW8017ERSM
Best Air Purifier: Coway AP-1512HH Mighty
Best Air Quality Monitor: Temtop M10 Quality Monitor
Best Bagless Vacuum: Shark Navigator Lift-Away NV352
Best Dutch Oven: Lodge 6-Quart Enameled Cast Iron Dutch Oven
Best Pressure Cooker: Instant Pot Duo 6-Quart

By the way, we consider the word "appliance" in the broadest sense, meaning it also includes power tools and lawn and garden products. So here are 3 of those among "The New Essentials":

Lawn Mower: Ego Power+ Select Cut Mower
Leaf Blower: Toro Power Jet F700
String Trimmer: Ego ST15215 Power+ String Trimmer

And in "Self-Care"
Best Electric Toothbrush: Oral-B Pro 1000

Thank you to the following companies that supplied whitepapers and other technical pieces for this issue: Avery Dennison, Infinitum Electric, International Copper Association, International Products Corp., Intertek, JBC Technologies, Littelfuse, New Age Industries and UV Resources.

And thanks to our readers and advertisers, without whom THE APPLIANCE & HVAC REPORT would not exist.

See you in April. Feel free to contact me before then if you like at brad@appliancehvacreport.com

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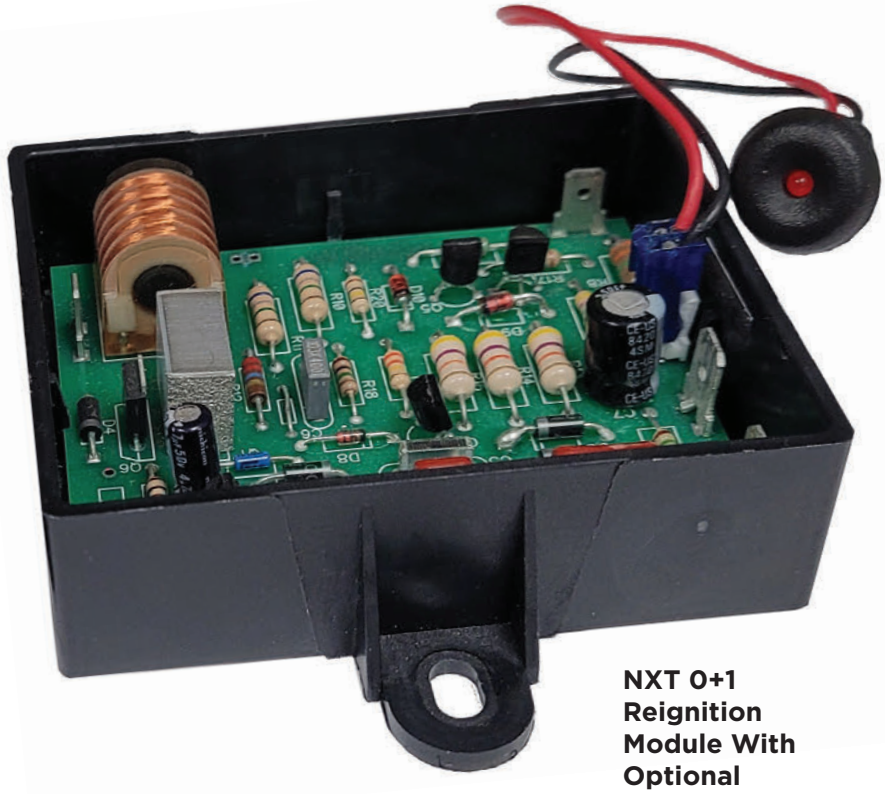
## Ad Index

| | |
|---|---|
| **ARaymond** araymond-industrial.com | 25 |
| **Cesar-Scott** cesar-scott.com | 4 |
| **Continental Fan** continentalfan.com | 31 |
| **Hernon Manufacturing** hernon.com | eBlast |
| **Infineon** Infineon.com | 21 |
| **International Copper** copperalliance.org | 11 |
| **John Guest** johnguest.com | IFC |
| **NPE** npe.org | IBC |
| **Portage Electric** pepiusa.com | 15, eBlast |
| **Soler & Palau** Soler-Palauinc.com | 41 |
| **Sprinter Marking** sprintermarking.com | 29 |
| **SurfaceIgniter** surfaceigniter.com | 19 |
| **Vitrek** vitrek.com | BC |

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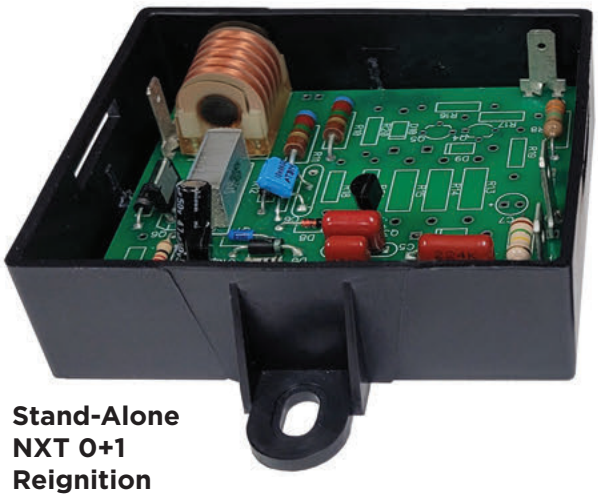
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CONTENTS

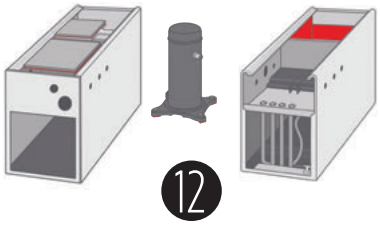
## FEATURES





**Evaluating O-Ring Insertion Force**
by Jennifer Sun and Linda Wolfe

In this work, a general factorial design was used to evaluate the roles of lubricant type, insertion speed, bore size and operator technique in radial O-ring insertion.




**Pressure-Sensitive Tapes in HVAC Applications**
by Richard Soto

Pressure-sensitive adhesives (PSAs) offer an effective solution for HVAC design challenges.




**Reinvented Motor For Sustainable HVAC and Appliance Design**
by Bhavnesh Patel

New approaches in motor architecture and materials with smaller, lighter, quieter, more durable, more efficient and connected design.



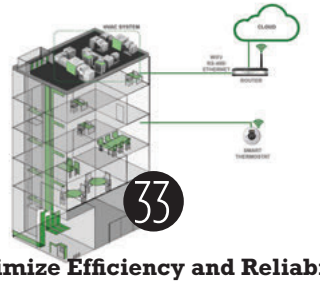

**Converted Material Solutions for Noise, Vibration, and Harshness**
by Joe Bliss

There are a myriad of materials that design engineers can use to absorb, damp, or even eliminate the source of excess sound in new products.



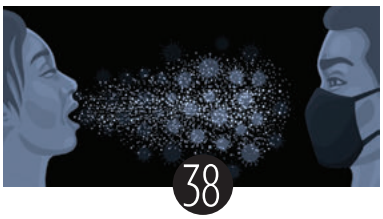

**Top 20 Tubing & Hose Buying Tips**
by NewAge Industries

Tips to highlight details that can be overlooked, present questions to ask your supplier, and suggest research you can do to help avoid buying errors.



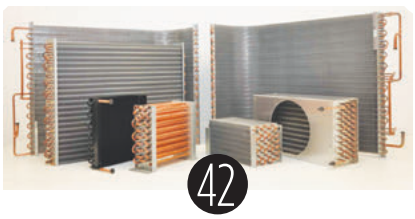

**Maximize Efficiency and Reliability of HVAC Systems**
by Ryan Sheahen

Two major factors are driving growth: Government requiring more energy-efficient systems and consumer demand for improved indoor air quality.




**Inactivate Airborne Pathogens with UV Airstream Disinfection**
by UV Resources

Since the onset of COVID-19, UV-C has become one of the most in-demand technologies around the world.




**Three Trends in Ecofriendly Appliance Design**
by Yoram Shabtay and Kerry Song

Typical environmental action plans include: Decarbonization, F-Gas reduction, Energy efficiency Ecofriendly design of heating and cooling appliances supports all three of these strategies.




**Harmonized Standard For Commercial Refrigerating Appliances and Icemakers**
by Craig Grider

In September of 2024, the industry will see a change to certification requirements in North America for electrical refrigerating appliances and icemakers.


## DEPARTMENTS


26 **News Beat**

30 **New Products**








# Evaluating O-Ring Insertion Force

## Using General Factorial Design

BY JENNIFER SUN & LINDA WOLFE

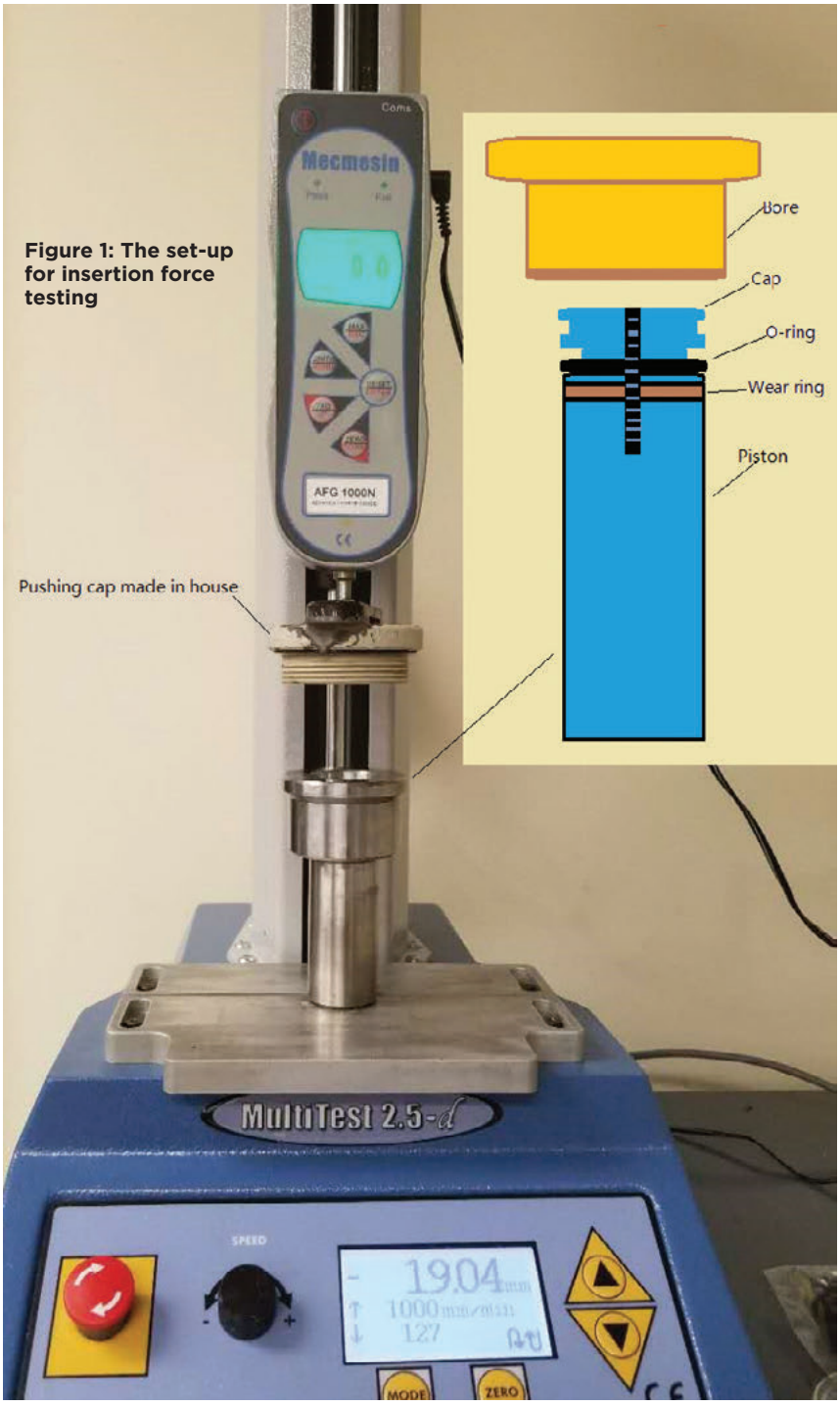



**Figure 1: The set-up for insertion force testing**


### Abstract

In this work, a general factorial design was used to evaluate the roles of lubricant type, insertion speed, bore size and operator technique in radial O-ring insertion. It was found that the type of lubricant had the most significant influence on the insertion force reading. By using the right type of lubricant, the insertion force readings decreased tremendously. The insertion speed and bore size as well as the interactions between some factors (lubricant type and insertion speed; lubricant type and bore size) also showed significant influences on the final friction reading, but their influences were much less than the type of lubricants reflected by the F values and p-values (F value for lubricant type factor: 1151.31 with p-value 0.0001; F value for bore size: 94.53 with p-value < 0.0001; F value for assembly speed: 24.51 with p-value < 0.0001; F value for interaction of lubricant type and bore size: 16.98 with p-value < 0.0001F; value for interaction of lubricant type and insertion speed: 2.49 with p-value of 0.0170). Operators did not have significant influence on the insertion force readings. This information is useful to help engineers select the right conditions for easy radial O-ring insertion.


### Introduction

O-rings can be made of various materials, but the most common type is elastomeric[1]. Elastomeric O-rings can be used as seals in sealing joints. A sealing joint consists of a shaft and O-ring assembly in which the sealing joint is inserted into a bore[2]. During

the insertion process, the O-ring is compressed, resulting in a high insertion force. In order to assemble the seal properly, an operator needs to continuously push the bore onto the piston. Consequently, too high of an insertion force can damage the elastomeric O-rings, resulting in a shorter shelf life or even leakage.

Factors affecting the insertion force include O-ring material type, O-ring lubrication, bore size, insertion speed, operators, etc. There are various lubricant chemistries available to aid elastomeric part assembly. Water-based lubricants have certain advantages over those that are solvent-based because the solvents may cause compatibility issues with the assembled elastomeric parts. Another disadvantage to using solvent-based lubricants is the environmental concerns associated with them. When the part needs to be assembled, the precoated elastomer can be dipped into water. Water activates the lubricating effect of the coating and lowers the assembly friction.

In this study, four factors were evaluated for their influence on the insertion force via a general factorial design. The factors evaluated were lubricant type, insertion speed, bore size and operators. The results can be used as a reference for design engineers and operators to select the optimal conditions for a seal joint insertion operation.

## Experimental

### 1. Materials and Apparatus

a. O-rings: E0603 2-121 and E0603 2-125 (EPDM, Parker Hannifin Corporation);

b. P-80® Emulsion Temporary Rubber Lubricant (International Product Corporation; Denoted as P-80® Emulsion below);

c. Rubber Slide® Assembly Lubricant (International Product Corporation);

d. Water Activated Dry Film Lubricant (International Product Corporation);

e. PTFE pre-lube spray;

f. Molybdenum disulfide powder;

g. Graphite dry film lube;

h. Bores and pistons to simulate an O-ring sealing joint (bore sizes: 31.72 and 38.07 mm);

i. Mecmesin AFG 1000N force gauge;

j. Mecmesin MultiTest-d Digital Motorized Test Stand;

### 2. O-ring preparation for testing

The molybdenum disulfide powder was suspended in tap water at 5% (w %). All the other lubricants were used as is. The O-rings were pre-coated with PTFE pre-lube, 5% molybdenum disulfide and the Water Activated Dry Film Lubricant, respectively. The pre-coated O-rings were allowed to dry at room temperature for a week. For the insertion force testing, the dry films of PTFE pre-lube and 5% Molybdenum disulfide were tested as is while the O-rings with the Water Activated Dry Film Lubricant were dipped briefly into tap water to activate the lubrication effect. The P-80® Emulsion and Rubber Slide® Assembly Lubricant were used as typical line lubricants; they were applied to the O-rings followed immediately by assembly.

### 3. Insertion force testing procedure

The set-up for insertion force testing is shown in Figure 1.

The testing procedure is as follows.

a. Screw the piston on the platform of the stand.

b. Place an O-ring with respective lubricant on the piston.

c. Screw the cap on top of the piston.

d. Place the bore loosely on top of the piston with the cap on.

e. Set up the force gauge meter and zero it.

f. Select the right insertion speed and the stop position of the stand.

g. Push the start button to push down the bore and let it pass over the O-ring.

h. Record the maximum force reading of the gauge, which is the insertion force of each trial.

**TABLE 1:** GENERAL FACTORIAL DESIGN DETAILS

| | A [Categoric] | B [Categoric] | C [Categoric] | D [Categoric] |
|---|---|---|---|---|
| Name | Insertion Speed | Lubricant Type | Bore Size | Operator |
| Units | mm/min | N/A | mm | N/A |
| Type | Ordinal | Nominal | Nominal | Nominal |
| Levels | 3 | 5 | 2 | 2 |
| L(1) | 150 | P-80® Emulsion | 31.72 | 1 |
| L(2) | 300 | PTFE pre-lube | 38.07 | 2 |
| L(3) | 450 | 5% MOLYBDENUM DISULFIDE | N/A | N/A |
| L(4) | N/A | Water Activated Dry Film Lubricant | N/A | N/A |
| L(5) | N/A | Rubber Slide® Assembly Lubricant | N/A | N/A |

**TABLE 2:** ANOVA RESULT TABLE

| Source | Sum of Squares | df | Mean Square | F Value | p-value (Prob > F) | |
|---|---|---|---|---|---|---|
| Block | 1.47E-06 | 1 | 1.47E-06 | | | |
| Model | 0.16 | 19 | 8.48E-03 | 256.66 | < 0.0001 | significant |
| A-Insertion Speed | 1.62E-03 | 2 | 8.10E-04 | 24.51 | < 0.0001 | |
| B-Lubricant Type | 0.15 | 4 | 0.038 | 1151.31 | < 0.0001 | |
| C-Bore Size | 3.12E-03 | 1 | 3.12E-03 | 94.53 | < 0.0001 | |
| AB | 6.57E-04 | 8 | 8.21E-05 | 2.49 | 0.0170 | |
| BC | 2.24E-03 | 4 | 5.61E-04 | 16.98 | < 0.0001 | |
| Residual | 3.20E-03 | 97 | 3.30E-05 | | | |
| Cor Total | 0.16 | 117 | | | | |

**TABLE 3:** ANOVA RESULT PART 2

| | | | |
|---|---|---|---|
| Std. Dev. | 5.75E-03 | R-Squared | 0.9805 |
| Mean | 0.098 | Adj R-Squared | 0.9767 |
| C.V. % | 5.87 | Pred R-Squared | 0.9712 |
| PRESS | 4.74E-03 | Adeq Precision | 42.839 |

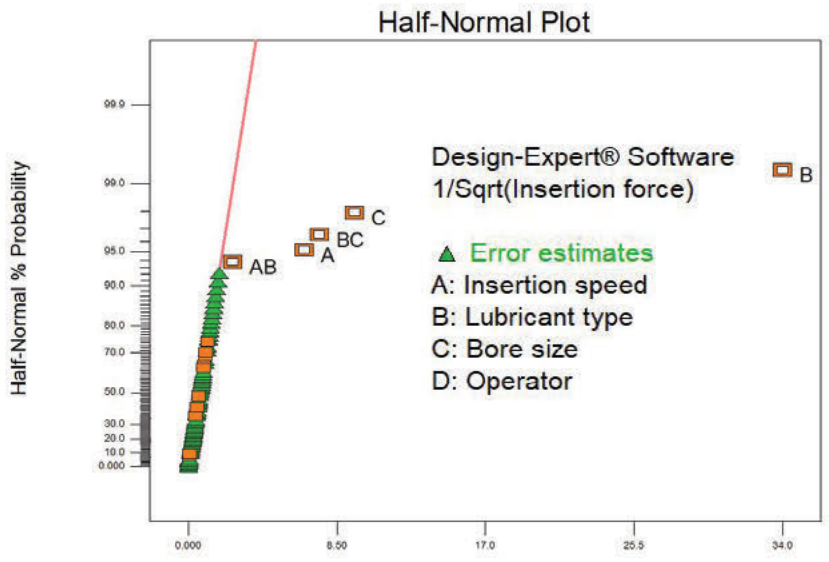



**Figure 2: Half-Normal Plot of the effects of selected factors**

### 4. Design of experiments

A general factorial design was selected to evaluate four factors as shown in Table 1. The goal of this design was to evaluate the degree of influence of each factor on the insertion force. A graphite dry film lube was tried, but it overloaded the gauge (over 1000 N of insertion force). When the insertion speed was set higher than 500 mm/min, the insertion force readings for some dry film lubes were also higher than 1000 N. Therefore, insertion speeds higher than 500 mm/min and the graphite dry film lubricant were not included in the design.

