

## This Issue Features:

- Four-Wire Kelvin Testing
- Anatomy of a Perfect Deal
- Training in the Virtual World
- Co-op Students - the Key to Plant Manager's Success
- Cathodic Protection: Keeping Corrosion to a Minimum
- Three Considerations for Choosing the Right Enclosure
- Komax Holding AG and Schleuniger AG Seek Merger
- High Performance Cable Jacketing for the eMobility Market

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## Company Profile: Wire Harness Integrating Solutions

By Joe Tito  
 Wiring Harness News

Monterrey is the capital of Mexico's north-eastern state of Nuevo Leon. This cosmopolitan city, with its picturesque location at the foothills of the Sierra Madres, has long been a center for art and design. But it is also a major manufacturing hub. In terms of GDP, it's the second most productive city in Mexico. It's also the home of Wire Harness Integrating Solutions (WHIS) who graciously offered to be featured in this issue's Company Profile.

I had the great pleasure of having a zoom conference with Maggie and Jose Enrique Fernandez (who everybody calls JEF by his initials). JEF is the Owner/President at WHIS, and his daughter Maggie is the Chief Lo-

gistics Manager. They spoke about the history of this impressive company, areas of specialty and exciting plans for the future.

JEF started the business in 2002. He got his start in the industry in 1984 when he went to work for a small harness manufacturer. It didn't take long for Yazaki to recognize his talents. They brought him on board as an engineer on various harness projects in the automotive industry. He quickly moved up the ladder as he worked on harnesses for Ford, Toyota and Nissan. JEF made several trips to Japan where he received valuable training in design for manufacturability. "He got a lot of experience with automotive wire harnesses and overall production efficiency during this time," Maggie explained.

After 15 years with Yazaki, JEF felt the tug of entrepreneurship and start-



WHIS team member completes complex assembly for the HVAC industry.

ed WHIS in a 4,000 square-foot warehouse. He began production with some simple harnesses and power cords for a local company. Maggie was only 17 at the time, but became an integral part of the business, even at this early stage. They were presented with some opportunities and began building cables for local companies in the HVAC industry. A good portion of these harnesses were for a large producer of refrigeration equipment for supermarkets and convenience stores. They learned the language and challenges of the industry and gained a great deal of proficiency in build quality.

Through his contacts in the industry, JEF was able to obtain an early opportunity in the automotive industry, and WHIS began making a

battery cable for Nissan. But JEF explained that, to his surprise, he much preferred the opportunities they were uncovering with refrigeration products. The rigors of the intense cost pressures in the automotive industry were also a bit unpalatable. "We halted the automotive project," JEF recalled, "because we wanted to center more of the business and expertise in the HVAC industry." That strategy paid off, as WHIS continued to further penetrate the industry. Not only are they a major supplier to the refrigeration companies today, they are also supplying cables for industrial and residential air-conditioning, as well as water cooling and heating equipment.

Continued on page 12

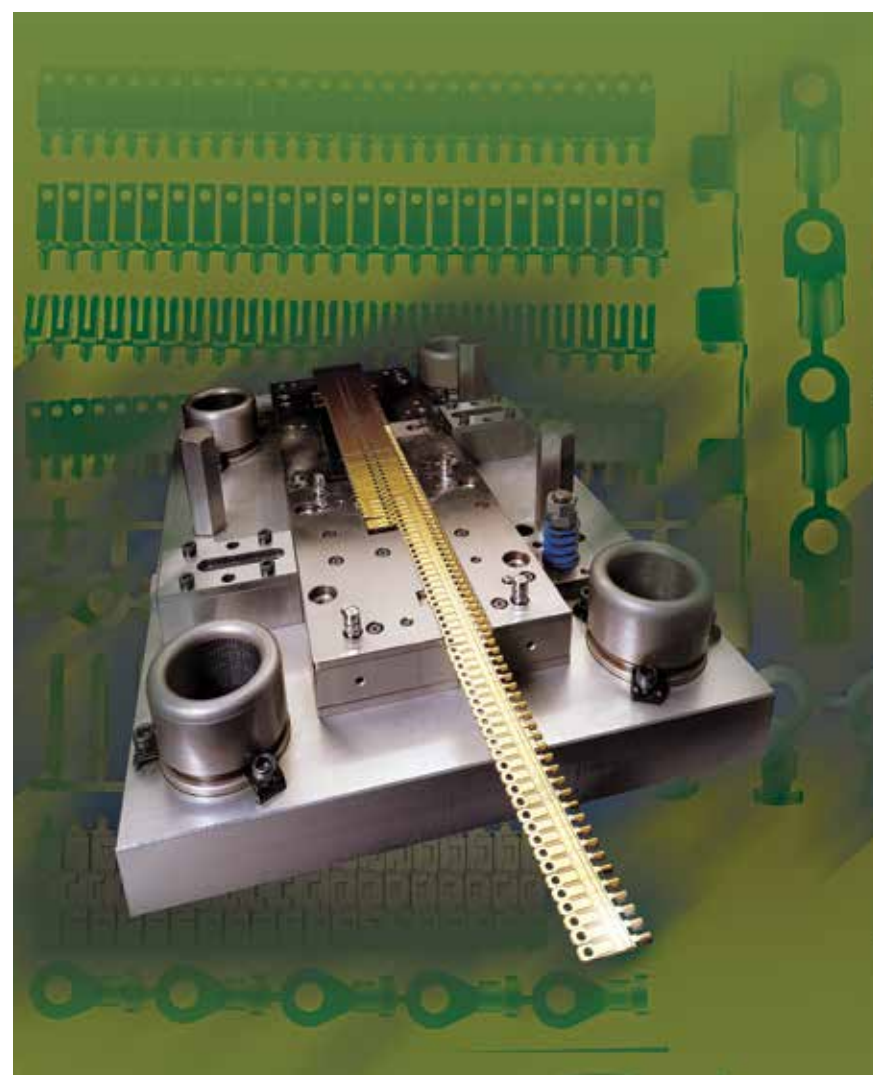
## ETCO Celebrates 75 Year Anniversary

Originally called Electric Terminal Corporation, ETCO was incorporated in RI on September 11, 1947. The original 2,000 sq.ft. factory was in Pawtucket RI. Its wood floors would flex up and down with 15-ton Perkins presses. David Dunn, owner of ETCO recalled the original product being stamped. "It was what we call blades at the time but are really the prongs on a wall plug. They were sold to cord set manufacturers like Belden Corporation in Chicago and American Insulated Wire in Pawtucket RI," he informed. The advantage ETCO had was a process of manufacturing the blades in strip form and putting them on reels of 5,000 parts. ETCO

also manufactured a patented attaching machine to take the parts from the reels and attach them to the customer's parallel cord set wire, two at a time. "It sounds pretty basic now but prior to this, they were being soldered to the wire one at a time, so this was a huge productivity gain (Fig. 1).

The small factory stamped millions of these parts and expanded to a new facility in Providence RI with more room and more presses. Belden had a policy of not depending on one factory for essential products, so ETCO bought another factory in Warwick RI which it still operates.

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Stamped wall plug blades coming off press at ETCO.