## Results and Discussion

### 1. ANOVA results

The ANOVA result table is shown In Table 2. The model had an F value of 256.66 and a p-value < 0.0001, which indicate that the model was significant. Among all of the factors, the lubricant type played the most significant role (F value of 1151.31) in determining the insertion force as seen in Table 2 and Figure 2. The bore size, insertion speed, interaction between the lubricant type and speed, and the interaction between the lubricant type and bore size all showed some significance in the final insertion force readings.

In Table 3, the second part of the ANOVA results is displayed. The Adj R-Squared and the Pred R-Squared values were very close to each other with a difference much smaller than 0.2 between these two values. The Adeq Precision was also much higher than the desired value of 4 for the signals to be adequate, indicating good testing precision.

The significance of each factor can be seen in Figure 3. In Figure 3(A), the interaction of lubricant type and insertion speed is illustrated. It can be seen that the lubricant type played the major role in determining the insertion force at whichever insertion speed. Similarly in Figure 3(B), the main effect was still the lubricant type.

### 2. Solutions for low insertion force

In order to increase O-ring shelf life and avoid O-ring damage, minimal insertion force is desired. In the

**TABLE 4:** SOLUTIONS OBTAINED IN THE OPTIMIZATION PROCESS

| Number | Insertion Speed | Lubricant Type | Bore Size | Operator | Predicted Insertion Force | Desirability |
|---|---|---|---|---|---|---|
| 1 | 150 | P-80® Emulsion | 31.72 mm | 2 | 44.7 | 0.963 |
| 2 | 150 | P-80® Emulsion | 31.72 mm | 1 | 44.7 | 0.963 |
| 3 | 150 | Rubber Slide® Assembly Lubricant | 31.72 mm | 2 | 49.9 | 0.873 |
| 4 | 150 | Rubber Slide® Assembly Lubricant | 31.72 mm | 1 | 49.9 | 0.873 |
| 5 | 300 | P-80® Emulsion | 31.72 mm | 2 | 49.9 | 0.872 |
| 6 | 300 | P-80® Emulsion | 31.72 mm | 1 | 49.9 | 0.872 |
| 7 | 450 | P-80® Emulsion | 31.72 mm | 2 | 54.1 | 0.799 |
| 8 | 450 | P-80® Emulsion | 31.72 mm | 1 | 54.1 | 0.799 |
| 9 | 150 | P-80® Emulsion | 38.07 mm | 1 | 57.1 | 0.748 |
| 10 | 150 | P-80® Emulsion | 38.07 mm | 2 | 57.1 | 0.748 |
| 11 | 150 | Water Activated Dry Film Lubricant | 31.72 mm | 2 | 58.6 | 0.722 |
| 12 | 150 | Water Activated Dry Film Lubricant | 31.72 mm | 1 | 58.6 | 0.722 |
| 13 | 450 | Water Activated Dry Film Lubricant | 31.72 mm | 1 | 59.5 | 0.705 |
| 14 | 450 | Water Activated Dry Film Lubricant | 31.72 mm | 2 | 59.5 | 0.705 |
| 15 | 300 | Water Activated Dry Film Lubricant | 31.72 mm | 1 | 59.7 | 0.702 |
| 16 | 300 | Water Activated Dry Film Lubricant | 31.72 mm | 2 | 59.7 | 0.702 |
| 17 | 300 | Rubber Slide® Assembly Lubricant | 31.72 mm | 1 | 60.0 | 0.698 |
| 18 | 300 | Rubber Slide® Assembly Lubricant | 31.72 mm | 2 | 60.0 | 0.698 |
| 19 | 150 | Rubber Slide® Assembly Lubricant | 38.07 mm | 2 | 60.1 | 0.695 |
| 20 | 150 | Rubber Slide® Assembly Lubricant | 38.07 mm | 1 | 60.1 | 0.695 |
| 21 | 450 | Rubber Slide® Assembly Lubricant | 31.72 mm | 2 | 62.8 | 0.648 |
| 22 | 450 | Rubber Slide® Assembly Lubricant | 31.72 mm | 1 | 62.8 | 0.648 |
| 23 | 300 | P-80® Emulsion | 38.07 mm | 2 | 64.6 | 0.616 |
| 24 | 300 | P-80® Emulsion | 38.07 mm | 1 | 64.6 | 0.616 |
| 25 | 450 | P-80® Emulsion | 38.07 mm | 1 | 70.9 | 0.507 |
| 26 | 450 | P-80® Emulsion | 38.07 mm | 2 | 70.9 | 0.507 |
| 27 | 300 | Rubber Slide® Assembly Lubricant | 38.07 mm | 2 | 73.7 | 0.459 |
| 28 | 300 | Rubber Slide® Assembly Lubricant | 38.07 mm | 1 | 73.7 | 0.459 |
| 29 | 450 | Rubber Slide® Assembly Lubricant | 38.07 mm | 1 | 77.5 | 0.391 |
| 30 | 450 | Rubber Slide® Assembly Lubricant | 38.07 mm | 2 | 77.5 | 0.391 |
| 31 | 150 | Water Activated Dry Film Lubricant | 38.07 mm | 1 | 83.1 | 0.294 |
| 32 | 150 | Water Activated Dry Film Lubricant | 38.07 mm | 2 | 83.1 | 0.294 |
| 33 | 450 | Water Activated Dry Film Lubricant | 38.07 mm | 1 | 84.7 | 0.267 |
| 34 | 450 | Water Activated Dry Film Lubricant | 38.07 mm | 2 | 84.7 | 0.267 |
| 35 | 300 | Water Activated Dry Film Lubricant | 38.07 mm | 1 | 85.0 | 0.261 |
| 36 | 300 | Water Activated Dry Film Lubricant | 38.07 mm | 2 | 85.0 | 0.261 |

optimization process, all four factors (lubricant type, bore size, insertion speed and operator) were kept in range while insertion force was set to be minimized to search for the best O-ring insertion conditions.

By using a general factorial design, four factors (lubricant type, bore size, insertion speed and operator) were evaluated for their roles in affecting insertion force of O-rings to simulate an O-ring sealing joint. Among all the factors, the lubricant type plays the most significant role in determining the insertion force. Dry film lubricants such as PTFE, molybdenum sulfide and graphite types are convenient to use for the end users, but they don't perform well in this application. ●



***Jennifer Sun*** *has a PhD in analytical chemistry and has published dozens of papers in peer-reviewed scientific journals throughout her career. Her training is in instrumental analysis method development in the fields of GC-MS, HPLC-MS and ICP-OES. Her expertise also includes Design of Experiments and the formulation of precision, specialty cleaners and lubricants. Jennifer is the Research Supervisor at International Products Corporation and directs all laboratory projects. She has worked at International Products since 2011.*



***Linda Wolfe*** *has an MS in Biology from Rutgers University and is currently pursuing her MBA from Boston University. Linda is a research chemist responsible for application-specific method development and execution, technical support for customers, quality control, and is the technical writing liaison with marketing. Linda developed the chemical hygiene plan for the company's manufacturing facility. She has been with International Products since 2013.*

***References***

*1. Corporation, P.H., Parker O-Ring Handbook. 2007.*
*2. Samuel J. Tomlinson, et al., Radial O-Ring Insertion Force Optimization for Functionality and Assembly. SAE International, 2017 (2017-01-0326).*

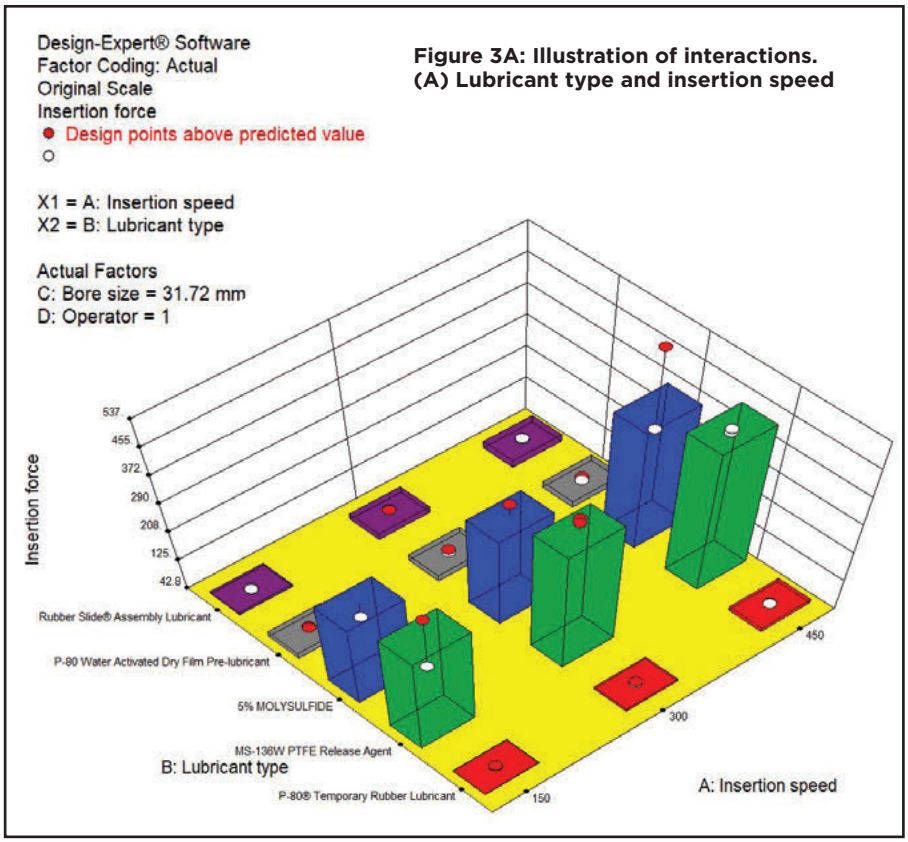



**Figure 3A: Illustration of interactions. (A) Lubricant type and insertion speed**

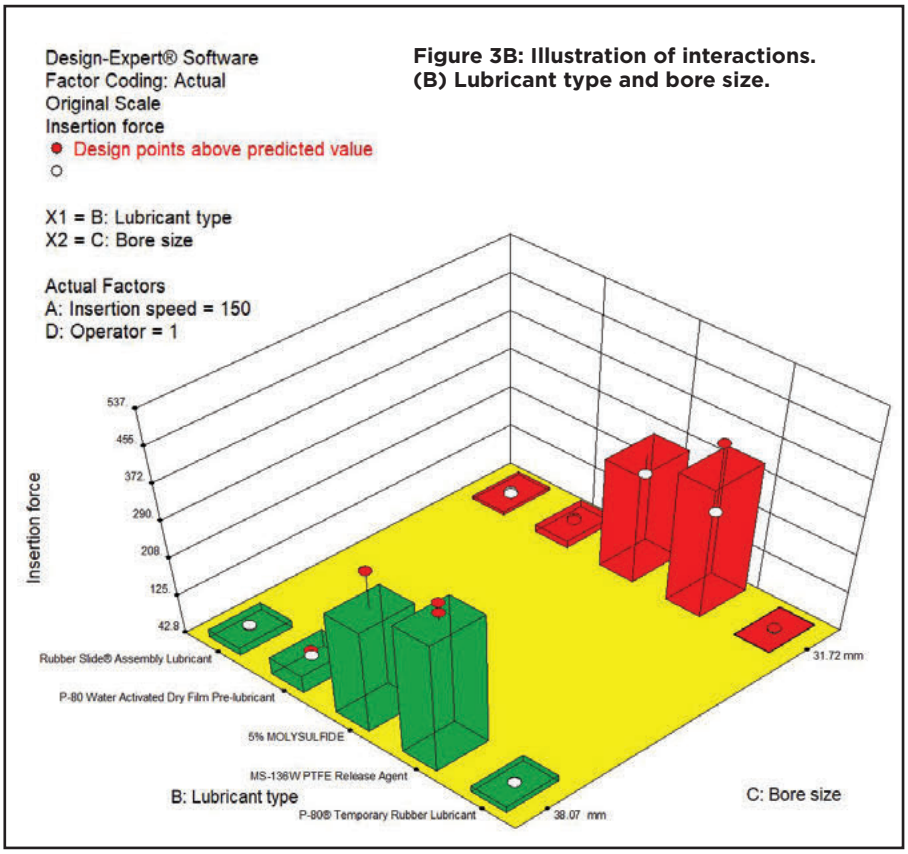



**Figure 3B: Illustration of interactions. (B) Lubricant type and bore size.**

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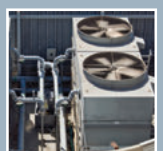
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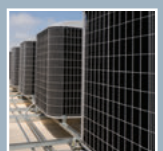
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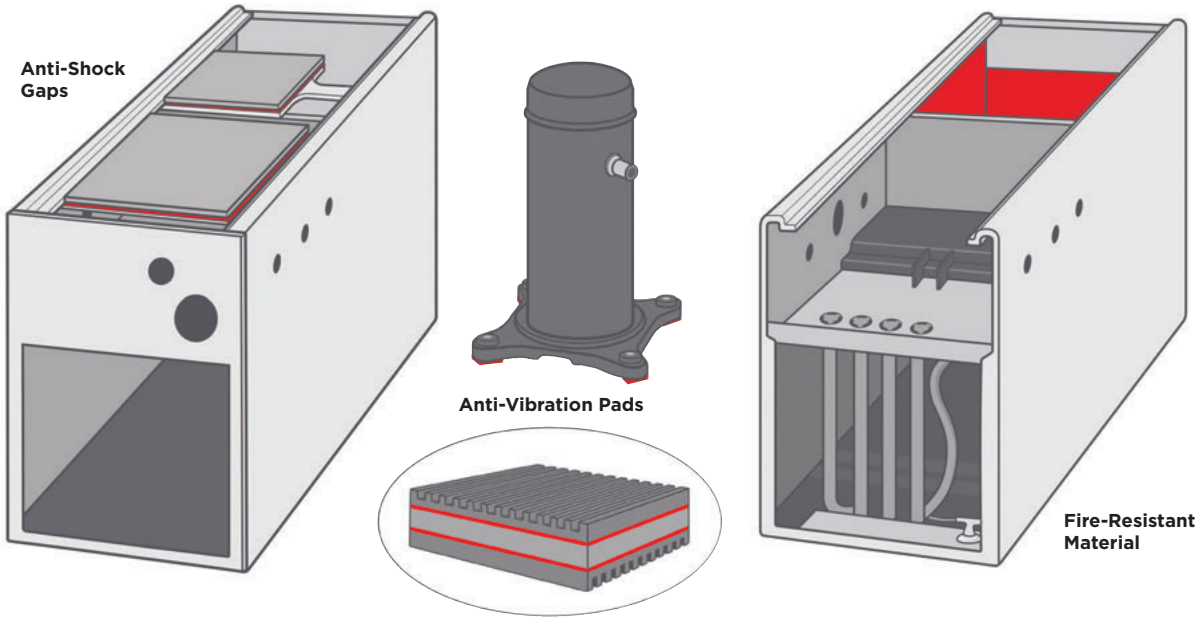
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## Best Practices

# Pressure-Sensitive Tapes in HVAC Applications

**BY RICARDO SOTO**

HVAC manufacturing continues to evolve to increase unit efficiency and streamline production processes while maintaining high levels of quality and reliability. Pressure-sensitive adhesives (PSAs) offer an effective solution for these HVAC design challenges. Virtually any place a fastener assembly can be used, a PSA (typically a tape) can perform the same task, offering reliability and service life equal to or better than that of bolts, rivets and welds.

Making effective use of PSAs within the HVAC industry requires a basic understanding of the types of PSAs available and evaluating their feasibility in both traditional and non-traditional applications.

### Understanding PSAs

PSAs provide an extremely versatile solution to HVAC design challenges because they are available with a range of adhesives and in a variety of constructions. Key adhesive types include:

• **Rubber:** Rubber-based adhesives bond well with low-surface energy materials such as painted metal and plastic. Rubber often provides high initial tack, high quick stick adhesion, and fast "wet out." Wet out is the quality of the adhesive that enables it to flow and covers a surface to maximize the contact area and the attractive forces between the adhesive and bonding surface. The flexible quality of rubber adhesives makes it an acceptable choice for vibration damping, although acrylics and silicone outperform rubber for this application.

• **Acrylic:** Acrylic adhesives deliver high durability and are very long lasting. They also have a high resistance to UV light and solvents, and they are temperature resistant to 350° F (180° C). A wide range of acrylic polymers are available to tailor properties to the application. A common use of acrylics in HVAC is acrylic foam bond tapes (AFB). This tape technology carries an adhesive on an acrylic foam core to provide an alternative to metal joining techniques such as riveting or welding. When properly matched to the application, AFB tapes streamline production processes while delivering excellent durability, fatigue resistance, distribution of stress and corrosion resistance.

• **Modified Acrylic:** Modifying acrylic adhesives extend the versatility through use of modifiers formulated to enhance specific characteristics, such as heat resistance or adaptability to specific substrates. In addition, acrylic modifiers can provide fire retardance, improve initial tack and adhesion and enhance foam bonding. Some

modified acrylics are UL® 969 and 746C recognized.

• **Silicone:** Silicone adhesives are resistant to weathering, moisture and some chemicals. They also remain flexible at low temperatures and provide strong adhesion in heat-resistant applications. Their excellent temperature resistance makes them ideal for units operating outside as they can support temperatures ranging from -60°F (-50°C ) to 500°F (260°C). Silicone also has excellent vibration damping characteristics and creates a strong bond with silicone and other low surface energy materials.

These adhesives are matched with a variety of tape materials to meet the requirements of the applications. Among the constructions commonly used in the HVAC industry are high performance double-sided adhesive tapes, acrylic foam tapes, double-sided foam tapes and foil-based tapes.

## Choosing the Right PSA

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

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

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

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

Environment is the next issue, with temperature and humidity as key considerations. Tapes used in HVAC systems, particularly those designed for outdoor installation, must be able to withstand a wide range of environmental conditions and, depending on the particular application, UV exposure. Generally, acrylic-based adhesives offer better adhesion performance to high levels of these conditions compared to rubber-based adhesives. However, if the specific application has an extremely high exposure to these conditions, technical support from your partner is recommended to provide a specific solution.

Rubber-based adhesives are generally a good choice for temperatures below 150° F; acrylic-based adhesives can generally resist temperatures up to 350° F. High performance acrylic (HPA) and silicone adhesives can be utilized for higher temperature ranges, which often require testing or existing application data to help support a proper recommendation.

## PSAs in HVAC

HVAC manufacturers can take advantage of the versatility, adhesive strength and durability of PSAs to enhance product aesthetics, performance and reliability.

While some PSAs may initially be more expensive than the fasteners they replace, brand owners can more than make up for the differential through enhanced manufacturing repeatability, precision and performance over the life of the product.

The use of tapes also eliminates the need to drill holes or weld, streamlining production processes. Noise and vibration are also common considerations in HVAC equipment. Tapes provide a more consistent, lighter weight joining solution for noise and vibration damping components. Fasteners, over time, can break from the back-and-forth motion, leading to costly repairs. Replacing metal fasteners with tapes can also create small weight savings that add up to noticeable transportation savings when thousands of units are shipped in a year.

PSAs for HVAC systems – many of which may need to be UL® recognized, depending on the application – cover a wide variety of applications within the segment. Key areas of opportunity include:

• **Badging and aesthetics:** Nearly every HVAC system carries a brand badge or emblem to help build brand equity. Durable acrylic foam bonding (AFB tapes) can provide an affordable solution for these applications, providing excellent tack, adhesion and cohesion performance for attaching brand badging to the unit. These adhesives also add shock dissipation for system vibrations during startup or operations, allowing the component to withstand such shocks over the life of the system.

• **Critical joining:** For this application, high performance acrylic (HPA) tape provides long-term adhesion with high temperature performance and excellent environmental resistance. It offers

high holding power and reliable performance on high, medium and low energy substrates, including a variety of engineered plastics. Foil-based tapes are also an excellent option for attaching components like coils, helping to prevent the coil from moving over the product's lifespan. As mentioned previously, using tape for critical joining eliminates more time-consuming production processes, such as welding or attaching screws.

• **Thermal and moisture insulation:** A variety of tape constructions and adhesives can be used to support thermal insulation within HVAC systems. Hot-melt rubber transfer tapes are ideal for bonding vacuum insulated panels (VIP) used in refrigeration units. A combination foam and aluminum foil tape serves as an ideal sealant to adhere to irregular surfaces, preventing condensation build-up on surfaces to which it is mounted. This construction also reduces vibration and sound and seals ductworks and hole covers. Aluminum foil tapes can also effectively maintain desired temperature differentials between components inside the unit.

• **Noise and vibration damping:** Reducing negative impacts of thin gauge metals that can cause noise and vibration, while increasing the product's working life by resisting metal fatigue over time is key for HVAC system design. Aluminum-foil based acrylic tapes provide a high-performance solution that reduces resonate noise, vibration and stress fatigues as a constrained layer damper,with excellent resistance to heat and humidity. Transfer tapes are commonly used with pads to minimize noise and vibration for compressors, fans and blower wheels. Transfer tapes and double-coated tapes are also used with anti-shock pads that protect components and filler pads used to fill empty spaces between materials.

## Thinking Outside the HVAC Box

While the primary focus of this article is to help OEMs explore new opportunities for the use of PSAs in manufacturing, it's also important to think about the tapes that will be used during equipment installation.

In residential installations, fiberglass and flex duct work are still commonly used in some parts of the country and these require tape for sealing to ensure efficiency. Improper sealing resulting from a sub-standard tape can reduce unit performance and reflect poorly on the brand. Likewise, commercial installations require tape for pipe insulation and to create a vapor barrier. Manufacturers should ensure the tape being used by contractors delivers the performance required.

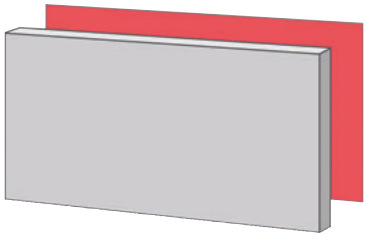
## Conclusion

Tapes have always been important in the HVAC industry, but their use is expanding beyond traditional applications to include critical joining and increased use in noise and vibration damping and thermal insulation.

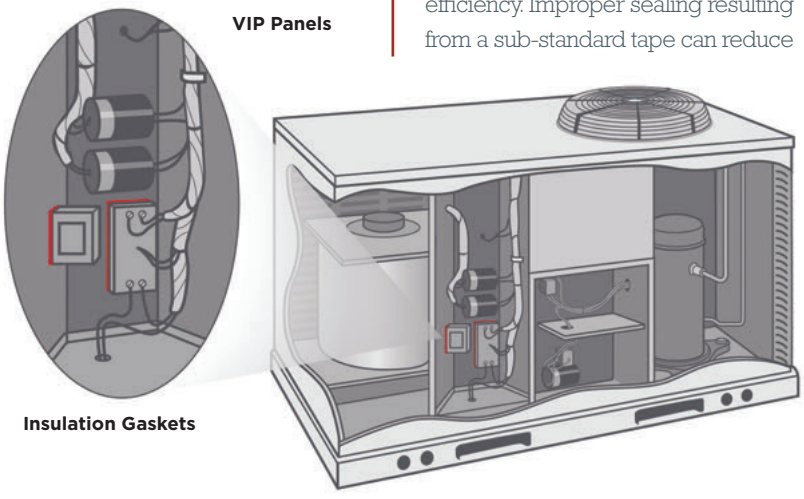
The best time to develop bonding solutions is early in the design phase, before production begins. Design engineers can bring to bear the expertise of the tape converter and tape manufacturer to prove out bonding solutions. Early consultation with these experts is the key to PSA assembly success. ●



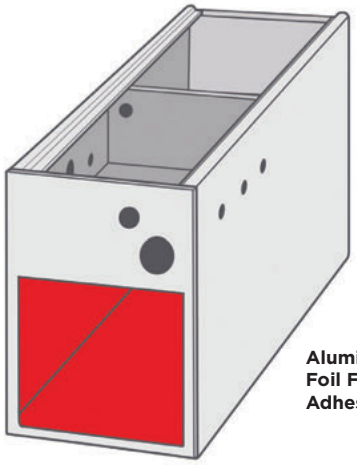
***Ricardo Soto*** *is a senior design and application engineer with Avery Dennison Performance Tapes. Soto, who has more than 10 years' experience in the pressure-sensitive adhesives industry, is responsible providing Avery Dennison clients with new product development and technical application support. For more information:* ***tapes.averydennison.com****.*



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# A Reinvented Motor
## For Sustainable HVAC and Appliance Design

**BY BHAVNESH PATEL**

George Carlin once said, ''Electricity is just organized lightning.'' And while we may not be able to organize lighting, imagine what could actually happen if we ''reorganized'' electricity and made it more efficient?

The world consumes twenty-five trillion kilowatt hours of electricity per year, of which 53% percent is consumed by electric motors alone. In the home, according to the U.S. Energy Information Administration's Residential Energy Consumption's survey, the air conditioner is the largest user of electricity, followed by the refrigerator. This leaves a significant opportunity for the HVAC and the appliance industry to design machines with ultra-high efficiency electric motors, which consume far less energy.

Electric motor design has gone virtually untouched for more than 100 years. But that is changing thanks to technological innovation beginning in the HVAC market. New approaches in motor architecture and materials are offering OEMs the same output as traditional electric motors, but with a smaller, lighter, quieter, more durable, more efficient and connected design.

These reinvented, ultra-high efficiency motors are enabling OEMs to not only step into a new era of sustainability, but also gain a competitive edge by making HVAC and appliance products much more efficient, serviceable and cost effective. And because of their smaller size, lighter weight, and quieter operation, they're ideal for a host of residential HVAC applications and appliances, such as vacuum cleaners, dryers, refrigerators, dishwashers and blenders.

## Reinventing The Motor

By rethinking the overall motor architecture and design, many benefits are realized. These not only include efficiency gains, reduced size and weight, and lower noise, but also lower vibration, integrated power electronics and IoT capabilities.

One of the key differences in this new motor design is its approach to the motor's stator core. The new design approach uses a multilayer printed circuit board (PCB), instead of the cumbersome and rudimentary iron core and copper wire found in a traditional motor.

A PCB stator is a unique technology that allows the copper windings of the motor to be etched as coils into a thin, disc-shaped PCB. The PCB stator greatly reduces the size and weight of the motor. Infinitum's motors are axial flux PM machines, commonly referred to as ''pancake'' or ''disc'' motors. By virtue of not having a stator core, IE's motors have 30% of the volume and weight of conventional AC induction motors and are approximately 50% smaller than electrically commutated (EC) motors.



**Infinitum Electric motor for vacuum application**

In addition, advancements in power electronics also optimize its consumption of electricity. Embedded IoT circuitry on the PCB stator and on board processing with the power electronics can take products into an era of instant monitoring and control for greater insights into key metrics, automation and serviceability in the field.

## DesignFor Total Efficiency

One benefit of the PCB ironless stator is the improved efficiency achieved through the elimination of stator hysteresis and eddy current losses, which are common in traditional ferromagnetic cores.

An additional benefit is the ability to optimize the stator winding design, thus minimizing eddy current losses and/or I2R losses without the limitations imposed by stator slot geometry and distribution, and consistently produce identical coils through precise and repeatable PCB manufacturing processes. These efficiency gains are seen across almost the entire speed range of motors.

## Low Acoustic Noise and Low Vibration

Some of the benefits of PCB stator design are the low acoustic noise and low vibration due to the absence of typical magnetic forces acting between the rotor and the stator, and negligible torque ripple due to the absence of reluctance torque.

In a typical electric machine, both the stator and rotor are built out of ferromagnetic materials. Once electric currents are applied to the winding of the machine, rotating magnetic fields are established. These magnetic fields produce two forces: one that produces useful torque and causes the rotor to rotate and one that pulls the rotor radially towards the stator, similarly to the force that pulls two magnets together. The latter not only does not produce useful torque, but because of its pulsating nature due to presence of slots in the stator, it also contributes to noise and vibration.



**Infinitum Electric motor for washing machine application**

Other sources of noise in electric machines are the blowers (internal and external) needed to cool the machine. The Infinitum Electric motor does not have core losses, and has negligible rotor losses. The only significant losses are I2R losses and eddy current losses in the copper, substantially reducing the need for internal blowers, which allows for quieter machines.

Iron core electric machines typically have some torque pulsations due to the variations in the reluctance as the rotating magnetic field travels around the motor. The magnetic force acts in such a way as to reduce the reluctance of the magnetic path. As the rotor moves in the direction of rotation, the alignment of the rotor poles changes

relative to the stator to a point where the magnetic flux produces a force in the opposite direction of rotation. This alternating magnetic force will produce a torque ripple.

### Reduced Volume and Mass

Coreless PCB stators weigh almost 90% less than equivalent stators with an iron core. With the iron removed and attractive forces eliminated from the machine, the structural requirements for our machine are drastically reduced. Further, the continuous coil design in our stator optimizes coil geometry, providing maximum power density and efficiency at a fraction of the size and weight.

The motor's current density can be more than four times higher than machines with traditional iron laminations and copper windings (~13,000 A/in2 vs. ~3,000 A/in2), substantially reducing the copper mass for the same current rating. The table and image below show volume and mass comparison of two motors with the same rating — a 1 HP 3,600 RPM Electric motor vs. a 1 HP 3,600 RPM NEMA Premium induction motor.

### Integration ofThe Inverter

A variable frequency drive (VFD) has been developed to optimize the performance of the motor. The motors feature an integrated VFD with inverter section built with SiC MOSFET devices from Infineon with industry-leading efficiency. These devices provide superior performance, reliability and offer new degrees of flexibility for power circuit design.

The extremely low switching and conduction losses of the SiC MOSFETS enable the use of high switching frequencies (100 to 250 kHz), which helps reduce the size of line filters and associated losses, reducing the overall size of the VFD and its cooling system. The higher switching frequency results in a 'cleaner' waveform that reduces current ripple allowing the motor to operate more efficiently.

Many benefits can be achieved with this innovative new motor technology. And thanks to engineering breakthroughs, proven results and more efficient motor options available, OEMs can deliver on advanced product designs to gain new competitive advantages.

Motors with higher efficiency levels, reduced weight and size, lower noise and vibration, along with advanced power electronics and IoT capabilities can make HVAC and appliance products much more durable, serviceable, cost effective and sustainable. That is how we can "reorganize" how machines use energy by choosing more efficient motors for our machines, and contribute to a much more sustainable future. ●



***Bhavnesh Patel,*** *VP of Business Development, Infinitum Electric, is an accomplished enterprise technology executive with 17+ years of international sales, marketing, strategy, and start-up experience across a variety of domains including Software, Hardware, Manufacturing, Energy, Industrial Automation, and Industrial IoT. He's built and led highly effective sales and marketing teams, led the commercialization of innovative services and developed global partnerships with system integrators, OEMs, channel and alliance partners to accelerate international growth.*



***Paulo Guedes-Pinto,*** *VP of Technology, Infinitum Electric, Has twenty three years of experience in manufacturing and engineering including eighteen years in engineering management, three years in production management, and two years in quality management. Expertise in designing of electric rotating machines; manufacturing process development; tool design; process improvement; strategic planning; six-sigma and new product introductions.*

*For more information go to www.infinitumelectric.com*

**VOLUME AND MASS COMPARISON**

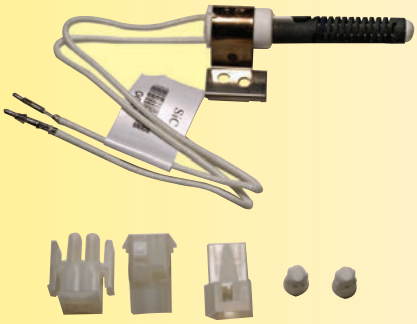
1 HP 3,600 RPM INFINITUM ELECTRIC MOTOR (RIGHT)
***VS.*** A 1 HP 3,600 RPM NEMA PREMIUM INDUCTION MOTOR (LEFT)

| 1 HP MOTOR | DIAMETER | LENGTH | WEIGHT |
|---|---|---|---|
| NEMA Premium Induction | 6.5 in. | 12 in. | 32 lbs. |
| Infinitum Electric | 8 in. | 2.5 in. | 14 lbs. |

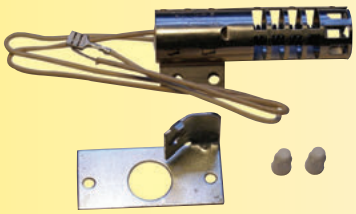


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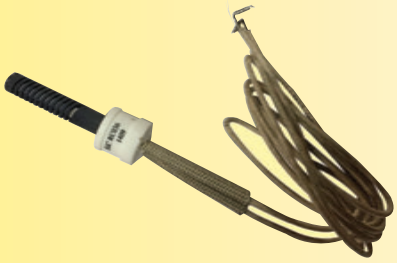


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# Converted Material Solutions for Noise, Vibration, and Harshness

**BY JOE BLISS**

It's no secret that when it comes to appliances, consumers equate quiet to quality. No one wants to talk over the noise of a dishwasher, subject themselves to the constant drone of a furnace or air conditioner, or deal with the constant hum of a refrigerator. And yet by their very nature, the motors and fans that power these appliances create noise, vibration and harshness. Fortunately, there are a myriad of performance materials that design engineers can use to absorb, damp, or even eliminate the source of the excess sound in new products they are bringing to market.

This article touches on the science of sound, provides high level insight into performance material options, and hits on five ways the right converter can positively impact your outcomes.

## 5 Factors to Consider When Designing Noise Reduction Die Cut Components

When addressing the problem of unwanted sound, the first step is to identify the source and then the method by which the sound transfers. Airborne noise transfer is direct radiation by pump or motor. Structural transfer is different in that it passes through the structure and radiation of panels.

While the ideal solution is to eliminate it at its mechanical source, that is not always practical. After all, how do you eliminate the water rushing through a dishwasher? And, even if the sound is purely motor driven and the airborne sound omitted from the source is minimal, the structure-borne sound may still exist.

When approaching a noise solution, there are multiple factors to consider -- from the job to be done to the way the die cut gasket or seal that achieves that objective is presented for deployment on your line.

### 1 - Job to Be Done

Do you need to absorb the sound, block the sound, reflect the sound or keep the sound from occurring altogether? Do you have a lot of room to work with, or do you need to minimize the footprint of the insulation in order to maximize the space in the appliance cavity? Narrowing the material selection and part design down starts with identifying how you want to eliminate the sound: damp it, absorb it, or block it.

***Damping*** - If you cannot stop the sound at the source, you can often isolate it by damping the vibrations so they don't propagate into the rest of the structure. Damping can be achieved by changing the resonant frequency through either the addition of a heavy elastomeric material to the surface, or by applying a thin visco-elastic polymer protected with a dead soft aluminum foil facer called a Constrained Layer Damper (CLD). Either method must be securely coupled to the vibrating surface.

***Absorbing*** - If space allows, another way of attacking the problem is to put material within the structure that absorbs sound waves through energy transfer. When properly sized fibers are exposed to certain sound frequencies the interlocked fibers microscopically vibrate and create heat. This motion converts acoustical energy into thermal energy causing a reduction in sound. Although almost any fibrous material will reduce sound, better results are achieved when using a sound absorbing insulation that is specifically engineered to mitigate sound at the offensive frequencies. Synthetic blankets such as 3M Thinsulate® and Aim Fiber Autozorb® are extremely effective in reducing noise, vibration, and harshness, are hydrophobic, and resist moisture and bacterial growth. Depending on your application, PVC also provides ideal sound and vibration absorption as well as strong UV resistance.

***Block or Isolate*** - Another way to inhibit sound transfer is to block or isolate it. This can be done using dense, closed cell and high density microcellular foam materials which create and maintain a mechanical separation when applied between two surfaces. Examples include Rogers Poron® , and many K Flex® materials. Fiberglass and foil-faced composites can also absorb and block unwanted noise and are ideal for both acoustic and thermal control.

### 2 - Environment

Where and how the gasket and the appliance itself will be used also plays an important part in material selection. What is the operating temperature range the gasket must withstand? Is UV resistance important? Do you need a material that has hydrophobic properties? Is outgassing a concern? All of this must be considered. Not only do you want to make sure the material you choose meets the required properties, you also want to make sure that you don't over-engineer the gasket. This is where our deep relationships with material manufacturers comes into play. Quite often, we find that engineers design in materials that come with a high

price tag, when there are other less expensive options that are more than adequate for their application.

### 3 - Material Availability

In converting, yield matters. A lot. Every bit of material that goes into the scrap bin adds cost to the piece price of the part that goes out the door. For this reason, it is important to start working with your converter as early in the design stage as possible. Any material choice has a limitation on its manufactured production width. The larger the die cut part, the more important consideration should be given to the raw material width in order for the engineer to make an informed choice on how that material is used for their part. By doing so, we can help you design for optimal yield and work with our supply chain partners to provide master rolls sized to enable the best possible efficiency.

### 4 - Manufacturability

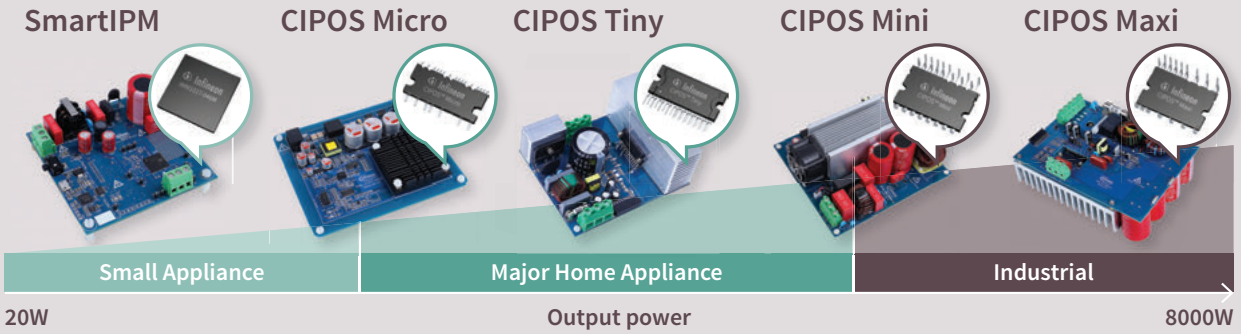
Some materials are easier to work with than others. There is quite a bit of engineering acumen that goes into turning roll goods into finished parts. With over 30 years of process engineering and design for manufacturability under our belt, our team can help you specify solutions that are not only effective at solving your noise challenge, but can be made efficiently.

### 5 - Part Presentation/ Deployment

There are quite a few ways in which a die cut gasket, seal, or insulation panel can be presented for deployment on your line. They can be kiss cut to a liner, butt-cut, gapped, or individually through cut. They can be on large rolls or small rolls with varying core sizes. They can be adhered to plastic clips using automated assembly. They can be boxed, bagged, or supplied in totes. The point is that there is a nuance to every requirement and it is important to look at the entire process -- from the way the part will function, to the way it will be applied in the next stage of the manufacturing process. By doing so, JBC can offer a solution that is easier, better, faster and lower cost. Sometimes it is as simple as adding pressure sensitive adhesive to aid with assembly or adding a pull tab for easier liner removal, other times it can be as complex as an automated assembly solution.



***Joe Bliss*** *Chief Executive Officer at JBC Technologies, Inc JBC Technologies is a full-service manufacturing partner that converts flexible materials into custom die cut parts for leading manufacturers around the globe. To learn more, go to* ***www.jbc-tech.com***.


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# Part 1
# The Top 20 Tubing & Hose Buying Tips



**BY NEWAGE® INDUSTRIES**

## Introduction

It can be challenging to make sure you've covered all the bases during the plastic tubing and hose selection process. Have you considered all the elements involved with the application? Temperatures, chemicals, pressures, flexibility needs? Have you ever ordered hundreds, even thousands, of feet of plastic tubing or reinforced hose and then found it wasn't the best product for your application?

The Top 20 Tubing & Hose Buying Tips were developed to help avoid the downtime, costs, and frustration involved with ordering the wrong product. The tips highlight details that can be overlooked, present questions to ask your supplier, and suggest research you can do to help avoid buying errors.

### 1. Check for ingredient approvals

You may need to know if the tubing or hose under consideration is manufactured with FDA (Food and Drug Administration), NSF (National Sanitation Foundation), USP Class VI (United States Pharmacopoeia), 3-A SSI (a food safety organization), or other association-approved ingredients.