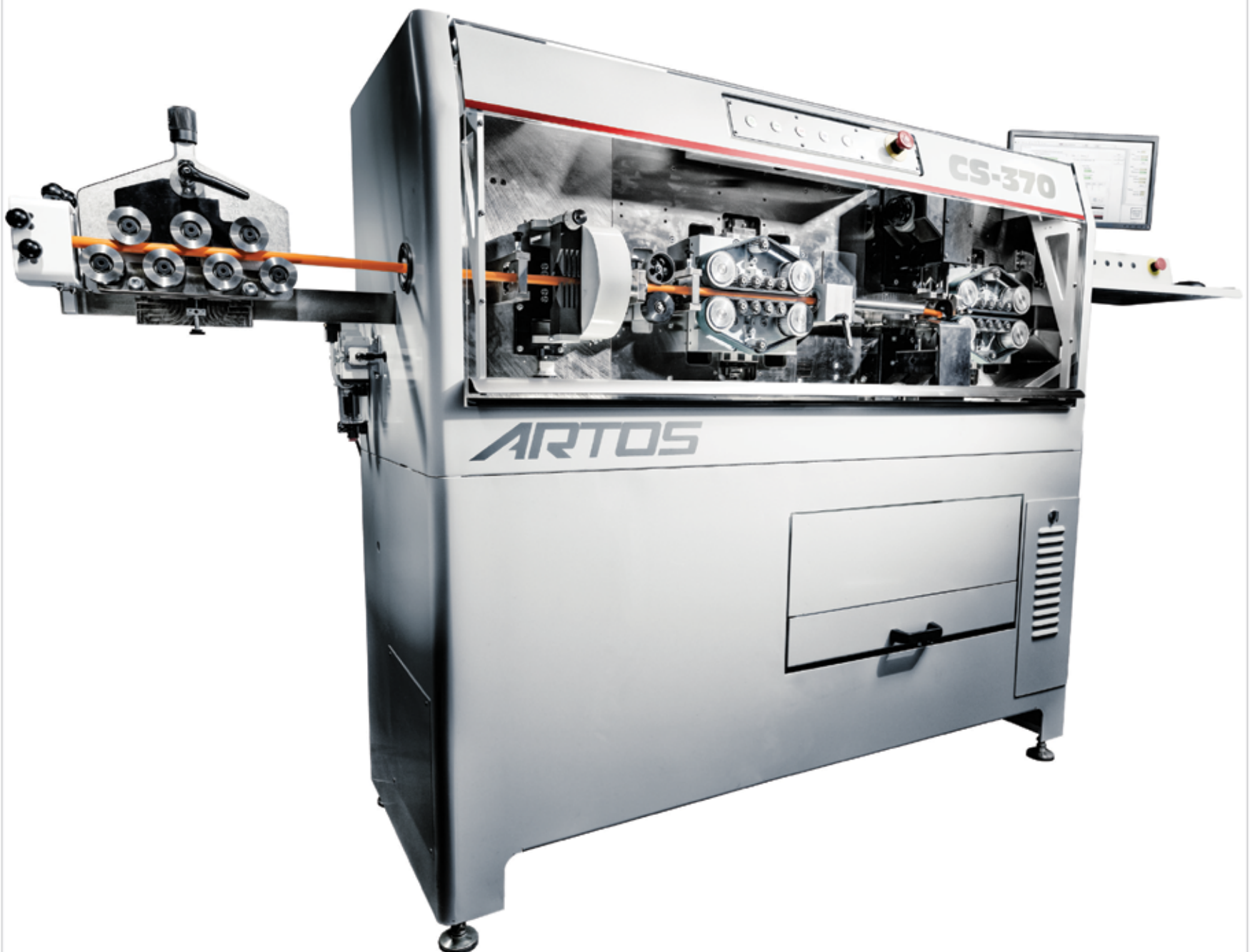




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**March/April 2022**

**FEATURES**

**Industry Profile:  
Wire Harness Integrating  
Solutions . . . . . 1**

Read about how this father/daughter team got its start and how, along with their valued crew in production and engineering, they are constantly improving processes and looking forward to propel this amazing company

**ETCO Celebrates  
75 Year Anniversary . . . . . 1**

ETCO established some core principles at an early stage that have remained relevant through the years. Read about how this culture led to a successful 75 years in business.

**Komax AG and Schleuniger AG Seek to  
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Read about the intricate details on this quasi-merger between two industry powerhouses.

**High-performance Cable for  
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**Training in the Virtual World . . . . . 43**

Events of the last couple years have greatly increased the need for eLearning. DIT-MCO was out in front designing pre-recorded, self-paced learning methods. More recently they have created live, instructor-led training courses with an online meeting format. This article describes both in detail.

**Electronic Device Manufacturers  
Shouldn't Fear Custom Connector  
Solutions - They Should Embrace  
Them . . . . . 46**

It's always easiest to select an off-the-shelf option when it comes to connectors. Custom connectors however, can often be a viable option, and should not be overlooked.

**Four-Wire Kelvin Testing . . . . . 56**

This is Part 3 in a series of articles on automated testing from the folks at Cirris. (Part 1 - Sept/Oct, Part 2 - Nov/Dec 2021). In this article, they expand the range by looking at four-wire Kelvin testing, a capability inherent in many automated testers.

**IN EVERY ISSUE**

**M & A 101 . . . . . 6**

Is there any such thing as the perfect deal? As Loren Smith points out, it's rare. He did, however, have one deal that was as close to perfect as he has seen. Read how both the buyer and seller in that transaction were well prepared.

**Leadership . . . . . 27**

In the past several issues we have been treated to Paul Hogendoorn's wisdom from his many years in business. Here he continues with more essential business tips and suggestions.

**Wire Wisdom . . . . . 36**

Whether you are talking about pipelines or cable assemblies, corrosion is a problem and needs to be kept to a minimum. This article deals with a wide range of situations where corrosion is found, however the principles apply directly to our industry.

**News Plugs . . . . . 54**

Read about the latest products on the market and points of interest about companies and people in the industry.

**WHMA - Wired In . . . . . 58**

We often hear the phrases wire harness and cable assembly interchangeably without really thinking about it. But there really is a definite difference. Christine Siebert from WHMA takes a dive into the subject with five main distinctions.



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## From the Editor

One particular article in this issue really got me thinking about our industry and how we cover it at Wiring Harness News. It's nothing earth shattering, just a decent little article on cable jacketing material for EV charging stations (page 28). Back in the 90's when I was working for a supplier/advertiser, I don't think you would have seen such an article on these pages. It would have been far too esoteric for the mostly build-to-print harness manufacturers of the day. But things have changed. What is expected of you as manufacturers has changed immensely.

Ours is far from a strictly build-to-print industry. Instead, your customers are relying on you to look upstream to help specify materials that will perform well in their products once they are in the field. They don't necessarily have the level of engineering expertise they did in the past. Hence, they rely on you for help with not just manufacturability, but also performance and reliability. And boy, have you met the challenge! (Just another reason I brag about you folks to my friends in other industries.) It seems logical this trend will continue.

This need seems especially true in the eMobility sector. There are many fledgling companies who are desperately seeking a harness and cable assembly supplier to give them advice, assistance and expertise in producing designs. We'll continue to report on that sector for you.

It's our goal to help you develop the tools you need to be a top performer for your customers in all industries. Feel free to email or call me with any ideas on subjects you would like to see us cover. As always, we hope you think of us as your research arm.

Keep plugging away!

*Joe*



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# M & A 101:

## Lessons learned from decades of deals

### Anatomy of a Perfect Deal

By Loren Smith

I was recently asked an intriguing question: “What does a perfect deal look like?” I started to respond that perfection might not exist, but then I recalled a deal a number of years ago that seemed to click on all cylinders—from the time the letter of intent (LOI) was signed right through the closing.

I described how the buyer had conducted a financial audit, thoroughly reviewed everything in the confidential information memorandum (CIM), evaluated all the company’s systems and procedures, and drafted all the legal documents—accomplishing everything in less than

60 days. “From LOI to closing in 60 days for a \$25 million deal is exceptional,” I said.

But then I got another question: “How did that happen? What were the factors that enabled the buyer to achieve so much so quickly?”

That excellent question I was unable to answer on one foot, but I did answer it the next day. Here are the six characteristics I identified that had allowed that long-ago deal to proceed so seamlessly:

#### 1. Financial clarity

The company’s books and records were impeccable. They did not require a lot of interpretation, and the financial review conducted by an in-

dependent auditor confirmed EBITDA and did not uncover any red flags.

#### 2. Urgency

The seller was highly motivated because he wanted to retire. And the buyer had a sense of urgency because he was very experienced at acquiring companies and understood that a drawn-out process is not your friend in getting a deal done.