If this is the case, check the supplier's tubing specifications for this information. If you're unsure whether the application calls for association-approved ingredients, find out from an informed source, such as the end user or product design engineer. Educate yourself about required ingredient approvals to avoid the hassle of buying something you may need to return.

### 2. Be aware of pressure or vacuum requirements

Applications can range from simple drainage lines, well handled by gravity and involving virtually no pressure, to those requiring a robust product able to manage full vacuum (29.9 in./Hg.).

You'll need to consider whether your application is one of these extremes or, more likely, one that falls in between. Some unreinforced tubing can deal adequately with low pressure situations, but it often depends on the tubing material and how hard or soft it is (i.e., hard polypropylene or soft latex).

Reinforced hose is frequently called for in pressure and vacuum applications. In fact, depending on the type of reinforcement (braid, fabric, stainless steel wire, convolutions), certain types of reinforced hose are well suited for pressure applications,

while others are better for vacuum.

Research your needs, ask questions or conduct tests to help avoid situations where the tubing or hose ruptures – or even explodes – because it was not the right product for the application.

### 3. Know the temperatures involved

Several things need to be investigated when it comes to tubing, hose, and temperatures. The first item that usually comes to mind is whether the tubing or hose being considered can withstand the temperature of the product traveling through it, whether that product is a liquid, gas, dry material, or even electrical wiring.

But you also need to think about the temperature of the environment it's in. Will the tubing be inside a controlled environment that's kept at a constant 72°F (22°C)? Will it lay next to other equipment that throws off heat? Will the hose or tubing be outside and subject to both heat and cold, plus variable sunlight? Will it need to operate and remain flexible below freezing?

Another thing to keep in mind is that the higher the temperature, the less pressure the tubing or hose can handle. Your application may be well served with, for instance, 1/4" silicone tubing conveying water at 200°F and a working pressure of only 20 psi at 70°F. But if the temperature increases to 300°F, your pressure handling capabilities will decrease. Reinforced silicone hose should then be considered.

### 4. Consider flexibility and resistance to kinking

Flexibility is a property that varies greatly depending on the type of plastic or rubber material and its construction. Factors that affect flexibility include durometer (softness or hardness), force-to-bend, size, wall thickness, reinforcement style, and temperature. Some plastic tubing and hose, like that made from softer-durometer PVC or polyurethane, is very flexible. Most rubber tubing such as silicone, latex, and Viton™ is also flexible. Examples of harder durometer flexible plastic tubing include nylon, fluoropolymers, polyethylene, and polypropylene. These are fairly stiff in their common straight tubing styles but are bendable. Customization such as coiling, convoluting, and corrugating can make them more flexible.

Closely related to flexibility concerns is kink resistance. If your application calls for the tubing or hose to bend around machinery, its resistance to kinking and collapsing upon itself must be considered. Sometimes a very flexible material – silicone, for instance – can address the issue. But if pressure and/or durability requirements will not allow the use of such a soft material, the hose's construction can come into play. Braid or wire reinforcement can help to reduce the occurrence of kinking, as can products that are multi-layered. Stiff materials can also resist kinking provided that enough length is incorporated into the design.

### 5. Consider weight

The weight of a tube or hose can have a big impact on a final product. If you're designing or planning for, say, the aerospace industry, weight can be critical. You need a product that will help keep overall equipment weight at a minimum but one that can handle the job.

Tubing material, size, wall thickness, and reinforcement affect its heaviness. For example, a typical 100 ft. coil of unreinforced polyurethane tubing, 1" I.D. x 1-1/4" O.D., weighs about 21 lbs. A similar size and length of reinforced PVC tubing weighs 35% more.

Multi-layered hoses – especially those incorporating metal reinforcement – can be quite heavy. Add metal fittings and clamps to form an assembly, and that increases the weight further.

Be sure to research and select a tubing product that meets your application's requirements but doesn't add unnecessary weight.

### 6. Know whether the tubing or hose will impart a taste or odor to the product flowing through it

If your application involves items such as foods, beverages, dairy products, laboratory fluids, or medicines, any taste or odor transferred to those products could be critical.



**Reinforcement such as corrugations adds flexibility to stiff hose.**

Some tubing and hose materials contain plasticizers (chemical agents) to aid processing and add flexibility to the finished product. Under certain circumstances these additives can leach out from the tubing or hose and appear in the streams conveyed by the tubing or hose or possibly affect the stream with a taste or odor. That may be fine if the line is used for drainage or a waste product, but if the fluid is part of a finished product that someone will consume, taste and odor transfer is a significant concern.

Other tubing and hose materials (silicone and polyurethane, for instance) are naturally flexible. There are no plasticizers used in their manufacture, so the potential of taste and odor issues that can come from the use of plasticizers is eliminated. In any case, if taste or odor is a concern in your application, you should sample a candidate hose or tubing to test if the material might affect your stream.

**7. Determine whether the products being conveyed must be seen within the tubing or hose**

Do you need to see the flow of product through the tubing or hose to check for consistency, progression, or to note measurements? Perhaps the nature of the application makes it undesirable to see what's inside, so an opaque color is called for.

Do not assume that because one style of a particular hose material is crystal clear that all hose of that material is the same. The hose's construction, whether it's reinforced with wire, braid, or spirals, can greatly affect its clarity. Several tubing products are available in clear styles – PVC, polyurethane, and some fluoropolymers are examples. But when they're in the form of reinforced hose, their clarity can be compromised.

Many tubing materials can be tinted or colored to varying degrees of clarity. Clear or color-tinted transparent tubing allows light to pass through so that objects within or behind can be easily seen. Some tubing materials (silicone, polypropylene, latex) offer translucency and allow light to pass through but not detailed images.

Other tubing, such as that made from Viton™, is available only in solid colors. Materials like polyethylene and nylon are readily available in colors and are often desired to identify transfer lines, conceal fluids within, or coordinate with equipment.

**8. Learn whether the tubing or hose can be sterilized and reused**

Plastic tubing is often considered a disposable item, but it doesn't always have to be. Learning whether the tubing or hose for your application can be cleaned and used again can save you money.

Discover whether the tubing or hose can handle one or more standard cleaning methods. Other important information to know is how many cycles, or how many times, it may be cleaned using the same procedure. Testing for your specific application is best.

Research the best cleaning method for the type of tubing material you have in mind. Can it be autoclaved? Low-pressure steam sterilized? Gamma irradiated? Cleaned with a specific chemical? Does the application call for a simple flush cleaning with water?

Consider, too, that depending on the labor, equipment, and resources involved with cleaning or sterilizing the tubing or hose, it may be more efficient to replace it.

**9. Evaluate surface characteristics**

Many people naturally think of plastic as having a smooth surface. The plastic products we use regularly (computers, toothbrushes, phones, pens, cars, items from your kitchen) often have smooth, glossy surfaces. In some cases, the surface is textured for aesthetic or gripping purposes.

What type of surface does the



Clear tubing allows fluid flows to be viewed.



Smooth nylon tubing is available in colors for easy line traceability.

tubing or hose in your application need? Whether it will carry fluid, air, or a granular substance, you'll likely want a smooth interior for the most efficient transfer. An irregular surface can cause resistance and slow the rate of flow.

What about the exterior? Should it, too, be smooth, or does it need a surface texture like ribbing to make it easier to grip and hold on to? Be aware that surface properties can also affect electrical conductivity and static dissipation.

**10. Know your packaging requirements**

Are 100-foot coils of tubing or hose acceptable? Do you need 10,000 straight pieces, each five feet long? Must they be bagged, boxed, or are stacked coils on a wooden pallet satisfactory? Can lengths of rigid products be cut and boxed to meet requirements for shipping by UPS or a similar carrier, instead of forcing a truck shipment?

Knowing how the tubing or reinforced hose will be used can help determine your packaging needs. If it's going to be inventoried, you may want a protective covering like a bag or box. Ask about bulk packaging (multiple coils or lengths in one box) and see if it will save you money.

Perhaps the tubing is part of a kit that you assemble. You'd like six-foot lengths of 1/8" I.D. clear, unreinforced PVC coiled into 4" diameter circles, and then placed in individual bags and sealed. Order it that way, so you don't need to do anything with it other than place each bag with your kit.

Do you want the tubing bagged and labeled with your part number, your customer's, or other useful information such as temperature limitations? Will the tubing be used in a medical, pharmaceutical, or other clean application? Check into having it sterilized before it ships to you, so it's ready for use upon delivery.

Consider the tubing's application and how the proper packaging can assist the end user. Keep in mind that special packaging is a custom process that will likely involve minimum order quantities, additional lead time, and added costs. ●

***Part 2*** *The Top 20 Tubing & Hose Buying Tips is available at* http://www.newageindustries.com/whitepaper-request.asp

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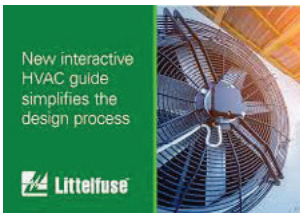
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# What's New



**Grand River Rubber & Plastics**, a gasket and vacuum cleaner flat belt manufacturer in Ashtabula, Ohio, announces **Robert "Bobby" Nelson** as its Lathe Cut Production Manager. Throughout his 27 years at Grand River Rubber & Plastics he has touched nearly every department at the company. After 2 decades on the plant floor, Mr. Nelson transitioned to the Sales Department, where he has worked for the last 6 years.

"Bobby has been an asset to Grand River Rubber & Plastics, continually driving innovation and efficiency across every department he has worked. His extensive knowledge of lathe-cut production, combined with his sales experience gives him a unique skill set to drive production, quality, and value for our customers," says Donald Chaplin, President, and CEO of Grand River Rubber & Plastics.




**Littelfuse, Inc.** unveiled a new HVAC guide, **www.littelfuse.com/HVAC**. Developed to simplify the HVAC system design process, end-users will be able to find the right combination of protection, control, and sensing solutions by product or application type.

"Our new interactive guide allows real-time access to technical information, including data sheets and product specifications, to help streamline product selection," said Debra Jayson, senior marketing manager at Littelfuse. "Engineers, contractors, and electricians can learn which combination of products work best to safeguard HVAC equipment, improve system performance, manage loads and sense temperature reliability."



**WACKER** opened a **global competence center for thermal interface materials** (TIMs) in Shanghai, China. The new laboratory will conduct fundamental research in order to develop silicone-based thermal interface products and solutions for the electrical vehicle market, as well as for consumer electronics and telecommunications.

Over the past decade, thermal interface materials have been one of the fastest-growing segments of the materials market globally, with an average CAGR of more than 6%. Widely used in personal computers, consumer electronics, automotive, and telecommunications, the demand for silicone-based TIMs is expected to grow continuously, as power density is rising exponentially and thermal management systems become increasingly important. Electronic devices and batteries generate a great deal of heat that impacts their functionality and service life and can lead to serious faults. Efficient thermal management is therefore increasingly essential.

"For improved thermal management of components, the industry is increasingly turning to heat-dissipation materi-als," said Christian Gimber, head of Engineering Silicones at WACKER's silicone division. "Our thermally conduc-tive silicones can be processed very efficiently, and they also meet the stringent and rising safety and reliability requirements imposed by the electronics and automotive industries."

The company's new R&D lab in Shanghai will focus on the development of silicone-based thermal interface materials and novel applications, Gimber emphasizes.



**3M** recently announced that each 3M product entering the new product commercialization process will include a **Sustainability Value Commitment** that demonstrates how it drives impact for the greater good. This new, formal requirement embeds sustainability into the pipeline that produces 3M's global products. Historically, about one-third of 3M's annual sales come from products created in the past five years, so the impact is expected to expand greatly with each successive year.

Beyond impacting 3M's own operations, another primary reason for the goal is to help customers achieve their sustainability goals. This new product goal creates more opportunities to collaborate with customers on solutions that improve lives around the world.

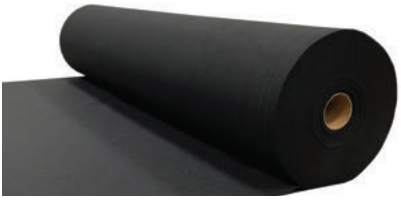
Examples of 3M's Sustainability Value Commitment for new products include reusability, recyclability, energy savings, waste reduction, water savings, responsible sourcing, and the use of renewable materials appropriate to the specific product, from the beginning to the end of each product's life cycle. This commitment can also include products with a core purpose of helping to solve an environmental or social challenge, such as improving air quality, reducing greenhouse gas emissions, and improving worker and patient safety in health care and industrial settings. 3M will measure the progress and impact of this commitment and report on it annually.




One of America's fastest growing privately held companies and leading composite manufacturers in North America, **Mar-Bal, Inc.** is **celebrating its fiftieth year** as an industry leader–known as 'The One-Source Solutions Provider'. From its inception in 1970 as a thermoset composite molder on Scranton Road in Cleveland, Ohio's flats region, the ISO 9001: 2015 Registered Company has charted a formidable and steady growth trajectory in providing customers with comprehensive thermoset composite solutions–including part design, specialized material formulations, decorating, assembly, and customized automation.

Family driven via a ''Total Value Commitment'' philosophy since day one, Mar-Bal, Inc. currently operates manufacturing facilities in Ohio, Virginia and Missouri, as well as an overseas facility in Taizhou, China and Asia Sales Office located in Shanghai. The company serves the appliance, electrical, industrial, food service, transportation, and construction industries–with approximately $70 million in annual sales and 450 employees.

Today, Mar-Bal continues to research and formulate advanced materials, and develop innovative products via its portfolio of brands and proprietary products to deliver composite solutions–driving their customer's technology and success.



**Avery Dennison Performance Tapes** released the **first in a series of bonding studies** that make it easier for converters to evaluate the performance of Avery Dennison Core Series™ Portfolio adhesive products with commonly used materials. This first study focuses on Superior Felt & Filtration's Sunburst 1000™ Felt Series products.

The Sunburst 1000 bonding study was performed in collaboration with Superior Felt and Filtration at the Avery Dennison Performance Tapes Painesville Innovation Center, an ISO 17025-certified facility that can test adhesives under real-world and extreme conditions with tight control of environmental conditions. The study evaluated Core Series Portfolio adhesives using three different laminating methods on Sunburst 1000 products. Samples were tested at 180° F Peel Adhesion at 12 in/min.

The resulting study classifies the performance of Core Series adhesives when used with Sunburst Felt products. Using the study in conjunction with the Avery Dennison Core Series Product Selection Tool allows converters to evaluate bonding strength along with other application requirements to quickly select the right adhesive for the material and application.

"Felt bonding is affected by a variety of factors that range from material thickness to adhesive mass and pressure," said Deanne Lewis, product manager at Avery Dennison Performance Tapes. "Our goal with the study is to leverage our technical expertise and testing facilities to improve and simplify the process of selecting adhesives based on the specific characteristics of the material. Using this study, converters can specify and quote adhesives for Sunburst 1000 products with greater speed and accuracy."

The Sunburst 1000 Felt Series is an earth-friendly, 100% synthetic, needle punched felt used in automotive interior trim and aftermarket products such as seating, headliners, gaskets, and anti-squeak/anti-rattle components. The material is also used in appliances, aerospace, electronics, filtration, and light and heavy industrial applications. The Avery Dennison Core Series Portfolio features the full breadth of the Avery Dennison Performance Tapes adhesive technologies—from general purpose rubber to silicone—in a variety of tape constructions.



**LG Electronics** home appliance manufacturing plant in Tennessee has produced its **1 millionth washing machine.**

A tribute to the hundreds of men and women producing LG's award-winning washers in the United States, according to LG Electronics North America CEO Thomas Yoon.

"In addition to commemorating LG's top-rated washing machines for American consumers, this milestone highlights LG's proud role as a strong contributor to the local economy and leading employer in America," says Yoon.

The millionth washer – a new ENERGY STAR certified front-load model with smart features – rolled off the production line at the $360 million factory, believed to be the world's most advanced, integrated washing machine production plant.

**CIT Relay & Switch** is now further enhanced by the acquisition of **Picker Components** – both companies are designers and manufacturers of high quality electro-mechanical relays and switches. CIT Relay & Switch joined with Picker Components provide robust solutions for engineering. ''The combination of CIT and Picker will generate value for our customers through a large choice of tailored solutions, a global network of services and expanded engineering expertise. It will magnify our value with a wider breath of product while at the same time extracting synergies. We look forward to continued growth and strength this will give to our operation,'' noted Jeff Hampton, President of CIT Relay & Switch.



The world's leading smart home device manufacturers and suppliers have joined forces to develop a global standard that eases smart home implementations. **The Zigbee Alliance**'s working group **"Connected Home over IP", CHIP** for short, aims at increasing compatibility among smart home products, with security as a fundamental design tenet. As a world leading security solutions provider, **Infineon Technologies AG** has helped to define security features in CHIP that are both easy to integrate for manufacturers and easy to use for consumers.

''We are convinced that Project CHIP as an industry-wide standardization effort has the power to boost smart home device manufacturing and deployment'', said Steve Hanna, Senior Principal at Infineon and lead of several security teams within the CHIP Working Group.




**AHR Expo Show Management** has announced the forced cancellation of the 2021 AHR Expo after working with Chicago's McCormick Place Convention Center to tentatively reschedule the Show for March 2021.

With roadblocks set in place by the ongoing COVID-19 pandemic and resulting current state and local restrictions that prohibit mass gatherings over 50 people, an in-person event will not take place in 2021. Instead, Show Management will shift its focus to 2022 and prepare for an in-person event in Las Vegas, NV.

"We've examined every scenario and questioned every roadblock to see how we might hold an in-person event in 2021," said Mark Stevens, Show Manager. "Unfortunately, the pandemic continues to present unpredictable challenges and other variables that are beyond our control. The safety of all our participants — attendees, exhibitors, speakers, employees, venue staff and everyone involved at every level — continues to be our top priority. With these barriers, along with state and local restrictions due to COVID-19, we have unfortunately exhausted all efforts to bring the Show to Chicago in 2021."

Show Management worked alongside Show co-sponsors AHRI and ASHRAE, as well as an advisory council inclusive of Choose Chicago, representatives from McCormick Place and many vendor partners, to explore every possibility that could lead to hosting an in-person event that maintained the expectation for AHR Expo. In consideration of time and planning requirements to participate in the Show, October 15th was marked as the deadline for the decision.

"We were hopeful that March would be a feasible solution, but there are too many obstacles that are beyond our control," said Stevens. "We know how disappointing this news is for the HVACR industry and we are disappointed too."

Since 1930, the AHR Expo has remained the industry's best place to experience the latest trends, products and services in HVACR. The Show serves as a key meeting place for professionals across the industry to network one-on-one with key manufacturers, industry leaders and colleagues at what has grown to be North America's largest HVACR event.

The AHR Expo will return January 31 - February 2, 2022 at the Las Vegas Convention Center in Las Vegas, NV.



**Cleveland-Cliffs Inc.**, has acquired the U.S. assets of **ArcelorMittal**, the world's largest steelmaker, for $1.4 billion in cash and stock. The acquisition means Cleveland-Cliffs will become the largest flat-rolled steel producer in the country, and the largest producer of iron-ore pellets, the company said.

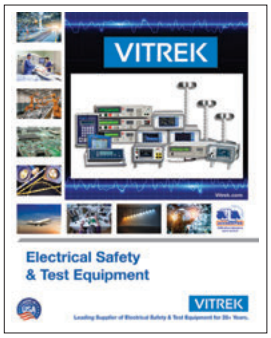
The deal comes just months after Cleveland-Cliffs purchased AK Steel Holding Corp. for $1.1 billion in stock.

Cleveland-Cliffs' history in Cleveland dates back to 1847. The company supplies iron ore pellets to the North American steel industry from its mines and pellet plants in Michigan and Minnesota.

ArcelorMittal said in statements that it expects to take in $1.4 billion, with about a third of that, or $505 million, upfront in cash. The company said that Cleveland-Cliffs also would take on the liabilities of ArcelorMittal USA, including pensions at $1.5 billion. The enterprise value of the deal is about $3.3 billion.

ArcelorMittal is the world's largest producer of steel. Its U.S. subsidiary has about 18,000 employees across the country, the company said.

The deal involves 25 facilities in the United States, including steel-making facilities and mines. The company has a facility in Cleveland on Eggers Avenue, at the Cuyahoga River.




**Vitrek**, a leader in high-voltage test and measurement equipment for over 25 years, introduces a **new Electrical Safety and Test Equipment product catalog**. This comprehensive resource provides detailed information about Vitrek's electrical safety and test equipment including hipot & ground bond testers, power analyzers, high voltage meters, lighting testing products and more. The catalog also highlights Vitrek's two latest product releases; the PA920 power analyzer with industry-leading power measurement accuracy (0.024%, 20Hz-1KHz) at an affordable cost; and the new full line of DC loads, the Vitrek DL Series offers exceptional performance in 125W-500W applications.

The 46-page catalog includes more than just product descriptions. Inside, readers can learn about Vitrek's success stories with industry leaders in a variety of applications that include electronics and appliance manufacturing, automotive, aerospace, military, medical and healthcare as well as calibration and testing labs and R & D departments. The catalog features pre-sale application information, detailed technical specifications as well as information about its academic discount program In addition, the catalog provides an overview of the calibration and certifications available from Vitrek's in-house ISO 17025 accredited calibration lab.



**Air Cleaning Blowers, LLC**, a quickly growing family-owned business, is working diligently to help control the spread of germs during this current pandemic. Thirty-five years ago the owner began his own business and has been marketing and manufacturing industrial HVAC products ever since. Over the years he found a growing need for some type of filter-less air filter, but found no one that made anything similar. In the past several years ACB developed and multi-patented series of technologies that enable a blower to clean the air without having a filter element that clogs and constantly needs replacing. Because of how they work, ACBs really help ventilation during COVID-19 and will long after it ends.

ACBs ventilate, pressurize and clean particles from even exceedingly dusty air without using any filter elements. They help reduce the costs and complications of providing ventilation in industrial, commercial and residential buildings—even individual apartments or rooms. Their state-of-the-art technologies make them simpler to size and use than systems with ordinary air filters and air purifiers because they have no filter elements to clog. Without clogging, ACBs provide constant and predictable airflow, air pressure, air quality and energy consumption. For users, having no filter media provides numerous benefits, among them no filter media to buy or maintain, bring in dry fresh air from outside by removing mist and rain, and no deferred maintenance of filter media to cause surprise consequences.

ACBs are used in applications as diverse and challenging as an African diamond mine, electrical controls in Nucor Steel plants, dust control in a Mitsubishi food-manufacturing plant and US military satellite-tracking trailers in the Middle East. Currently, NIOSH (the National Institute of Occupational Safety and Health) is using them to develop systems to produce clean air to surround and protect coal miners.



**Global, The Source**, a master distributor of HVACR components headquartered in Universal City, Texas, announced the acquisition of **American Radionic Co. Inc.** of Palm Coast, Florida.

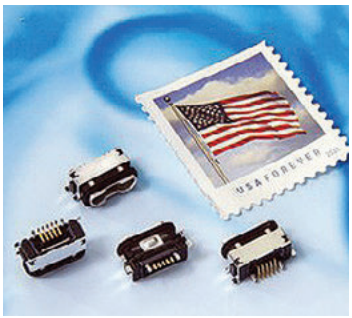
Originally founded in 1982, Global was purchased by CEO Dickie Sirotiak in 2001 and has flourished as a family owned business under the management of Dickie Sirotiak, president, Shaun Sirotiak, and vice president, Alison LeBleu.

"AmRad Engineering, founded in 1939, is the oldest film capacitor manufacturing company in the world that is still operated by the founding family," Dickie Sirotiak said. "Proud of their 'Made-in-America' heritage, the company has been an innovator in their field and has been awarded over 65 significant patents and trademarks across multiple industries, most recently more than nine patents for the Turbo® Series of universal capacitors."

"Global, The Source has played a huge part in our success," said AmRad President Robert Stockman. "Their dedicated and knowledgeable staff has effectively marketed our Turbo products to almost every HVACR wholesaler in the country and this new relationship will allow us to more effectively market some of our lesser-known products. There's a huge market out there and at the same time, we are looking to continue developing new products since our success has been based on innovation."

AmRad President Robert Stockman will be assuming a consulting role. Current Vice President Rich Stockman and all members of management along with AmRad's employees will continue working with Global.



The new **Sealed Micro USB connector** provides a space saving and low-profile interface connection for cellular phone and mobile equipment conforming to Micro-USB (Universal Serial Bus) standard with a IPX7 sealing rating (water tight for 30 minutes to a depth of 1 meter). The Sealed Micro USB connector ensures the waterproof performance of IPX7 by using the gasket and the cured resin. The low-profile height of only 3.4 mm (0.13") is achieved by having the rubber seal directly around the shell. The rugged construction includes a laser welded joint around the shell that provides strength against wrenching.

This low-profiled SMT connector is RoHS compliant. Rated at 30V AC/DC and available in 5 circuits, the signal contacts are rated at 1A AC/DC. When applying power, the signal lines are rated 0.5A AC/DC and the power contacts are rated at 1.8A AC/DC. The Sealed Micro USB connector has an operating temperature of -30 degree C to +85 degree C including temperature rise when applying an electrical current. The PCB mounted contacts are made of copper alloy, nickel under plating and gold plating. The housings are UL94V-0, thermoplastic resin. The shell is stainless steel, nickel base, tin plated and the shell cover is cooper alloy, nickel base, tin plated. SMT headers are provided on embossed tape for automatic insertion equipment.



**Master Bond** EP29LPAOHT is a two component, NASA low outgassing approved epoxy system featuring a long working life of 8-10 hours per 1,000 gram batch. Due to its low exotherm and flowable consistency, this product is suitable for specialty potting applications where large masses of the epoxy need to be cured. It can be mixed and poured in volumes of more than a gallon at a time. Even in deep cross section thicknesses, this product does not generate much heat. Since the epoxy does not start gelling quickly, it is especially advantageous for use in many production environments that require a long open time after mixing.

EP29LPAOHT has a 50 to 100 mix ratio by weight and a mixed viscosity of 10,000-30,000 cps. It possesses a high thermal conductivity value of 0.87-1.15 W/(m•K), and is electrically insulative with a volume resistivity of more than 1015 ohm-cm. Upon curing EP29LPAOHT exhibits low shrinkage, dimensional stability and a low coefficient of thermal expansion. Other noteworthy properties include a compressive strength of 24,000-26,000 psi, a Shore D hardness of 80-90 and a tensile modulus of 450,000-500,000 psi. This epoxy is serviceable over the wide temperature range of -60°F to +350°F.

EP29LPAOHT bonds well to a variety of substrates including metals, glass, ceramics and many different plastics. It resists many chemicals including, but not limited to, water, fuels and oils. It is available for use in ½ pint, pint, quart and gallon container kits. EP29LPAOHT does not contain solvents and is RoHS compliant.



The new **USB Type-C connector** features the next generation USB standard for data, power, and audio/video connections which allow for faster speeds, more powerful connectivity, and a simpler directional connection for a wide range of products including PCs, printers, mobile devices, and a multitude of consumer & industrial applications. The connector enables lightning fast speed transmission of 10 Gbps maximum and provides power supply of 5A AC/DC maximum. The USB Type-C receptacle provides a space saving and low-profile interface connection with a height of only 3.48 mm (.137") and a depth of only 8.8 mm (.346"). The reversible mating interface enables secure, reliable mating without regard to the up or down direction of the plug.

This low-profiled SMT connector is RoHS compliant and features non-Halogen resin. When applying power, the signal lines are rated 5A AC/DC and the power contacts are rated at 20V AC/DC and are available in 24 circuits (2 rows or 12), the signal contacts are rated at 1.25A Pin (DC) Vbus & GND & CC1 & CC2 circuits and 0.25A Pin (DC) for the other circuits. The USB Type-C connector has an operating temperature of -25 degree C to +85 degree C including temperature rise when applying an electrical current. Contact leads are DIP type for front side and SMT type for rear side which allows for superior performance over time due to the accumulated impact of the insertion process.




**TDK Corporation** presents the EPCOS Compact S14 AdvanceD-MP series of metal oxide disk varistors that feature smaller dimensions with the same excellent performance as comparable S14 AdvanceD-MP types. The disk diameters of the new B72214P2* varistors range from 13 mm to 14 mm, a reduction of approximately 3 mm. Like their current S14 counterparts, these components offer a maximum surge current capability of 6 kA at 8/20 Qs according to IEC 62368-1. The Compact S14 series covers a wide operating voltage range from 130 to 460 VRMS. The multiple pulse varistors are designed to be used in power supplies as the primary protection against low-level repetitive surge currents. Their optimized design results in an improved derating performance over time. All types have UL, CSA, VDE and IEC approval. Thanks to their compact dimensions and outstanding electrical characteristics, the Compact S14 varistors help design engineers reduce the size of their products and are suitable for a wide range of applications. These include switch-mode power supplies, drivers for LED lighting, home appliances and smart meters.

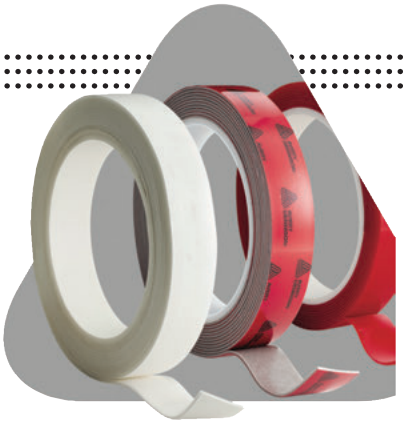
**Main applications**

- Primary protection against low-level repetitive surge currents
- Switch-mode power supplies, drivers for LED lighting, home appliances and smart meters

**Main features and benefits**

- Compact disk diameters of 13 mm to 14 mm
- Surge current capability of 6 kA at 8/20 Qs

Multiple pulse capability against low-level repetitive surge currents



**Avery Dennison Performance Tapes**, today extended its Acrylic Foam Bonding (AFB™) portfolio with the release of the 94 Series product line. The new 94 Series AFB heat-activated tapes are engineered to deliver the high holding power required for rubber extrusion bonding in industrial applications. The new line also features an easy release liner to aid in removal during application. These products are offered in full web, spool wound or level wound formats to increase flexibility for converters and their customers.

"Rubber extruders and OEMs are actively seeking alternatives to their current bonding solutions for extruded rubber applications," said Scott Krusinski, application engineer at Avery Dennison Performance Tapes. "With this new high-performance tape product, we are delivering on their needs by offering a lower cost option without compromising performance. We are pleased with performance data on the 94 Series AFB tape."

The new product delivers savings over adhesive tapes with similar bonding performance used in the marketplace today and also provides advantages compared to alternate attachment techniques such as pins, channels, wire carriers and liquids. With tape, OEMs component manufacturers do not have to deal with the holes required for pins or add extra weight to the assembly as with channels and wire carriers. Compared to liquids, tape provides a more uniform application of adhesive.

The Avery Dennison AFB portfolio includes pressure-sensitive tapes that feature excellent bonding to a broad range of substrates, high temperature resistance and exceptional durability. These capabilities enable AFB tapes to be used across a wide range of component assembly, mounting and fixation applications.

The tapes are designed for a variety of applications, including:aerospace, appliance, automotive, recreational vehicles, building and construction, electronics, print and packaging and other transportation applications.





**WACKER** recently announced that technology service provider TÜV Nord has approved its manufacturing method for silicone sealants according to the new REDcert2 standard. WACKER's approach involves determining the mass fraction of raw materials and auxiliaries derived from fossil-based resources and offsetting this with methanol produced from biomass. According to WACKER, it is the first chemical company to produce the organic components of its sealants exclusively on the basis of plant-based materials instead of raw materials derived from petrochemicals.

Silicone sealants consist primarily of a silicone polymer that cures at room temperature to form a rubber-like elastomer, plasticizers, fillers, and additives. Apart from silicon, which is manufactured by reducing quartzite with coke, an important raw material for manufacturing the polymer is methanol. The compound is first converted to methyl chloride, which then reacts with elemental silicon in the Müller-Rochow process in order to produce a mixture of various methylchlorosilanes. These, in turn, serve as starting products for silicone production. WACKER reports that it uses methanol derived both from fossil raw materials and from biomass, which makes no difference in chemical terms since the molecule is identical with respect to its structure and properties.

The mass balance method reportedly takes advantage of that. If methanol from both plant- and fossil-based sources is used within an integrated production system, the portion of raw materials derived from biomass can be determined and explicitly allocated to individual sales products.



**The winner of the Innovation Award** in the ventilation category at the 2020 AHR Expo was not originally planned. Rather, it was born out of necessity.

At the inception stage of the development process, the product was supposed to be a concept to harvest waste from residential HVAC systems. Fast forward to 2020, and **Infinitum Electric** has created a significantly smaller, smarter and quieter HVAC motor. The product, the IEx series motor from Infinitum Electric, has benefits that equate to an ultra-high-efficiency motor that results in up to 25% lower costs for customers.

"The printed circuit board (PCB) stator concept came from the necessity to reduce the cost of the motor in our original product idea. We designed the first stator, kept iterating and decided that the stator itself was where our focus should be," he said.

Schuler said the electric motor has evolved very little since it was invented more than a century ago.

"In a world of ever-increasing efficiency, it's an invention that has lagged behind. With patented PCB-based technology, we've solved this problem (by) revolutionizing the motor," he said.

Designed specifically for HVAC applications, the motor mostly replaces traditional fan, compressor and pump motors in HVAC units. By entering the HVAC market, the company is on a mission to disrupt the way electric motors consume and create electricity, he said.

"On top of increased efficiency, replacing the traditional stator with our patented version equates to quieter operation and reduced vibration—both benefits especially impactful in HVAC units," Schuler said.

Conventional motors include a stator made of copper windings wound around an iron-laminated core. Infinitum replaces the copper windings and iron core with a smaller, lighter-weight printed circuit board that includes etched copper conductors.



**Master Bond MasterSil 151S** is an addition curing two part silicone system that may be used as an adhesive, sealant, coating or form-in-place gasketing material. A unique feature of this product is that despite its silicone chemistry, it passes NASA low outgassing specifications. Also, it retains superior electrical conductivity with a volume resistivity of 0.004 ohm-cm at 75°F. "This silicone is ideal for applications where low stress is required, since it is highly flexible across a wide service temperature range. It is capable of resisting aggressive thermal cycles and shocks," says Rohit Ramnath, Senior Product Engineer.




**Coto Technology's RedRock® RR122-1B52-511 / 512 Series TMR Digital Magnetic Sensor** offers the highest sensitivity and lowest power consumption available in an active magnetic sensor.

Features an operating frequency of 250 Hz, a voltage supply range of +1.7V to +5.5V and an extremely strong magnetic sensitivity (30 G or 3 mT) in an ultra-miniature package size at a highly-competitive price. Ideal for use within products ranging from small battery-powered electronics to industrial machinery. Specific applications could include proximity detection, rotary sensing, fluid level detection, door and lid closure detection, utility meters, motor controllers and consumer electronics.

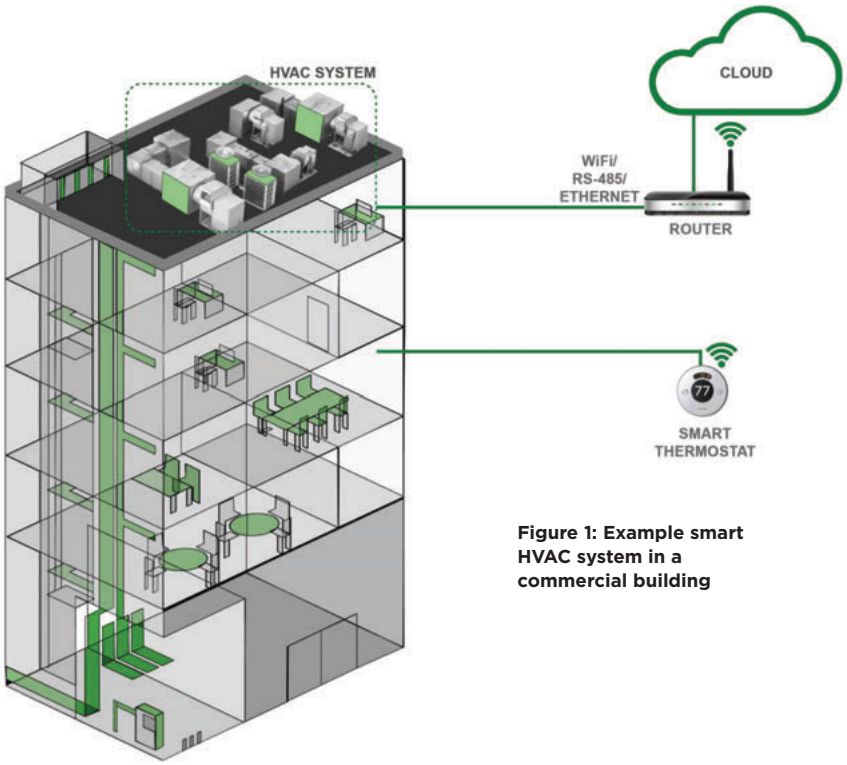



**Figure 1: Example smart HVAC system in a commercial building**

# Maximize Efficiency and Reliability of HVAC Systems

**BY RYAN SHEAHEN**

Heating, ventilating, and air conditioning (HVAC) systems are major consumers of electric power. Controlling growth in demand for power necessitates the development of more efficient HVAC systems. Manufacturers are rising to the challenge by developing smart HVAC systems for commercial buildings (see Figure 1). Two major factors are driving growth: Government initiatives requiring more energy-efficient systems and consumer demand for improved indoor air quality. As a result, the HVAC market is expected to grow from 110 million units in 2020 to 140 million units in 2024.[1]

Smart HVAC systems must be both efficient and reliable while maintaining a comfortable environment. To minimize consumption of energy, the system must maximize the efficiency of the drives for all motors. Of importance for commercial systems is the need to ensure reliability for maximum uptime. Designers can incorporate the necessary efficiency and reliability into HVAC system designs by including appropriate protection, control, and sensing components into the circuitry. These components provide the following capabilities:

- Protection components prevent overloads and transients from damaging circuitry
- Control components aid in minimizing power consumption for maximizing efficiency
- Sensing components protect the system from overtemperature conditions

Figure 2 illustrates the types of components and the circuits that help to achieve the dual objectives of efficiency and reliability for commercial HVAC systems. The next paragraphs will provide insight into these components.