#### 3. Effective time management

Both the buyer and the seller had mastered the elusive art of managing their time. For the seller that was essential because it is quite challenging to run a business while tending to the myriad issues required to get a deal closed. Likewise, the experienced buyer recognized that he



Loren Smith CEO  
Blue Valley Capital

would need to stay on top of his time management game throughout the back and forth with the seller. As a result of both parties’ dedication to timeliness, they were available when required—sometimes daily.

#### 4. Experienced attorneys

It is vital that the attorneys on both sides of a transaction are seasoned in the M&A arena. When a seller uses his family’s general practice attorney, a lack of specialized knowledge can slow or even jeopardize the deal.

#### 5. Due consideration of market valuation

Sellers can have an inflated idea of their company’s worth, which is certainly understandable, but fixating on an unrealistic number can create a formidable hurdle. Understanding that the market is the key determinant of a company’s value is vital to reaching the goal line.

#### 6. Single point person

Giving one individual full decision-making authority on all aspects of the deal, on the seller side and on the buyer side, expedites the entire process. A seller might have several partners or a buyer might have a number of individuals in his decision matrix, but in this case the seller’s CEO served as our solo point person, and the VP of Acquisitions for the buyer had parallel decision-making authority on all issues.

Often, only one or two of these crucial factors exists, leading to any number of snags or worse. But in this instance we were blessed with the rare advantage of having all six prime ingredients. So maybe I have experienced a perfect deal.

Loren Smith can be reached at [lms@blvcapital.com](mailto:lms@blvcapital.com) or [www.bluevalleycapital.com](http://www.bluevalleycapital.com).



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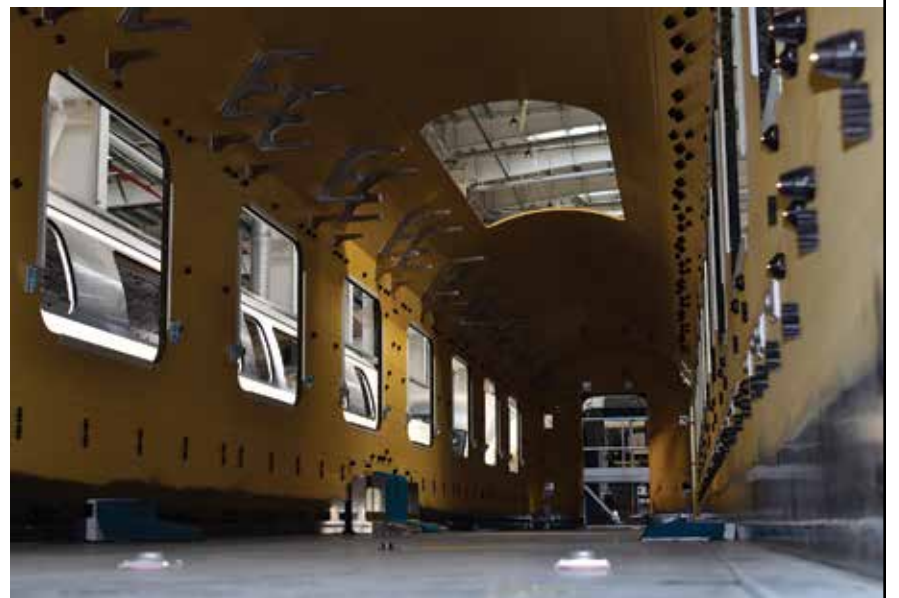
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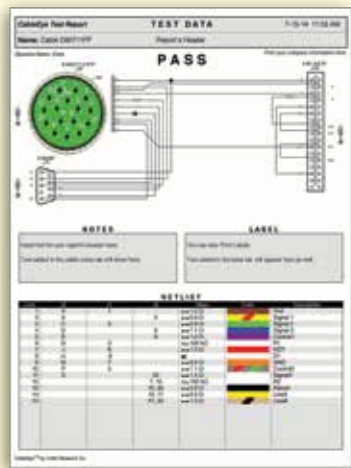
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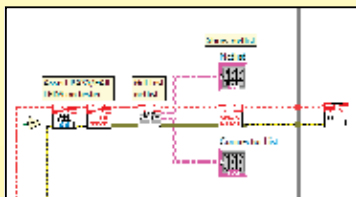
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## Komax Holding AG and Schleuniger AG Seek to Merge

For both the Komax Group and the Schleuniger Group, the market for automated wire processing offers many opportunities, but these require significant investment. In order to exploit these opportunities with the necessary speed and thereby secure competitiveness over the long term, the two companies are seeking to implement a quasi-merger. With their combined innovative strength, solutions for further increasing the degree of automation in wire processing on a lasting basis will be brought to customers more rapidly. To finance the merger, Komax will propose to the Annual General Meeting of 13 April 2022 the creation of new shares by means of a capital increase. These shares will be allocated in exchange for the Schleuniger shares of Metall Zug AG, giving Metall Zug AG a 25% stake in Komax Holding AG. In addition, the Annual General Meeting will be asked to rescind the 15% voting rights restriction and elect Jürg Werner, the current Chairman of Schleuniger AG, as an additional member of the Board of Directors.

In order to secure their long-term competitiveness and continue to consistently drive forward the automation of wire processing with cutting-edge products and solutions, Komax and Schleuniger are seeking to merge. To this end, Metall Zug AG will

bring its Wire Processing division, the Schleuniger Group, into Komax Holding AG and receive a 25% stake in Komax Holding AG in return. Komax and Metall Zug have signed the corresponding agreement. The transaction will be carried out through a quasi-merger. This will involve Komax Holding AG creating 1,283,333 new shares through a capital increase – subject to the approval of the Annual General Meeting of 13 April 2022 – and then allocating these shares to Metall Zug AG in exchange for the Schleuniger shares.

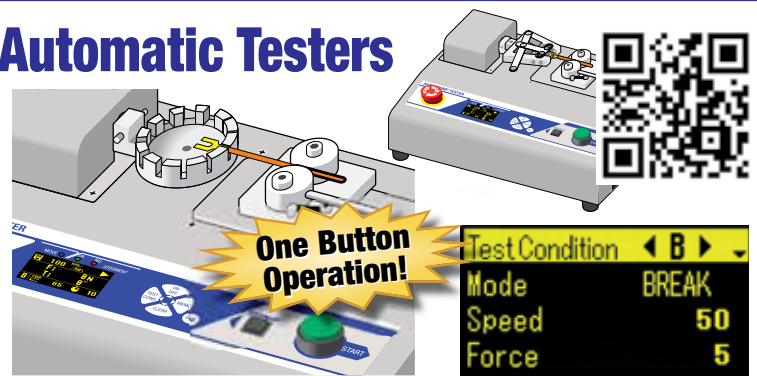
### Trends require a high level of investment and personnel resources

A number of trends offer numerous opportunities for Komax and Schleuniger. In order to exploit these and be in a position to meet customer needs with sufficient rapidity across the necessary breadth, a high level of investment and personnel resources is required. One of the trends is the ongoing shift of the automotive market to Asia. Companies that want to assert themselves in the growing Asian market and avoid the risk of gradually losing market share must invest in new solutions and services. Another trend is automation. This has picked up pace in recent years, and offers considerable growth potential