## Protecting an HVAC System and Minimizing its Power Consumption

Figures 3 and 4 show a representative block diagram of a commercial HVAC system's circuits. The block diagrams

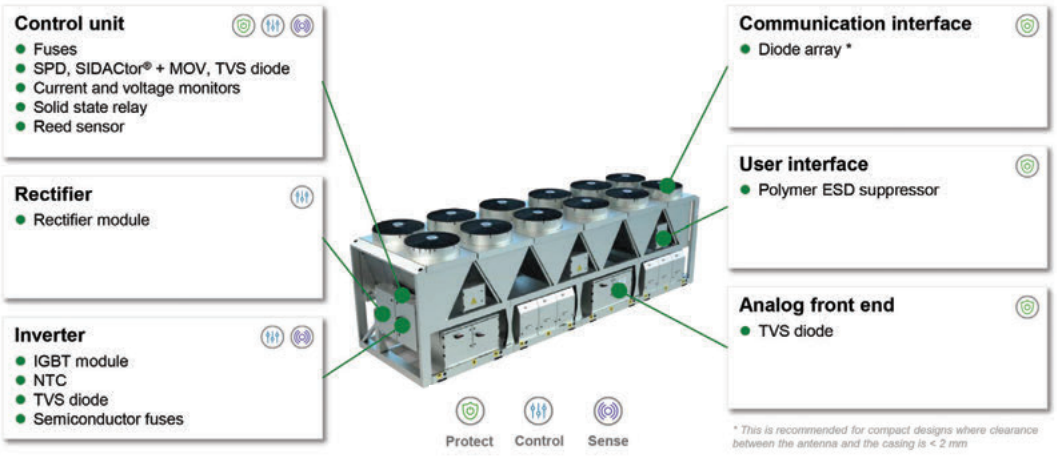
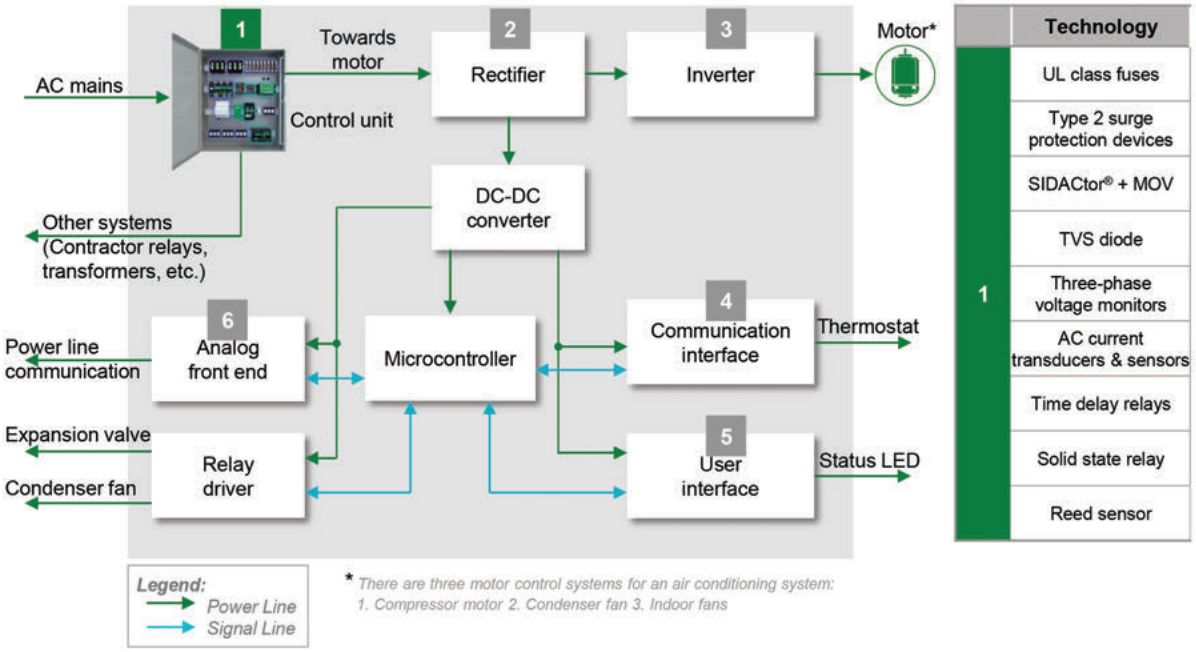



**Figure 2: An example commercial HVAC system showing the recommended protection, control, and sensing components needed to ensure a reliable and efficient system**

**Figure 3: HVAC block diagram showing the recommended protection, control, and sensing components for the Control unit**




for the two figures are identical, but the recommended components in each figure apply to different circuit blocks. Figure 3 details components for the Control Unit, and Figure 4 lists components for the other circuit blocks.

## Control Unit

The Control Unit draws power form the AC mains and provides the power to control a motor. The Control Unit interfaces with the AC mains and is subjected to both its overloads and transients.

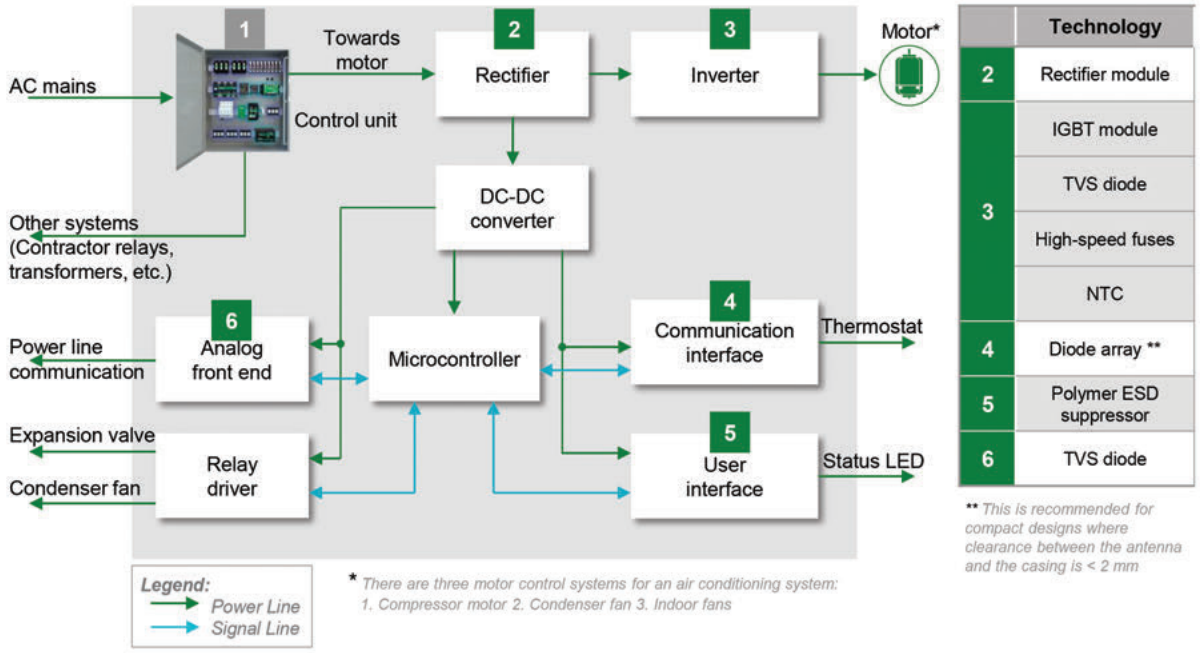
Consider employing a fuse to protect the Control Unit from current overloads. Since the HVAC system is powering motors, the fuse must withstand inrush currents drawn by the motors. A time delay fuse, preferably a two-element fuse, will avoid nuisance failures due to motor inrush current. A two-element fuse can be safely sized for overload circuit protection while supporting the momentary high inrush current. The benefit of fuses for protecting the Control Unit from overloads is their response compared with the response of a circuit breaker. Fuses operate faster than circuit breakers, and fuses do not require maintenance testing or calibration. Ensure that the selected fuse is rated in excess of the maximum operating voltage of the Control Unit circuit. With 600 V ratings, nominal fuse current ratings can be as high as 1200 A to meet the requirements of large HVAC systems. You will want to use a fuse with a high interrupting rating so that the fuse will open and interrupt the worst-case overloads. Many fuses have interrupting ratings of 200,000 A. Also consider the fuse's time current response to continuous overload currents. You will want the fuse to open to 200% overloads in well under a minute. Finally, if circuit board or panel space is a concern, look for a fuse that will meet your requirements in the smallest possible package size.

AC mains can subject a system to a wide range of high voltage transients. A number of components protect the Control Unit from the various types of transients. A surge protector protects against high energy transients such as lightning strikes which are fast high voltage and high current transients. A surge protector is comprised of a metal oxide varistor (MOV) with a series thermal detector in each AC mains line. A surge protector can safely absorb a transient as large as 40,000 A and can respond to the overload in < 25 ns.

Specifically, for protecting the sensitive electronic circuitry in the control panel, consider using a bidirectional protection thyristor in series with an MOV. The MOV can absorb peak surge currents as high as 10,000 A or with energies as high as 400 J. The thyristor has a crowbar-type response and can also handle large surge currents while maintaining a low clamping voltage.[2] The thyristor enables use of an MOV with a low clamping voltage and provides greater safety for downstream electronic circuits.

After covering the primary side of the circuit, using a transient voltage suppressor (TVS) diode to clamp

**Figure 4: HVAC block diagram showing the recommended protection, control, and sensing components for the other circuits**




transients on the secondary of the transformer is recommended. TVS diodes also provide electrostatic discharge (ESD) protection by safely absorbing 15,000 V strikes through the air or 8,000 V strikes from direct contact. Furthermore, TVS have ultra-fast response times of under 1 ps.

## Protecting the HVAC Motors

There are three locations where you should make sure to protect the HVAC Motors:

• ***Monitor the AC mains power at the motor:*** Use a three-phase voltage monitor – Protects the motors from potentially harmful AC mains conditions. Select a monitor that will de-energize the motor if it detects voltage unbalance, high voltage, or phase faults.

• ***Monitor motor current:*** Use a current monitoring relay – Ensure proper and efficient motor operation. Using a magnetic sensor eliminates the need to place a resistive sensing element in the circuit which would consume supplied power and reduce the efficiency of the circuit. Select a current monitoring relay with outputs to feedback motor status to the control system

• ***Prevent short cycling of the motor:*** Use a time delay relay – Prevent the motor from re-starting too quickly (short cycling) after being de-energized. Time delay relays also enable proper sequencing when multiple motors must be powered in a fixed order. Select a time delay relay with sufficient adjustable timing for the type of motor in use. Select a solid -state relay for long operating life. Look for an encapsulated package to avoid degradation due to shock, vibration, and humidity.

Noise and transients generated by the motor can impact the control electronic circuitry. Use an isolation switch to energize the motor. Select an optically isolated switch with zero-crossing monitoring to minimize the generation of transients during motor turn-on.

The last protection element for the Control Unit is a reed sensor for sensing the position of the Control Unit door. The reed switch prevents users from accidental contact with dangerous voltages. Select a reed sensor model with appropriate

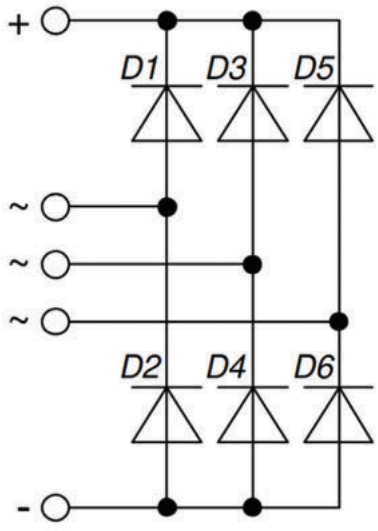



**Figure 5: 3-phase package of rectifier diodes**

sensitivity for the application. Also use a hermetically sealed model to avoid contamination of contacts and to achieve long life operation.

### Rectifier

The rectifier circuit converts the AC mains voltage to DC voltages for powering the motor-controlling inverter and for providing DC voltage to the communication and control circuits. Selection of the power rectifiers impacts power consumption. You want rectifiers with low forward voltage and low reverse leakage current to minimize energy lost in the rectifier. Low power-consuming rectifiers generate less heat and require smaller heat sinks which saves both cost and circuit board space. You can select a set of rectifiers in a single package to save even more space. Figure 5 shows an example of a rectifier package for converting three-phase AC voltage to DC voltage.

### Inverter

The Inverter converts DC to AC to drive the motor. This power circuit needs to be both efficient to minimize power consumption and robust to current overloads and transients. Consider using an insulated gate bipolar transistor (IGBT) which have fast switching times to reduce power loss. Select IGBT transistors with VCE(Sat) under 2 V and gate leakage current under 1 µA for maximum motor drive efficiency. Three phase, high-side, low-side IGBT modules are available in a single, space-saving package; and, the three outputs have similar characteristics which simplifies the control requirements. See Figure 6.

The high-speed switching of an IGBT reduces power consumption; however, their turn-off transient voltages can exceed the transistor's ratings and cause damage to the component. Using a TVS diode between collector and gate can clamp the transient and raise the gate voltage to reduce the collector-gate voltage. This slows the rate of rise of the transient voltage. Insertion of a TVS diode between collector and gate of a TVS diode is a protection technique known as active clamping. For more details on the benefits of active clamping for IGBT protection, see the application note.[3]

If you are using IGBTs that do not have an internal thermistor for monitoring their temperature, a negative temperature coefficient (NTC) thermistor is also recommended. Power semiconductors can be subject to thermal runaway if their junction temperatures exceed their temperature rating. Make sure that your thermistor has sufficient range to exceed the expected temperature rise of the IGBT. If you are using individual IGBTs in TO-style semiconductor packages, models of thermistors are available with lugs that mount directly on the package.

Protect the Inverter circuit from short circuit conditions with a fast-acting fuse. For example, high speed fuses will open in response to a 400% overload in under a second to protect the semiconductors. High speed fuse models for protecting power circuits have current ratings up to 800 A with voltage ratings of 750 V.

### Communication Interface

The Communication Interface provides wireless transmission of temperature information to a remote monitoring station. Since the Communication Interface is exposed to the external environment, you should provide protection from ESD with a bi-directional TVS diode which will absorb an ESD strike of either polarity. Select a diode rated to withstand as much as ± 15,000 V through the air and ± 10,000 V from human contact. For minimal impact on the integrity of the wireless transmission and reception, use a diode with capacitance under 1 pF.

### User Interface

Users access the system through a wireless LAN (Wi-Fi) interface. In this circuit, use a polymeric ESD suppressor to protect the Wi-Fi chipset form ESD. A polymeric ESD suppressor responds to a transient in under 1 ns. Look for models

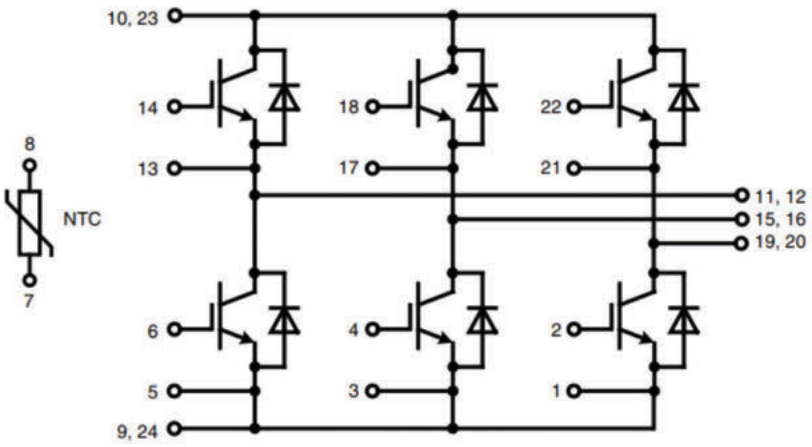



**Figure 6: 3-phase high side-low side IGBT power transistor module**

with leakage current under 1 nA to minimize power draw; and, look for models with low capacitance, under 0.15 pF, so as not to interfere with the signal communication. Of most importance, select a model rated for high levels of air and direct contact protection.

### Analog Front End

The Analog Front End communicates with the power utility over the AC mains via the power-over-Ethernet protocol. This circuit needs protection from voltage transients such as lightning that can propagate on the AC mains. A high power TVS diode can absorb up to 15,000 W of peak pulse pow-er. TVS diodes can respond in under 1 ps to clamp the transient quickly to a safe voltage for the circuit.

### Applicable Standards

Table 1 provides a list of important safety standards for industrial control panels and HVAC systems and an important international standard on requirements for ESD protection. Make sure that you are aware of these standards and plan for compliance in the early stages of your development project. Revising a design following a failure uncovered by a certified testing lab adds to project costs and delays introduction of your product.

### Benefit of a Robust and Power-Efficient Design

By including protection and sensing components as a design objective and incorporating standards compliance early in the project, you can cost-effectively develop a robust and reliable HVAC system. Using efficient control components can facilitate development of a low power consumption product. Of course, your design is always a trade-off between performance and total cost of ownership. While some technologies may cost more than others, additional factors may show that the lowest total cost of ownership requires a higher cost component technology. Take advantage of component manufacturer's engineering expertise when selecting protection, control, and sensing components. Using a trustworthy vendor saves your time and resources.

Reliability and efficiency enhance the reputation of your HVAC system. A reputation for high quality can result in market share growth and revenue growth. That leads to improved profitability. ●

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**2** High Power Semiconductor Crowbar Protector for AC Power Line Applications. 2020. https://info.littelfuse.com/hubfs/Electronics/Documents/Littelfuse_High_Power_Semiconductor_Crowbar_Protector_for_AC_Power_Line_Application_Note.pdf.pdf

**3** Application Note: Using High Voltage TVS Diodes in IGBT Active Clamp Applications. 2020. https://www.littelfuse.com/~/media/electronics/application_notes/littelfuse_using_high_voltage_tvs_diodes_in_igbt_active_clamp_application_note.pdf.pdf



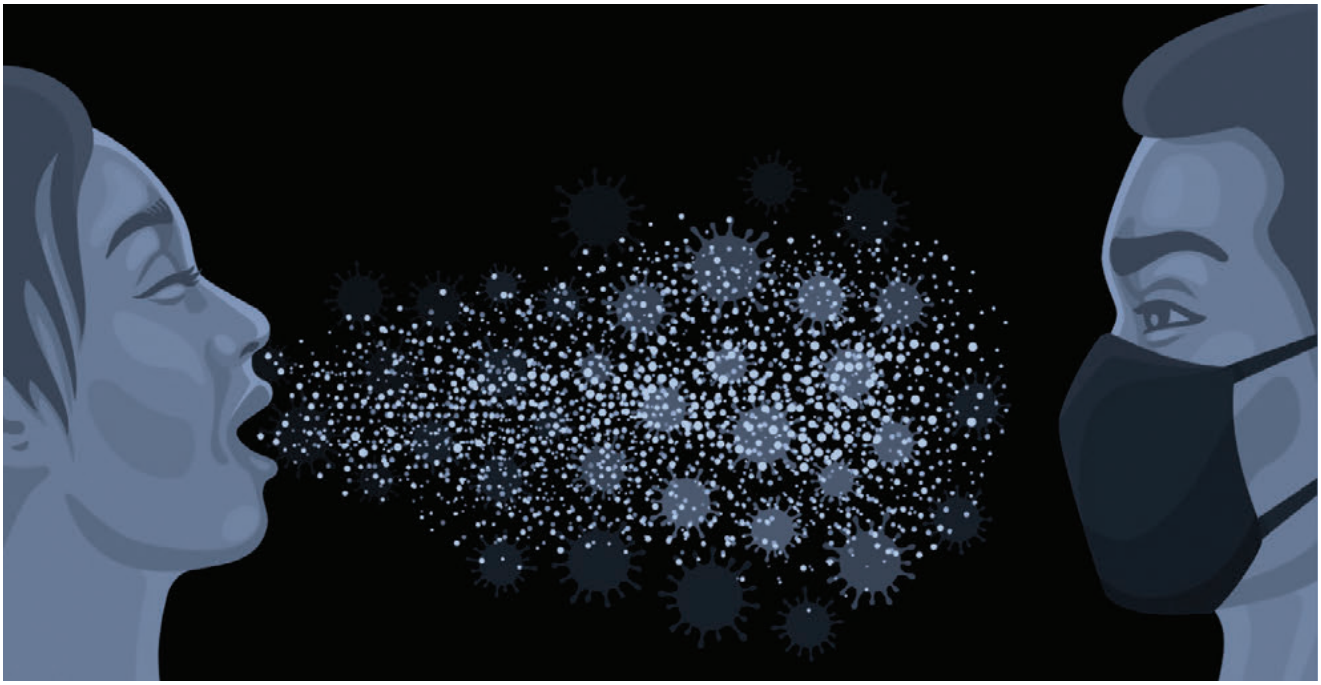


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***Circuit Protection Selection Guide***

***Sensing Products Selection Guide***

| Standard | Title | General scope | Region |
|---|---|---|---|
| UL 508 A | Standard for safety (Industrial control panels) | Industrial control panels intended for general industrial use, operating from a voltage of 1000 volts or less. This equipment is intended for installation in ordinary locations, in accordance with the National Electrical Code, ANSI/NFPA 70, where the ambient temperature does not exceed 40° C (104° F) maximum | NA |
| UL 1995 | Standard for safety for heating and cooling equipment | These requirements apply to the following stationary equipment for use in nonhazardous locations rated greater than 600 volts up to 7200 V, and remotely controlling assemblies for such equipment) heat pumps, for heating and cooling with or without factory, or field-installed electric resistance heaters, or hot water or steam heating coils) air conditioners for cooling with or without factory, or field-installed electric resistance heaters, or hot water or steam heating coils | NA |
| IEC 61000-4-2 | Testing – Electrostatic Discharge (ESD) | This standard is made to check the capability of the equipment to survive repetitive electrical fast transients and bursts | Global |



# Inactivate Airborne Pathogens with UV Airstream Disinfection

**BY UV RESOURCES**

Like other disease outbreaks, the 2019 COVID-19, coronavirus pandemic has intensified the search for effective infection control measures.

Ultraviolet Germicidal Irradiation (UVGI or UV-C) is drawing widespread attention as a formidable weapon against surface and airborne bacteria and pathogens.

Nearly eight decades of research and thousands of applications in hospitals, urgent care centers, primary and secondary schools, universities and first-responder locations have proven the efficacy of UV-C to inactivate airborne and surface-bound viruses, mycoplasma, bacteria and fungi.

Since the onset of COVID-19, UV-C has become one of the most in-demand technologies around the world. Both the U.S. Centers for Disease Control and Prevention (CDC) and ASHRAE now include UV-C as a recommended mitigation step to slow the spread of the COVID-19 virus.[1]

Almost overnight, UV-C systems have transformed from a HVAC efficiency option to a health and safety necessity.

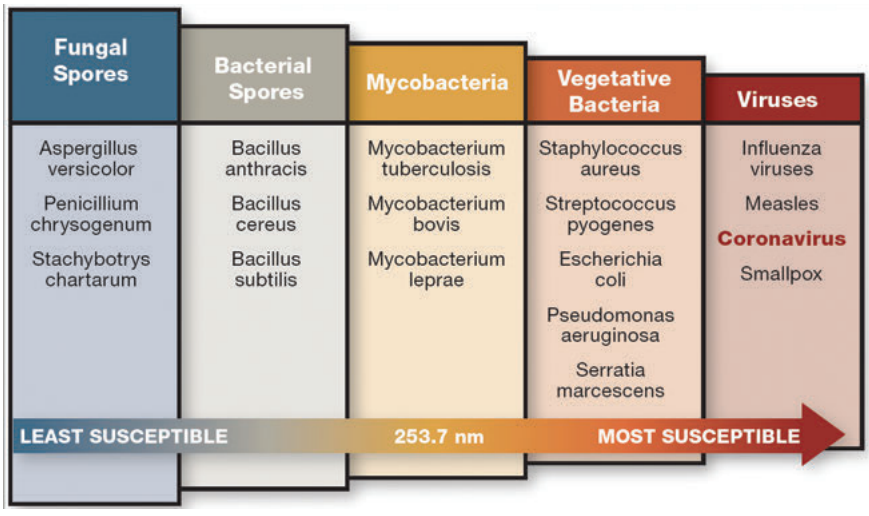



**Figure 1: Germicidal UV-C Inactivation of Microorganisms by Group. Data Source ASHRAE Handbook-HVAC Applications Ch 62.**

### Inactivating "Killing" Airborne Pathogens

Since the 1940s, many hospitals have relied upon germicidal UV-C energy to control airborne infectious diseases, but use waned with the arrival and proliferation of antibiotics.

In the 1990s, drug-resistant "superbugs" and hospital-acquired infections sparked a renewed interest in UV-C since it can inactivate or kill virtually any microorganism, including antibiotic- resistant germs.

UV-C's germicidal or germ-killing effects have been proven in multiple peer-reviewed studies over many decades.

The 253.7 nm electromagnetic waveform is well- absorbed by microbial DNA and RNA, making it impossible for viruses and bacteria to develop a resistance. In other words, UV-C radiation kills energetically, rather than biologically.

Through a process known as photodimerization, this electromagnetic damage destroys a cell's nucleic acids and disrupts its DNA, preventing microorganisms from infecting and reproducing. There are three primary means of applying UV-C for air and HVAC surface protection against infectious agents: 1) Upper-Room or Upper-Air, 2) HVAC airstream disinfection, and 3) HVAC coil/surface irradiation. For the purposes of this paper, we will focus on HVAC airstream inactivation, also known as in-duct UV-C treatment.

### HVAC Airstream-Disinfection Systems

UV-C air disinfection systems are installed in air- handling units, HVAC ducts, or air distribution systems to inactivate microorganisms and disinfect moving airstreams "on-the-fly."

Designed to disinfect air as it passes through an HVAC system and before it is recirculated or exhausted, in-duct UVGI irradiates the entire cross-section of a duct with high-intensity UV-C energy.

The required UV-C dosage for an in-duct system is based on the specific target pathogen and the application parameters and can be on the order2 of 1,000 up to 10,000 μW-s/cm$^2$.

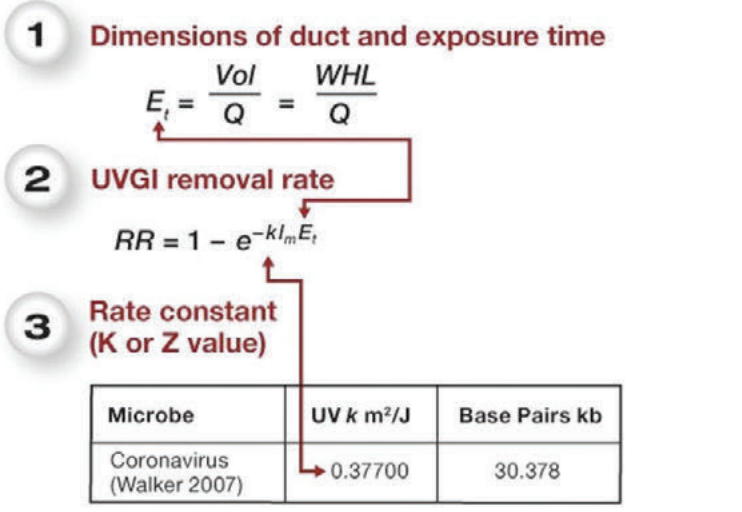
More specifically, UV-C dose is determined by the amount of germicidal energy a pathogen absorbs over a specific length of time. Therefore, UV-C dose is a function of time and intensity.

Consider, for example a surface-disinfection application involving cooling coils. The coil surface is stationary, so UV-C exposure or "residence" time is continuous. As a result, the UV-C intensity can be low. In the case of a moving airstream, however, exposure time is limited—a mere fraction of a second in some cases—so UV-C intensity must be greater.

### Environmental Factors that Influence Pathogen Control

In addition to calculating UV-C intensity and exposure time, there are many operational and site-specific conditions to consider for an airstream disinfection system including:

- **Target Pathogen** and its susceptibility to UV-C. The amount of UV- C energy needed to inactivate individual bacteria, viruses, and spores have been identified through decades of research.[3]
- **The volume and velocity of air** traveling through the HVAC system, which will impact the length of exposure (residence time). A higher volume of air and/or faster- moving air requires greater intensity (more UV-C lamps) and/or a longer duct run to increase residence time.




**Exposure time**

***Vol*** = volume of UV chamber, m$^3$
***Q*** = airflow, m$^3$/s
***W*** = width, m
***H*** = height, m
***L*** = length, m

**Removal rate**

***RR*** = removal rate, fraction or %
***k*** = UV rate constant, m$^2$/J
$I_m$ = mean irradiance, W/m$^2$
$E_t$ = exposure time, seconds

**FIGURE 2: Data Source: Kowalski, Wladyslaw. (2009). Ultraviolet Germicidal Irradiation Handbook.**

Said differently, as velocity increases beyond the typical 500 fpm, UV intensity must likewise increase. Conversely, less UV intensity is required for air velocities below 500 fpm.

- **The length of the plenum/duct**—the longer the plenum or duct run, the better, as residence time and, thus, dose is increased.
- **Temperature**—because cold air reduces the output of UV-C lamps and high relative humidity (RH) affects pathogen susceptibility to UV-C, airstream-disinfection measures can be more effective on the upstream side of a coil.
- **Although on-the-fly disinfection** is accomplished downstream of coils, it typically requires greater UV-C fluence/intensity (more lamps).
- **Lamps**—using more or higher-output lamps will increase the total dose. Lamps with 360-degree irradiation allow more UV-C energy to saturate a plenum, increasing UV-C influence.
- **Reflectivity of the plenum**—different metals boost UV-C dose, as the germicidal wavelength remains "in play" instead of being absorbed by the surfaces. These reflectance multipliers can significantly increase UV-C fluence levels (Figure 3).

| Duct/Plenum Surface | UV-C Multiplier |
|---|---|
| Stainless Steel | 1.40 |
| Galvanized Steel | 1.50 |
| Aluminum | 1.75 |

Use of reflective materials can increase germicidal UV disinfection dosage/fluence

**Figure 3**

- **Fixture spacing**—decreasing lamp-row spacing (e.g., from the surface- irradiation standard 36-in. centerlines to 15-in. to 18-in. centerlines) increases UV-C fluence.

## Pathogen Susceptibility to Germicidal UV

Although environmental considerations may increase or decrease the UV-C dose, it is best to utilize all the factors of a specific application in a predictive- modeling formula to design an effective airborne disinfection strategy.

In Figure 2, we can calculate the amount of time a pathogen is exposed to UV energy to determine the total exposure time and removal rate.

Bacteria and viruses vary in susceptibility to UV energy, with environmental organisms, fungal spores, and mycobacteria being relatively harder to kill than more rapidly replicating and non-environmental microbes and most bacteria. But even fungi are killed effectively with high-dose UV.[4] For example, studies have demonstrated that viruses are more susceptible to UV-C inactivation than typical bacteria (Figure 1).[5]

It is important to note that UV-C operates by line-of- sight; it kills only what it can see (e.g. the inside of a closed drawer cannot be disinfected unless the drawer is exposed to the UV energy).

## Lamp Placement

When designing a germicidal-UV disinfection system, engineers should consider the location within the AHU and its impact on performance.

Lamps are typically installed downstream of the cooling coil to address pathogen growth due to the presence of coil condensation and wet drain pans – both can serve as microbial breeding grounds.

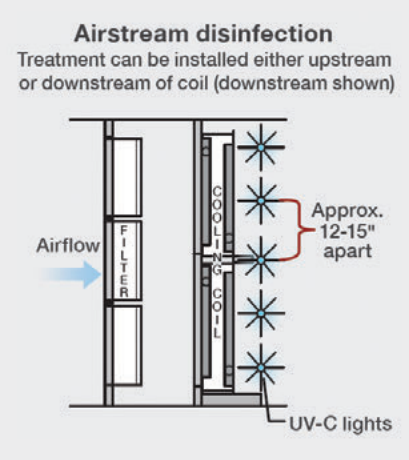



**Figure 4**

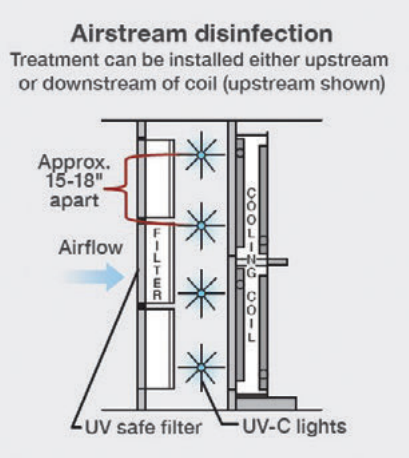



**Figure 5**

Today, many building engineers are converting their existing UV installations into airborne disinfection applications by simply installing additional UV-C lamps to inactivate airborne viruses. Others are installing new systems downstream of the cooling coil to obtain the benefit of airborne inactivation and coil/drain pan irradiation (Figure 4).

Installation of lamps upstream of a coil (Figure 5) can leverage higher lamp output with the warmer environment (70°F avg. upstream vs. 55°F avg. downstream) to enhance airstream disinfection.

For upstream applications, engineers need to specify UV-C safe air filters to prevent degradation by the germicidal energy.

## Conclusion

Although germicidal UV-C systems have been used successfully for more than 80 years, their application in infection control settings has waxed and waned.

Given the increased focus on the prevention of airborne transmission of infectious diseases, facility professionals can utilize germicidal ultraviolet technologies to greatly reduce concentrations of pathogens in a highly reliable and cost-effective fashion.

In fact, ASHRAE's position document on airborne infectious diseases (reaffirmed February 2020) identifies germicidal UV-C energy as a proven method of controlling airborne infections, alongside ventilation and particle filtration.

Germicidal UV has been extensively peer-reviewed and is recognized in two ASHRAE Handbook Chapters (2019 HVAC Applications and 2017 Fundamentals (Ch. 62) and two ASHRAE test standards (ANSI/ ASHRAE 185.1 "Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms" and 185.2 "Method of Testing Ultraviolet Lamps for Use in HVAC&R Units or Air Ducts to Inactivate Microorganisms on Irradiated Surfaces."

The technology is also reviewed in three ASHRAE Position Documents (Airborne Infectious Diseases; Infectious Aerosols; Filtration and Air Cleaning).

What's more, germicidal UV has been recognized in the CDC's guidance for office buildings,[6] health-care facilities[7,8] and dental settings.[9]

Recent guidance from ASHRAE, the CDC and published technical articles in HVAC trades provide building engineers and facility staff with the resources needed to size, select, install, operate, and maintain UV airstream disinfection systems. ●

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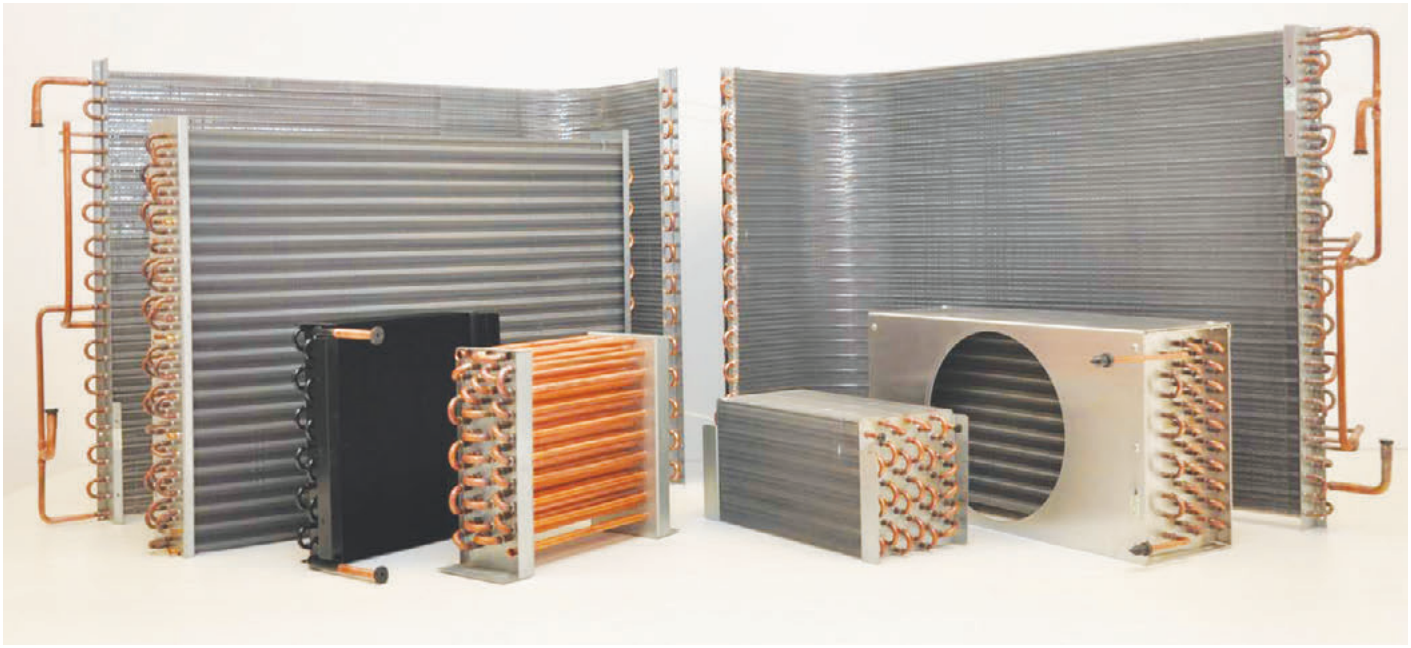


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# Smaller-Diameter Copper Tubes
## Support Three Trends in Ecofriendly Appliance Design

*HXSim Simulations Help to Optimize Heating and Cooling Performance*

**BY YORAM SHABTAY AND KERRY SONG**

There is a renewed sense of urgency with respect to climate action. ''Green deals'' are gaining popularity among citizens as well as governments, corporations and philanthropists around the globe. Net Zero Carbon is the rallying call for the management of greenhouse gases (GHGs).

The European Union has developed a package of initiatives known as the ''European Green Deal'' [1]. Meanwhile, In the United States, a full two-thirds of the population ''thinks government should do more on climate,'' according to a report from the Pew Research Center [2]. After a brief hiatus, the United States is expected to re-commit to the Paris Agreement as well as the Kigali Amendment. Signed in 2016, the Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC) deals with GHG emissions mitigation, adaptation, and finance [3]. The Kigali Amendment to the Montreal Protocol is an international agreement to gradually reduce the consumption and production of hydrofluorocarbons [4].

Although carbon dioxide (CO2) emissions pose the gravest threat to the atmosphere, CO2 is not the only molecule that behaves as a GHG when released into the atmosphere. The potency of GHGs is measured in terms of global warming potential (GWP). The GWP of carbon dioxide equals one. Synthetically produced hydrofluorocarbons (HFCs or F-Gases), which are widely used as refrigerants in air conditioning and refrigeration equipment, typically have GWPs that are hundreds or thousands of times greater than CO2.

Typical environmental action plans include the following:

- Decarbonization
- F-Gas reduction
- Energy efficiency

Ecofriendly design of heating and cooling appliances supports all three of these strategies. The HVAC&R industry in general and the appliance design community in particular can make significant contributions toward reducing GHG emissions, realizing Net Zero Carbon and averting an existential threat to humanity. While the global demand for HVAC&R will grow in the decades ahead, the use of ecofriendly heating and cooling appliances can aid the planet-wide

transition to Net Zero Carbon.

This paper will discuss various categories of heating and cooling appliances in relation to the decarbonization, F-Gases reduction and energy efficiency. Select HXSim simulation examples demonstrate the ecofriendly and efficient advantages of smaller diameter copper tubes. For more on HXSim, see the earlier white paper on computer simulations of heat exchanger performance [5].

### Trend 1. Decarbonization and Electrification

Net Zero Carbon cannot be achieved solely through the electrification of vehicles and heating and cooling appliances. Nonetheless, electrification is essential to decarbonization. The use of heat pumps and electric vehicles allows for coal, natural gas and petroleum to be phased down and replaced by renewable energy sources such as solar, wind and hydroelectric.

A heat pump is a cooling cycle in reverse (Figure 1). The hot gas of the compressed refrigerant heats spaces and water. The heat-depleted refrigerant subsequently expands in the evaporator, absorbing energy from the environment prior to re-entering the compressor. In this manner, a well-designed heat pump can operate with a coefficient of performance (COP) greater than three, producing 3x more heat-energy output than the work-energy drawn by compressor. In contrast, burning fossil fuels in a furnace or boiler is extremely inefficient: high-grade, high temperature energy resources are used to produce low-grade, low-temperature heat, with a COP less than 1. This is wasteful of our energy resources.

As an example, there is a type of heat pump that drives the compressor with a gas turbine. The waste heat from the gas turbine is recovered for heating; in addition, work is performed by the compressor to "pump" energy from the evaporator coil to the condenser coil. This technology takes advantage of an abundant supply of natural gas (e.g., from fracking and other sources in the USA) yet couples this resource with a heat pump that serves as an energy multiplier.

Another instructive example of an ecofriendly heat pump is EcoCute, which uses CO2 as a refrigerant. The first commercial domestic EcoCute was marketed in Japan in May 2001 and 1.5 million units had been sold in Japan by October 2008; and total sales in Japan exceeded six million units as of June 2018 [6].

The market success of ecofriendly EcoCute products encouraged the development of CO2 heat pumps globally. For the latest developments on the use of CO2 as a refrigerant, shecco's recently published "World Guide to Transcritical Refrigeration" in three parts is available online at no charge [7].

Spirotech, which now is a division within the LU-VE Group, has been making heat exchangers for heat pumps for a variety of appliances. Figure 2 shows heat exchangers using copper tubes for clothes driers, for example; current designs of evaporators and condensers for clothes driers are included in the 2020 LU-VE product catalogue [8].