*Continued on page 10*

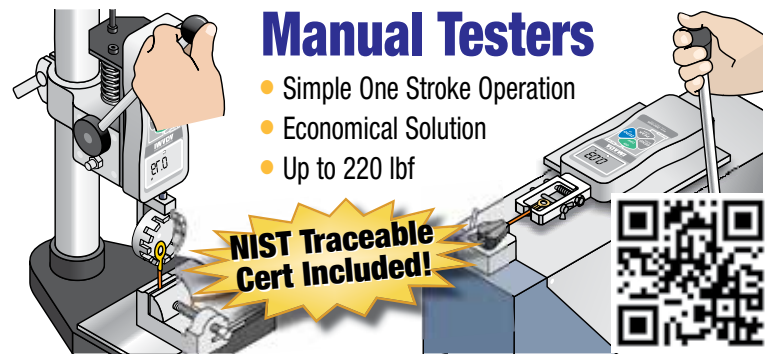
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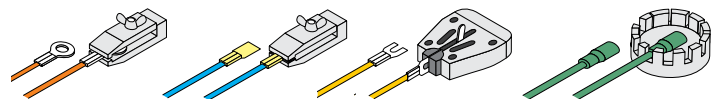
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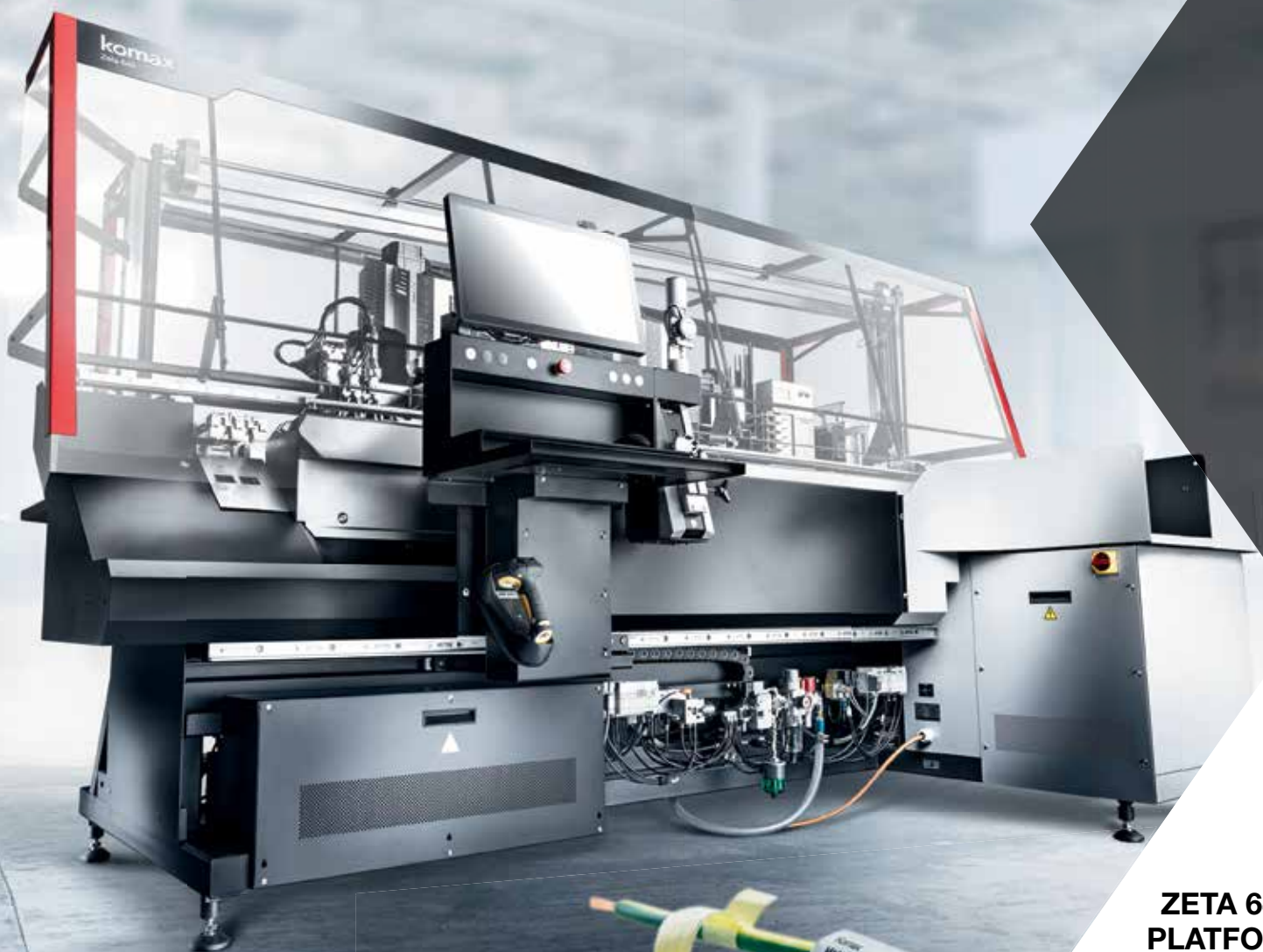
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# Komax Holding AG and Schleuniger AG Seek to Merge

Continued from page 8

due to the increasing global shortage of specialist personnel. "Through this merger, Komax and Schleuniger will have additional expertise and more resources to support their customers with innovative products and services in various market segments as the degree of automation continues to rise," comments Beat Kälin, Chairman of the Board of Directors of the Komax Group. The trends of digitalization, autonomous driving, and e-mobility also offer potential for growth and differentiation. These opportunities

call for significant investment and the further recruitment and development of highly qualified specialists.

## Ensuring competitiveness

"The merger will put us in a position to respond to all these trends appropriately - and most importantly of all with the necessary speed so that we can preserve our competitiveness," explains Matijas Meyer, CEO Komax Group. "As a result, the customers of the merged company will continue to have a reliable partner that can impress them with in-

novative products and services." This innovative strength and securing of competitiveness will also have a positive impact for shareholders and employees. The merger lays the foundations for growth over the long term, investment in the future, and the creation of further jobs and apprentice positions. The combined workforce of more than 3,000 employees will be given additional development opportunities in a cutting-edge technology group, and will have a key part to play if the available opportunities are to be exploited.

## One share, one vote

In addition to the capital increase, Komax will also propose to the Annual General Meeting that the existing voting rights restriction of 15% be rescinded. This will have the effect of strengthening Komax's corporate governance, in keeping with the principle "one share, one vote". In addition, subject to successful implementation of the merger, Komax will propose the election of Jürg Werner to the Board of Directors. Jürg Werner is Chairman of the Board of Schleuniger AG, a member of the Board of Directors of V-ZUG AG and Haag-Streit Holding AG, and served as CEO of Metall Zug AG from 2013 to 2020. He holds a degree in electrical engineering as well as a PhD (Dr. sc. techn.) from the Federal Institute of Technology (ETH Zurich). Beat Kälin as Chairman of the Board of Directors and the other five members of Komax's Board of Directors will stand for re-election.

## Anchor shareholder with a long-term focus

With Metall Zug, Komax will have an anchor shareholder with a long-term focus. In keeping with its new strategy communicated in 2019, Metall Zug is transforming into a holding company with significant stakes in attractive Swiss industrial companies. The first step in the implementation of this strategy came in 2020 with the spin-off and the independent stock market listing of V-ZUG, in which Metall Zug has held a 30% stake since then. The second step in the implementation of this strategy will now take place with the planned strategic stake of 25% in Komax following the merger with Schleuniger. "Metall Zug intends to hold its stake in Komax for the long term as an anchor shareholder," emphasizes Martin Wipfli, Chairman of the Board of Directors of Metall Zug AG. "We were therefore happy to accede to the request to commit to a six-year lock-up period, during which we will essentially not sell any shares."

Subject to the Annual General Meeting approving the capital increase, the merger will then be reviewed by the relevant competition authorities. The transaction will be executed once this process is complete, which is likely to be the case in the third quarter of 2022. Until then, Komax and Schleuniger will remain independent of one another, and no shared business activities will take place.

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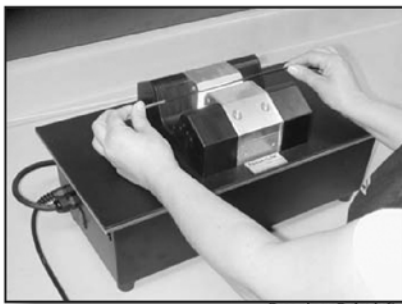
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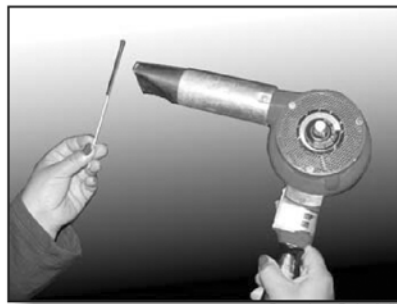
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# Wire Harness Integrating Solutions

Continued from page 1



The growth curve for WHIS was fairly steep in the early days, and in 2003 they moved into a 10,000 square-foot facility. New projects and the establishment of an agreement with Siemens to assemble electrical panels they were producing for Carrier, led them to move operations to a 22,000 square-foot facility. Following the Nuevo Leon State government's program to create employment opportunities in the southern regions of the state, they made the strategic decision to establish a 15,000 square-foot facility in the community of Galena, NL.