**Figure 1: The "refrigeration cycle" can be used for heating or cooling. The refrigerant withdraws energy from evaporator and deposits energy at the condenser or gas cooler.**

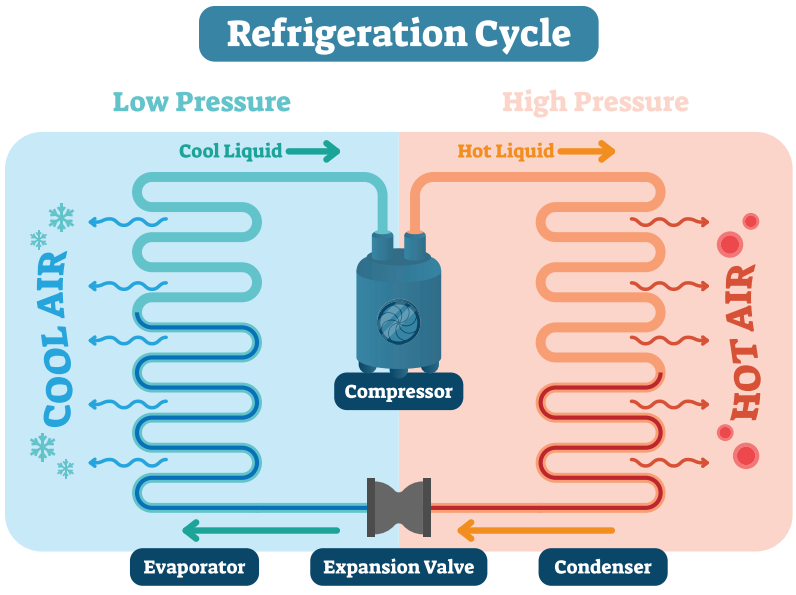
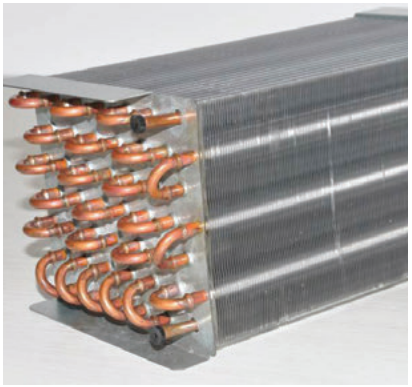



**Figure 2: This condenser coil for a clothes drier is designed with 5 mm diameter copper tubes.** (Courtesy SPIROTECH, LU-VE Group)



Heat pumps have received much attention from the U.S. Department of Energy (DOE), the California Energy Commission (CEC), the European Heat Pump Association, the EIA International Heat Pump Forum, the American Council for an Energy-Efficient Economy (ACEEE) and many other government agencies and non-governmental organizations (NGOs). The DOE is authorized to establish and amend energy conservation standards and test procedures for consumer water heaters [9].

Yoram Shabtay presented a well-received paper on the use of smaller-diameter copper tubes in high-efficiency heat pump designs at the 12th IEA Heat Pump Conference in Rotterdam [10]. Commonly asked questions about MicroGroove technology in heat exchangers are answered in a brochure titled "MicroGroove Technology for Heat Pumps Q&A" Figure 3 [10b].

Manufacturers prefer round-tube, plate-fin (RTPF) heat exchangers in outdoor evaporators for heat pumps because the open design drains easily and is less susceptible to icing in cold seasons compared to brazed aluminum heat exchangers. The serpentine-fin design of so called microchannel heat exchangers can trap condensate, which freezes in cold climates.




**Figure 3: New designs of heat pumps promise better management of temperature and thermal energy in homes as well as commercial and industrial applications.**

Outdoor evaporators for heat pumps come in many shapes and sizes. In the United States, they are typically C-Type heat exchangers similar to the outdoor condenser for a residential central air conditioning system (Fig. 4). Figure 5 shows an HXSim simulation example of a C-Type heat pump evaporator designed with 5 mm diameter copper tubes. Simple I-Type (flat slab) heat exchangers also can serve as evaporators in split systems (Fig. 6).



**Figure 4: Heating and air conditioning units used to heat and cool an apartment complex.** (Big Stock Photographs).

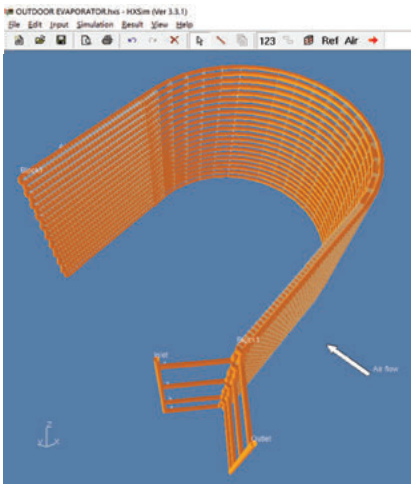


**Figure 5: Example of a C-Type outdoor evaporator coils in HXSim simulation Software.**





**Figure 6: Air conditioner and heat pump outdoor unit (top) and heat pump outside a residential home in winter (bottom).** (Big Stock Photography)

The adoption of heat pump water heaters (HPWHs) is inevitable globally. The challenge is the high initial cost compared to conventional electrical-resistance water heaters or natural gas burners [11]. With COPs exceeding 3.0 for HPWHs compared to COPs less than one for electric or gas water heaters, the long-term saving cannot be denied. The technology exists now but incentives and subsidies are required to accelerate adoption. Figure 7 shows an example design for the evaporator coil of a heat pump water heater in the HXSim simulation software.

At the 2020 AHR Expo, held in Orlando, Florida, just prior to pandemic lockdowns, many OEMs exhibited HPWHs. Notable were residential appliances from A.O. Smith, General Electric Appliances, Gree, Rheem, Rinnai, Stiebel Eltron and others. Bradford White Water Heaters, provider of the AeroTherm™ Series Heat Pump Water Heater, acquired the production assets from the heat pump water heater operations of GE Appliances (GEA), a Haier company.

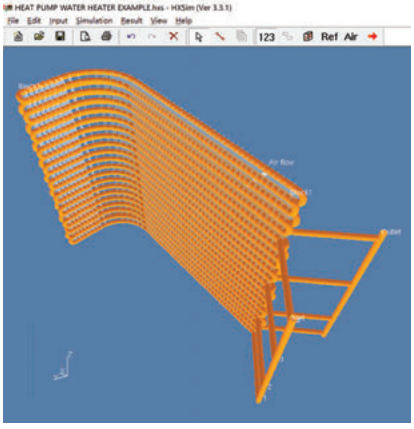


**Figure 7: Heat pump water heater L-type evaporator design example in HXSim simulation software.**

In conclusion, while progress is being made, it should be pointed out that much work needs to be done. The IEA Sustainable Development Scenarios (SDS's) were developed in alignment with the UN Sustainable Development Goals. An SDS tracks various aspects of

global energy usage with quantifiable targets for minimizing the adverse effects of climate change [12]. Heating is one sector that is "Not on Track" with respect to the latest numbers in June 2020 [13]. Here is an excerpt from a recent IEA report on heating:

> *"The heating equipment market continues to be dominated by fossil fuel-based equipment and less-efficient conventional electric heating technologies, which make up almost 80% of new sales. However, sales of heat pumps and renewable heating equipment such as solar hot water systems have increased, representing more than 10% of overall sales in 2019. To be in line with the SDS, the share of clean heating technologies – heat pumps, district heating, renewable and hydrogen-based heating – needs to more than double to 50% of sales by 2030."*

### Trend 2. F-Gas Reduction in Refrigeration Equipment

The development of heat pumps is promising from an environmental perspective but most heat pump appliances on the market today still use high-GWP hydrofluorocarbons (i.e., HFCs or F-Gases). Most F-gases are nonflammable (A1). R32 is a mildly flammable F-Gas that has a GWP of "only" 675. Certain mildly flammable HFOs have very low GWPs and therefore R32-HFO blends can be developed with GWPs less than 675. Many OEMs now use R32 or R32-HFO blends as a means of meeting F-Gas regulations in the near term.

R32, HFOs and HFO-R32 blends all belong to the A2L flammability subclass. They are considered flammable, hence the A2 designation, but their "burn rate" is slower than typical A2 refrigerants, according to certain standard tests. The A2L "mildly flammable" designation sits between the A1 and A2 designation and allows for less stringent use conditions compared to A2 (flammable) or A3 (highly flammable) refrigerants. The differences between A1, A2L, A2 and A3 safety classes are summarized in a "Factsheet" jointly published by the United Nations Environment Programme and ASHRAE [14].

For commercial refrigeration, the transition to hydrocarbon refrigerants is already underway. The adoption of R290 in light commercial refrigeration equipment is a major success for the reduction of F-gases and for MicroGroove technology. Smaller-diameter copper tubes allow for a given cooling capacity using less refrigerant. This advantage can be easily demonstrated with HXSim simulations.

Although propane (R290) is an A3 (highly flammable) refrigerant, it was approved for use many years ago, subject to a charge limit of 150 grams (5.29 ounces). Manufacturers of light commercial refrigeration equipment have been quick to transition to R290. This charge limit was sufficient to spur the design and development of a wide array of commercial refrigeration equipment including cold display cases. MicroGroove technology developed in parallel with the transition to low-charge R290 refrigeration equipment and is an enabling technology for many R290 refrigeration applications [15, 16]. Figure 8 shows example heat exchangers designs for light commercial refrigeration equipment that uses less than 150 gm R290 refrigerant.

More recently the International Electrotechnical Commission (IEC) voted to increase the charge limit for A3 refrigerants (e.g., propane) from 150 to 500 grams in self-contained commercial refrigeration equipment.



**Figure 8: Propane is now widely used as a refrigerant in light commercial refrigeration applications. The 150 gm limit on refrigerant calls for the use of smaller diameter copper tubes. Both the evaporator and condenser use 5 mm diameter copper tubes (top). Example of an R290 cool display cabinet (bottom).** (Photographs courtesy of MTL Technologies www.mtlcool.com)

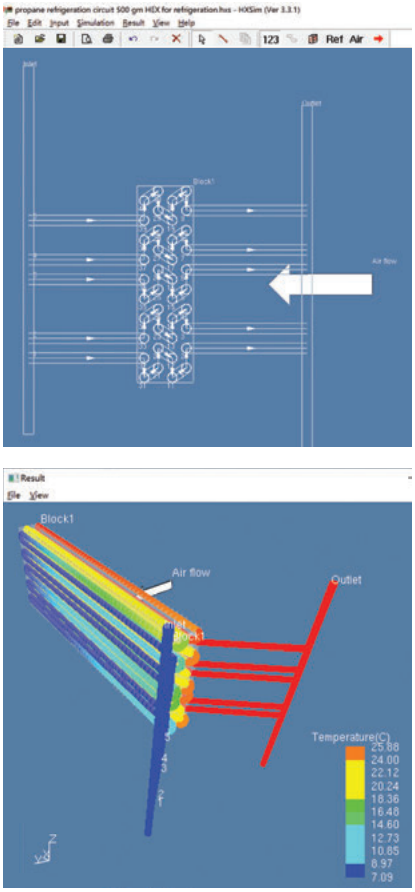



**Figure 9: Design example in HXSim showing tube circuitry (top) and simulation results (bottom) for a refrigeration system using 500 grams of R290.**

IEC is an international body whose standard 60335-2-89 is the basis for all other standards for commercial refrigeration equipment but will not immediately affect products in the United States. Nonetheless, this higher charge limit presents many opportunities for new commercial refrigeration technologies as the U.S. develops its own guidelines based on the IEC standard in the years ahead.

The wide variety of designs of heat exchangers for refrigeration equipment makes HXSim a valuable tool for appliance designers. Using HXSim one can vary the tube size, pitch, fin type and density and block dimensions of condensers and evaporators to fit the exchanger precisely to the application.

### Trend 3. Energy-Efficient Air Conditioners

Air conditioners require larger refrigerant charges than light commercial refrigeration systems. Consequently, most OEMs have resisted highly flammable refrigerants such as propane and opted instead for R32 or HFO-R32 blends. Nonetheless, especially in Asia, including China and India, air conditioners using propane as a refrigerant are being manufactured in volume.

A special virtual technical conference was held jointly with shecco (organizer of ATMOsphere events) and the Danish Technological Institute (DTI) on "The Future of Air Conditioning" in June 2020 [17]. Of special note was the discussion of air conditioners that use propane as a refrigerant. The transition to energy-efficient split ACs with R290 refrigerant will play a key role in creating a more sustainable HVAC&R sector, according to a market assessment titled "R290 Split Air Conditioners Resource Guide" published in 2019 by GIZ Proklima and Umweltbundesamt [18].

The guide says, *"Leapfrogging to high-efficiency appliances using R290 reduces the energy consumption and GHG emissions and thus provides a significant opportunity to contribute to national climate action plans. A market share of 50% [by] 2050 may cut down total GHG emission by 25%."*

Daniel de Graaf from the German Environmental Agency (UBA) noted that Midea received the Blue Angel ecolabel for its All Easy Series R290 units in 2018 in Germany and that Midea now has "better units." Midea intends to have these new units Blue Angel-certified and bring them to the European market. Two split-AC units from Midea qualified for the BlueAngel ecolabel in Germany, with cooling capacities of 2.6 kW (0.7 TR) and 3.5 kW (1.0 TR), respectively, and each uses 380 grams of R290. According to de Graaf, 700,000 R290 room ACs have worked in India with no problems and it should also be possible to install and operate them safely in Europe [19].

As noted in the article, "MicroGroove Coils Span the Globe: Smaller Diameter Copper Tubes Thrive In India," when the Bureau of Energy Efficiency revised its Star Labeling to encourage higher efficiency air conditioners in India, AC manufacturers began to specify condensers and evaporators that transfer heat efficiently [20]. Laboratory experiments showed that heat transfer coefficients (HTCs) are highest for smaller-diameter inner-grooved copper tubes compared to larger diameter tubes and smooth tubes. Higher HTCs result in more efficient AC systems that that also use less material and less refrigerant.

MicroGroove coils made from smaller diameter inner-grooved copper tubes deliver an unprecedented combination of compactness and energy efficiency. They are more affordable than traditional designs because they use less material. Typical MicroGroove copper tube outer diameters are 7 mm, 6.35 mm (0.25 inch) and 5 mm (Fig. 10).




**Figure 10: – Yoram Shabtay explains the advantages of MicroGroove smaller-diameter tubes at ATMOsphere America.**

MicroGroove copper tubes are the preferred tubes for India because of their corrosion resistance. A decade ago larger-diameter copper tubes began to lose market share to aluminum and a low point was reached in 2014. But the corrosion resistance of copper prevailed and copper heat exchangers are recapturing market share. The trend back toward copper has been dramatic as end users of aluminum microchannel experienced many cases of failure and leakage. The industry is rapidly switching to MicroGroove as a practical, economical, eco-friendly alternative to microchannel. The International Copper Association India (ICA India) exhibited at ACREX INDIA many times in the past decade, demonstrating the MicroGroove advantage to R&D staff from major Indian OEMs. (Fig. 11)




**Figure 11: Product design engineers learned about MicroGroove at ACREX India, an international exhibition on air conditioning, refrigeration and building services.**

Although India is both a large consumer and large producer of air conditioners, the global outlook for sustainable cooling strongly depends on the actions of China and the United States. Two crucial IEA reports on the "Future of Cooling" are worth noting by appliance designers [21, 22]

According to these detailed reports, all countries should focus on labelling programmes and Minimum Energy Performance Standards (MEPS) to raise energy efficiency of ACs and other cooling equipment. Countries need to quickly tap into the energy efficiency potential already possible using air-conditioning technology available in markets today. Governments should complement these with measures that "accelerate the transformation of the AC market towards high-efficiency products, including targeted programmes and research, development, demonstration and deployment."

The takeaway for OEMs and HVAC&R appliance designers is that more efficient AC designs are needed. The effects of increasing the efficiency of appliances are significant when multiplied over tens of millions of units.

One means for increasing the efficiency of appliances is through the use of smaller diameter copper tubes. The HXSim software can be used to compare the efficiencies of various heat exchanger designs.

## Conclusion

The world faces daunting challenges on the way to Net Zero Carbon. Renewable energy sources are needed to be developed. Whatever the renewable energy sources, electrification and energy efficiency are essential to obtaining Net Zero Carbon. Also, the HVAC&R industry faces the unique challenges of phasing out conventional F-Gas refrigerants that have high GWPs; most low GWPs are mildly flammable (HFOs) or highly flammable (hydrocarbons) or they require high pressures.

Many scenarios have been quantified to track progress toward sustainable development goals. Residential heating and cooling and domestic water heaters have been identified as major contributors to energy consumption. Appliance designers can help to hit vital targets by designing electrical appliances that meet minimal efficiency performance standards (MEPS) using ecofriendly refrigerants.

The HXSim simulation tools can help to evaluate heat exchanger efficiency and accelerate the design process. ●



***Yoram Shabtay*** *has been awarded numerous patents due to his innovations in the process and design of heat exchangers. He has an extensive background in administration and management.*



***Kerry Song*** *is a Project Manager with the International Copper Association. He holds a Bachelor's degree from the University of Shanghai for Science and Technology.*

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# Harmonized Standard

## For Commercial Refrigerating Appliances and Icemakers

**BY CRAIG GRIDER**

In late September of 2024, the industry will see a change to certification requirements in North America for electrical commercial refrigerating appliances and icemakers. These appliances – previously certified to UL 412, UL 427, UL 471, and/or CSA C22.2#120 – will need to comply with UL 60335-2-89/ CSA C22.2 No. 60335-2-89. The old standards will be sunset, allowing for a brief period where both old and new standards are acceptable. In the meantime, it is important for manufacturers to understand the requirements of the new standard to ensure a smooth and efficient transition.

Since this change was not driven by any existing safety issues or concerns, but instead comes from an industry need for global harmonization, some certifications of existing products may be allowed to continue to be certified under the previous set of UL and CSA standards. Manufacturers and interested stakeholders will need to check with their certifying body or test agency to determine if an existing certified product is required to update. In general, UL/CSA 60335-2-89 covers common hazards presented by appliances like refrigerated display/storage cabinets or trolley cabinet, service/self-service counters, and blast chillers/freezers.

Currently the 1st Edition of UL 60335-2-89 and CSA C22.2 No. 60335-2-89 is published and available for certification of new or existing products. The 2nd Edition is completing development and may be available late 2021 or early 2022. The 2nd Edition will align with the latest version of IEC 60335-2-89 with an expanded scope to include icemakers and refrigeration equipment previously certified under UL 1995/ CSA C22.2 No. 236. The new edition will also provide better coverage for partial units for both direct and indirect systems, give clearer product type specific requirements, and there will be an expansion in coverage for equipment and systems that utilize higher charge limits of a designated flammable refrigerant.

These harmonized standards will be helpful to manufacturers seeking access to multiple global markets and attention was given to ensure existing certified products would not require full retesting; however, there are several key changes to note.

## Construction

While the previous standards focused on construction, material properties, and compliance to industry standards to verify that components operate within specifications, the harmonized standard focuses on testing these components and assemblies within the appliance to meet safety requirements. There are also major differences in construction requirements that may require design changes or relaxation. These include:

- A Canadian deviation requiring evaluation to CAN/CSA-C22.2 No. 0 (CEC),
- Less stringent creepage and clearance distances, in many cases
- Less stringent strength test requirements for refrigerant-containing parts
- Different probes for access to live and moving parts: an IEC probe may be able to access a moving part (like a condenser fan) where a UL probe would not; this must be considered during construction.

## Components

It is important to remember that compliance with the standard for the relevant component does not necessarily ensure compliance with the requirements of the new standard. Components that have not been previously tested and shown to comply with the standard for the relevant component must be tested according to the requirements of this standard. Even certified or recognized components must be compared to the requirements of 60335-1 and 60335-2-89 to determine acceptability. Components comprised of non-metallic materials, such as polymerics, may require additional testing to new standards, especially those which support current carrying connections within the appliance.

## Markings and Instructions

Many of the markings requirements in UL 60335-2-89 are similar to those of previous UL refrigeration standards; however, there are several new markings required when moving to UL 60335-2-89:

- Ingress protection marking is required for outdoor units rated at least IPX4
- Units of physical quantities and their symbols must now include those of the international standardized system
- A symbol of supply is required for three-phase models
- Protective earthing (grounding) terminals should be indicated by the symbol of IEC 60417-5019
- Maximum allowable pressure markings for low- and high-side pressures of appliances with greater than 150g of charge and pre-charged line sets.

The 60335 standards also have specifications for instructions provided with the appliance. Instructions must address safety of children and persons with reduced physical, sensory or mental capabilities, or lack of experience and knowledge. They must include precautions to be taken during installation, means of disconnecting stationary appliances not provided with a supply cord and plug, and considerations for equipment intended for use at altitudes exceeding 2000m. There should also be information on what to do if the supply cord is damaged and how to fix equipment to its support or build it into a structure.

These changes are just some of the highlights which could affect existing products or new designs currently in development. Understanding the requirements of safety standards is always important for manufacturers. Knowing this harmonized standard is beneficial not only as an industry requirement on the horizon, but also to obtain access to multiple markets using the IEC standard. It is important to familiarize yourself with the new requirements coming under the standard change, and to work with experienced teams who know the standards, their changes and how best to test and certify products moving forward. ●



***Craig Grider*** *is the , Assistant Chief Engineer with Intertek. www.intertek.com*

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