One of JEF's biggest strategies has been to match capacity with growth. That's why they combined both operations into their current 44,000 square-foot facility in Apodaca in 2008. This location is very conducive

to express shipments, as it just a few miles away from Monterey's most important international airport.

In addition to making even further inroads into the HVAC industry, WHIS has branched into other important markets over the past few years. Among those are transportation, lighting, and electrical tooling. All in all, they sell over 10,000 part numbers among their various customers.

JEF and Maggie were also very excited to talk about the more recent addition of two additional markets. They are building thousands of harnesses for a huge player in the medical arena. The company makes devices and equipment for hospitals and surgical centers.

The other huge growth product is in automated warehouse material handling. They are very proud to be

building harnesses for the robotic devices for Amazon and are very excited about additional opportunities in the robotics industry.

With 160 employees, the company currently runs one and a half shifts. With a ton of business coming back to Mexico from China, they recently decided to add a new resource management system. They want to be ready for all the challenges of this influx of new business coming their way. "We recently brought in SAP enterprise resource planning software to effectively support our core business operations, supply chain management, warehouse management, sales, customer relationship and administrative functions," Maggie ad-

vised, "and we feel strongly that we can handle all of our workflow issues through the new SAP system." JEF and Maggie are convinced that flexibility is their key to growth, and have always stayed way out in front with manufacturing space, capital equipment, and enterprise software.

Monterey tends to have a better educated and more stable workforce than other areas of Mexico where harnesses are built. But WHIS enjoys a much lower turnover than other manufacturers, even in their region. "Part of this is because we have better wages for our employees than other similar facilities in our area, but

Continued on page 14





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## Wire Harness Integrating Solutions



JEF (Jose Enrique Fernández) and daughter Maggie.

Continued from page 12 \_\_\_\_\_

we also concentrate on having a safe and happy work environment, and that helps a lot," Maggie explained.

WHIS obtained their initial ISO certification in 2005 and are currently certified to ISO 9001:2015. Their cord sets, power supplies and wire harnesses have been certified by UL. The company uses Advanced Product Quality Planning (APQP) to ensure adherence to customer requirements. JEF wanted to make the point that strict adherence to quality standards does not mean inflexibility. They have built a reputation among their customers for being able to react quickly to any design changes. Team members are also encouraged to make recommendations for design improvement or to enhance manufacturability, which are then evaluated by engineering and with the customer.

One of the more noteworthy attributes of WHIS is their extensive injection molding department. They have six different machines enabling them to handle a variety of shapes and sizes of grommets, plugs and connector encapsulations. "Our power cord business is growing a lot right now," Maggie mentioned "and we currently have additional equipment on our wish list."

When asked how they bring new business onboard, Maggie indicated it's mostly through word-of-mouth and the website. Because of their quality and on-time delivery successes, they are constantly making deeper penetration into their current clients

who ask them to take on more intricate designs.

Many opportunities present themselves to WHIS when a customer has a problem with a current supplier. "We knock on many doors and it can be very hard to get that customer if they are not having any problems," Maggie explained. JEF added, "But when we do find that potential customer with a problem, it's very important to find out exactly what that problem is - is it quality, delivery time? We need to be able to understand the extent of the problem so we can answer with the right solution."

JEF and Maggie were eager to talk about their plans to expand their corporate footprint with a facility in the US. Since most of their customers are in the US, it makes sense for WHIS to have a physical presence there. Initially, the facility will be a warehouse to facilitate their JIT and consignment inventory programs. They will also be quickly ramping up to do some final assembly work as well as rapid prototyping. In short, the facility will allow them to be much more reactive to their US customers in the HVAC industry. Searches are now being conducted in several locations within a reasonable distance from the border.

It's hard to put into words the joy and exuberance JEF and Maggie exhibited when talking about their business. This father/daughter team, coupled with their valued engineering, production and support personnel, seem poised to grow the business and increase their global footprint.



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Figure 1. Early reels with stamped parts.

Sometime in the late 50's ETCO began to manufacture a new line of products for Ark-Les Switch in Watertown, Mass. This expanded the ETCO products to disconnects, rings and spade terminals, along with many other specially tooled products (Fig. 2). This was a very good relationship which lasted until Ark-Les decided to manufacture their own products sometime in the 60's. Ark-Les was a very quality conscious customer and demanded the best from their suppliers which helped ETCO in the long run.

With the gradual loss of the Ark-Les business Joe Dunn, David's father, began looking for new customers. He

added direct salespeople and developed a group of excellent manufacturers' reps across the country.

One of the customers onboarded by the new strategy was Echlin Corporation (later Automotive Controls) in Branford Connecticut. They became an excellent customer after Joe sold Jack Echlin on a cold crimp method to attach spade terminals to the ignition coils. This replaced the slow process of soldering of the leads on the wires. ETCO also had a patented piece of equipment that would weld the wire to the terminal, but the cold crimp was faster. All these prod-

Continued on page 18

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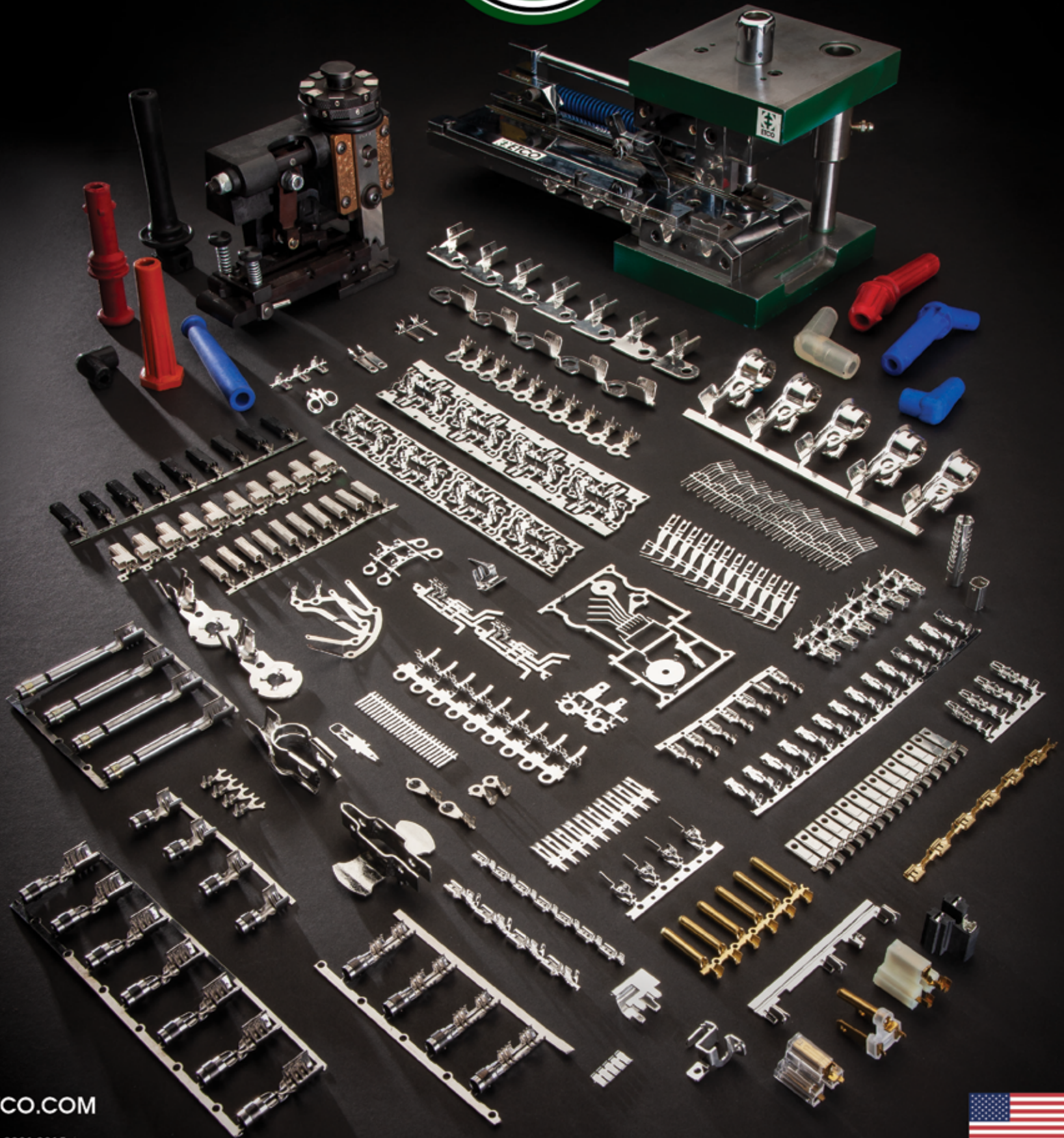
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# ETCO Celebrates 75 Year Anniversary

Continued from page 16

ucts were on reels of many thousands of parts.

Throughout their history, ETCO has looked for ways to increase the customer's productivity by putting the product on a strip and then applying it with a special piece of attaching equipment. Black and Decker became a terrific customer and ETCO

automated many of their processes. "In one case, we took a very complicated carbon brush terminal that was being welded and made the part in strip form with a crimp ear, thus eliminating the individual welding process," David detailed.

Sometime in the 70's ETCO started a research and development fa-

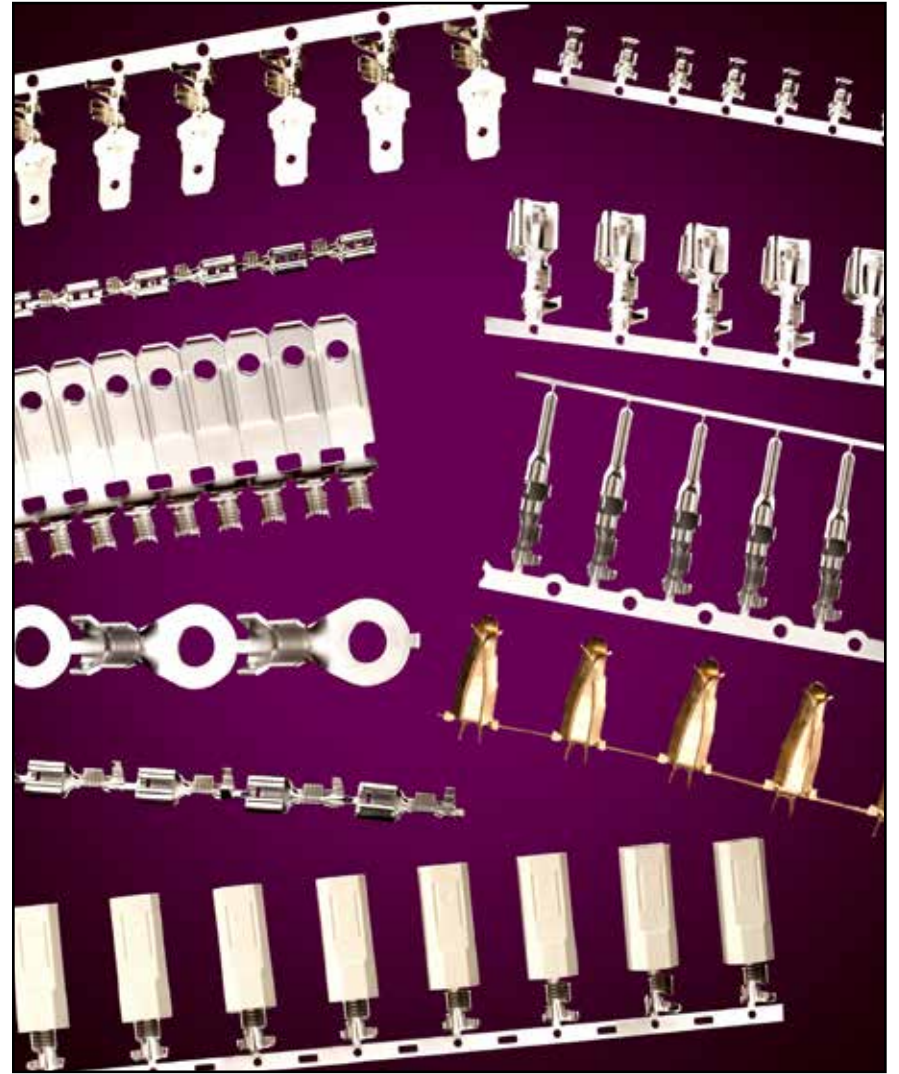


Figure 2. ETCO's disconnects, rings and spade terminals, and other specially tooled products.

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cility to expand their tooling and attaching capabilities. The business was expanding, and they needed productivity gains. ETCO was now manufacturing parts in the hundreds of millions and adding presses instead of speed. They also expanded their custom tooling and attaching equipment. There was great demand for productivity gains and that became the company's specialty. "I remember we made a custom terminal for Black and Decker and married it to a tool that fed their grass whip into a strip fed aluminum terminal. We did this in four weeks, and it ran millions of parts for as long as the grass whip sold," David said. The R&D facility also

came up with an insulated disconnect which could be crimped first and then inserted into the insulator. This was an F or B crimp or a heart shaped crimp which was far superior to the crush crimp being used at the time. "We again married it to a patented applicator to attach and insert at the same time. This product was a huge success, and we still sell millions of this product today."

ETCO Research also made great strides in the mid 70's to increase productivity as volumes increased. The presses were running very slowly by today's standards, and they were

Continued on page 20

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# ETCO Celebrates 75 Year Anniversary

Continued from page 18

stopping to change the reels and feed new coils of metal into the presses far too often. They decided to travel the world and see how other stampers were producing products. "It turned out the Germans and the Swiss had some amazing presses and tooling techniques. We learned about wire

EDM machines made in Switzerland that revolutionized our tool making," David described.

The Swiss also made the Bruderer Press which was much more precise and much faster than what ETCO was using. "Once we introduced these improvements at ETCO we had to also

tackle the issue of handling metal in much larger coils while collecting finished parts coming out of the press." The new press manufactured as many as 2,800 parts/minute versus the original tool which made 400 parts/minute (see image on Page 1). "You can see how this could change our factory. In one plant we went from 45 presses down to 15 (all Bruderers) and more than doubled productivity."


ETCO had one of the first wire EDM machines (Agie) in New England. The new equipment was not just fast, but much more accurate. "One of the reasons ETCO succeeded for 75 years is because we always invested as much as we could in the best people and the best equipment, so we were ready for the push for zero defect in the 80's.

At this point, ETCO now had three factories. But a new product that Ech-

lin and Belden wanted them to produce for their automotive Ignition sets would require further expansion. "In 1979 we started the Automotive Division in Bradenton FL to manufacture this new product. It was used on spark plugs and distributors and was another big success for ETCO," David cited. They used all the manufacturing techniques they had developed in their factories. The Bradenton facility soon grew to 50,000 sq. ft. with 125 employees. "We had almost all the aftermarket manufacturers and one very large OEM customer." Today the FL plant is the largest US manufacturer of spark plug terminals.


These automotive customers also used insulators for these terminals called boots. They wanted to buy these from ETCO, so they added a rubber molding facility. "We fabricated our own silicone rubber compounds

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ETCO's insulated disconnects.

for making these boots (insulators) so we could control the quality. Since there was one boot for every spark plug and distributor terminal, this area grew very quickly." Again, they hired the best people in the industry who, in many cases, were very happy to move to Florida.

ETCO was doing a fair amount of business in Mexico and were approached by one of their customers to enter into a joint venture to set up a manufacturing plant in Mexico City. It was named Telsa (Terminales Elec-

tricas SA). "We did this in the early seventies and ETCO owned 49% and the Mexican Company had 51%. We insisted, and they agreed, to give us a veto over any capital changes or borrowing," David described. This turned out to be a real problem when their Mexican partner was acquired by a very large conglomerate who wanted to have complete control. Surprisingly, everything worked out well. They offered ETCO a great deal for their 49% and ETCO ended up supplying all the conglomerate's plants as well as many others.

During the 80's and 90's ETCO grew sales and profits in all of their 4 divisions: Cord Products, Insulated Products, Engineered Products and Automotive Products. These were all run as separate profit centers with separate management and were fairly autonomous.

They also started a small manufacturing plant in Toronto Canada which was very capably run by ETCO's Canadian Rep organization. Canadian companies wanted to buy products

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ETCO Products



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# ETCO Celebrates 75 Year Anniversary

Continued from page 21

made in Canada, so this worked well for everyone. "This turned out to be a very good corporate structure and the divisions competed with each other in a very friendly way. It made for some fun quarterly meetings because these were all very sharp and competitive individuals," David outlined.

ETCO has kept the Research and Development and corporate management separate. Each division developed products for their customer base and became the experts in their product areas.

Sales and profits peaked in 2000 and the company had about 240 employees. For the next ten years sales and profits dropped more than half because of competition from

China. "Many of our customers-built factories in China and many more went out of business. This was the toughest time in ETCO's 75 years - to see so many friends and good companies fail." David lamented. "Having to lay off or retire over half our workforce who were like family, many who had been with us from the start, was very difficult. We only survived because we had no debt and were able to consolidate operations and slash our costs and overhead."

ETCO thought about producing in China and found a very solid company to partner with, but the lack of control was just not appealing. "At this time, we had become almost religious about quality and

zero defects. We all attended Crosby College and lived by the 4 absolutes."

1. The Definition of Quality is Conformance to Requirements
2. The System of Quality is Prevention
3. The Performance Standard is Zero Defects
4. The Measurement of Quality is the Price of Nonconformance.

"We didn't think we could build this same quality into a plant halfway around the world with only 49% ownership," David asserted.

For the past ten years, ETCO has been slowly building their products to fit what was needed in the US and Mexico. They also ship product to India and China and have kept costs low to be competitive. "We've seen some customers coming back to the US because the lack of quality, coupled with delivery problems, is costing more than the savings.

The R & D center performs tear downs of major and small appliance brands to see where manufacturers can improve their connections. "We buy refrigerators and washing machines etc. from local retailers and make a complete analysis of their connections. Many of the problems in the field come from faulty connections and cost the manufacturers much more than they save." They have also pointed out safety hazards and show how these situations can be avoided.

ETCO now has a lean and young management team, and their sales are making a comeback. "We are using the latest marketing techniques and even selling in smaller quantities on Amazon. We are working with customers on new proprietary parts since we still have our special tooling and assembly equipment capability," David informed. More recently, they came up with a solderless battery post terminal which they put in strip form. It saves on assembly and gets the lead out.

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John Macaluso, ETCO's President, spoke about current challenges and plans for the future. As with most companies, the biggest current challenge is the supply chain. ETCO anticipated a rebound in late 2020 and built-up inventories in raw materials (metals, plastic components & silicon ingredients). "Since we source from US suppliers, the global supply chain meltdown did not immediately affect ETCO as demand exploded at the beginning of 2021. However, as the other US manufacturers realized massive delays were coming from their traditional Asia and European suppliers, they turned to the domestic sources and bought everything off the shelf," John described. This demand has exploded lead times and costs. ETCO updates customers every quarter on the extensive lead times and strongly encourages them to book orders for at least six months.

ETCO took over the manufacture of Pancon terminals in 2020. When Pancon phased out production in its manufacturing facilities in Massachusetts and California, ETCO purchased many of Pancon's dies. "Modifying the dies to run in ETCO Bruderer presses continues to be a challenge. However, we are getting the parts out," John mentioned. They are now making more than 450 Pancon terminals in their US plants.

John is very proud of ETCO's support of the environment. "When sourcing materials, ETCO focuses on

domestic suppliers. The carbon footprint for US suppliers is dramatically less than international/overseas transit. It may cost more, but it is the right mindset."

ETCO's proprietary component program continues to explode since they reduced their production die cost to match Asia. As a result, companies looking for custom stamped metal components no longer need to go overseas. One of the more popular aspects of this program is the combination of high-speed stamping with a custom applicator from the equipment group. This combination allows them to take a complex part and break it into two stages. First, they lay out a basic design that will run at high speeds in strip form through the Bruderer presses. They then ship the reels to the customer, who run the strips through an applicator which can add additional bends while attaching it to wire or mounting it on a thin film element. "This method dramatically saves on packaging and shipping costs. At the same time, we keep the part from getting damaged during shipping," John concluded.

#### Current Products and Markets

ETCO's Standard Product line includes quick disconnects, spade terminals, male disconnects, pins, contacts and receptacles. Many of their standard parts can be used as equivalents to other popular manufacturers' parts.

Continued on page 25

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# ETCO Celebrates 75 Year Anniversary

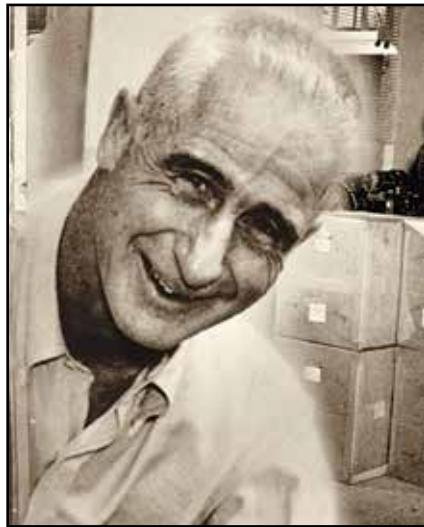
Continued from page 23

ETCO's Cord Products line comprises cord set blades, ground pins, including blade/pin assembled products for faster power cord termination and molding. This line also includes *Assembled* cord set components for mounting on printed circuit boards. This line also consists of Hospital Grade Blades and Pins required for hospital power supply cord applications.

The Insulated Products line includes fully insulated terminals, that are a standard in the appliance industry and other industries requiring high temperature insulated terminals.

Automotive Products are mostly spark plug terminals and spark plug boots. But ETCO also manufactures battery cable terminals, heavy duty ring terminals, and stamped top post battery terminals as a replacement for cast lead. They also make equipment to terminate these products to cable.

ETCO can also assist in the design of new terminals or special stampings either on a real or in loose pieces. They can tool the stamping die and make necessary application equipment. They are always eager to modify standard catalog part to conform to a customer's specific requirement.



Joe Dunn, ETCO's founder.

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This article was compiled from content supplied by David Dunn, Owner, John Macaluso, President, Sean Dunn, VP of Marketing, John Carr, Senior Sales Manager, and Fred Bainbridge, ETCO Representative. Many thanks to the ETCO team, and congratulations on 75 years!

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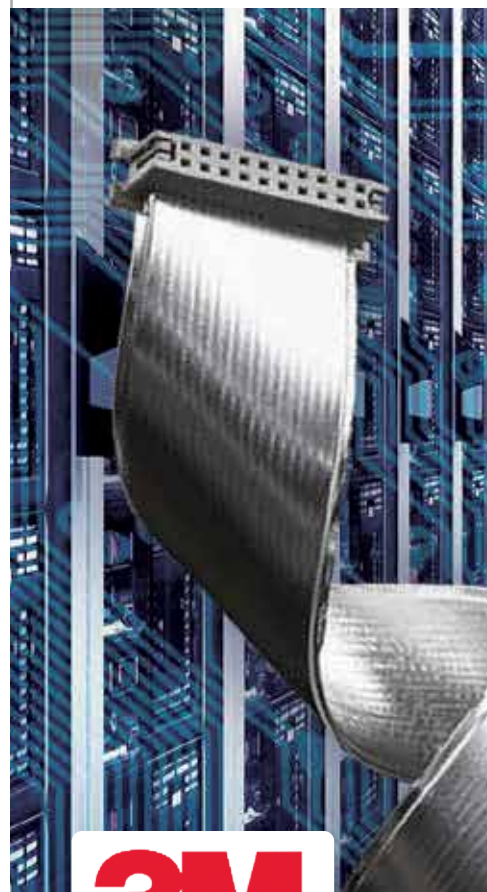
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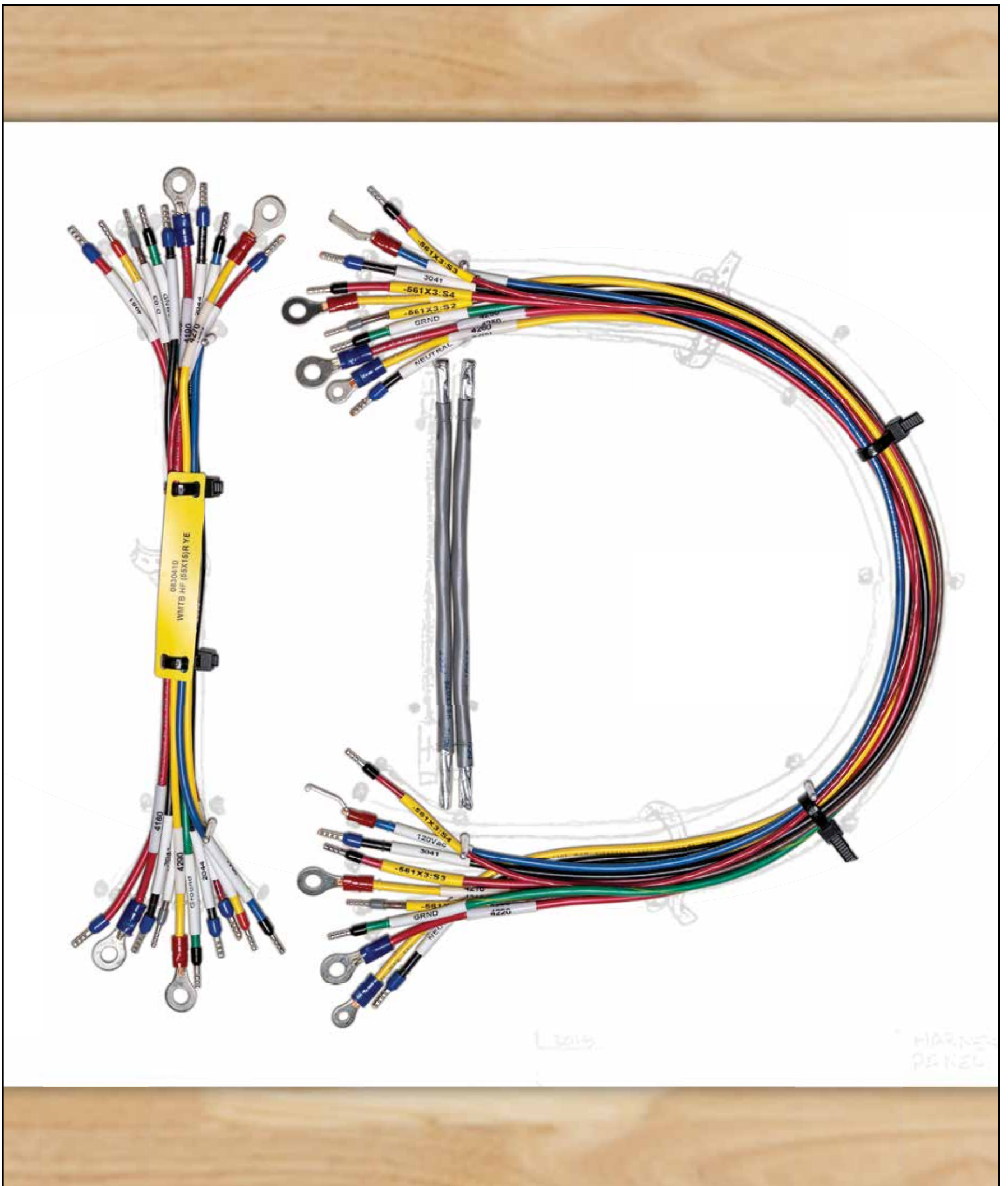
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# LEADERSHIP

PUTTING INSIGHTS INTO ACTION

## Co-op Students the Key to Plant Manager's Success

By Paul Hogendoorn

As I continue to share the Top 10 Tips I gleaned from industry leading manufacturers over my 40 year career, I almost missed sharing this one.

When it comes to digitizing processes on the plant floor in the pursuit of achieving "Industry 4.0" objectives, it occurred to me that many of my most successful customers had benefitted from the youthful, tech savvy enthusiasm of college students working under the direction of the plant manager, getting ideas put into action that the manager, or his seasoned staff, was not able to do as effortlessly themselves. New technology has its advantages, but it is not as exciting to the 'more seasoned' crowd as it is the younger generation that embraces it naturally and enthusiastically.

About a year ago, I was doing a presentation to a company that has 3 plants and about 500 employees. The owner of the company was still involved and was at the meeting along with his plant managers, CI manager, IT manager, CFO and a few others. Almost as a tag-along, one of them invited their co-op student to the meeting, likely because it was his responsibility to keep the co-op student gainfully occupied that four month term.

The demo went well and there were questions from all the different managerial perspectives; can the system do this? Can it show that? Can I have all this one report? Can one person have this dashboard and another that dashboard? How do you build dash boards? How easy is it to create different report templates? To answer the first few questions, I demonstrated step-by-step how those requests could be done. After a few questions, I deferred to the co-op student, asking "is this something you think you could do?", to which he replied affirmatively. Within minutes, all sorts of new ideas and suggestions came up from around the table, directed as much at the co-op student as to me.

A short time later, we closed the initial deal for the first plant, and as part of the onboarding process, we trained the co-op student along with the others. The results were outstanding, and near immediate. The dashboards they set up were unique to their operation and their respective roles. All 3 plants were autonomously run and had their own ways of doing things, but "corporate" (in this case, the owner) got the desired real time and period reporting information from all 3 plants in a consistent format. The 'magic', in this case, was more than the technology, it was the co-op student, working in conjunction with the owner and plant managers.

The seasoned veterans knew their respective plants and roles inside and out; they are very smart and accomplished people, but new technology often seemed foreign to them. It wasn't critical to their day-to-day



Paul Hogendoorn

priorities and having to learn it often made them feel 'stupid' - which for me is the biggest mistake any software or software company can make. (Never make the smart people in the plant feel stupid, and never make people look smart just because they know which way to swipe or what special jargon to use). At best, senior people only have enough time (and interest) to want to be taught how to use the system, not how to configure and tailor it; they leave that to other people in the organization (like the IT department), and those people are likely already overly busy or occupied. The co-op student, however, has no predisposition to existing information technology solutions, or any manufacturing processes for that matter. It makes them the ideal person to explore new ways of collecting, analysing and displaying information for all levels of the management team, and the folks on the floor.

In this particular case (and others I'm aware of), the co-op student gained tremendous insight into all the aspects of the manufacturing process, hearing what the needs were and developing the templates and reports, and the management team saw their best practices and insights properly leveraged and baked into a system that is useful and beneficial to them everyday. The managers weren't forced to adjust their thinking to the format and standards of existing systems but instead were able to get the information and metrics in the way they wanted and in line with how they saw their manufacturing operation run.

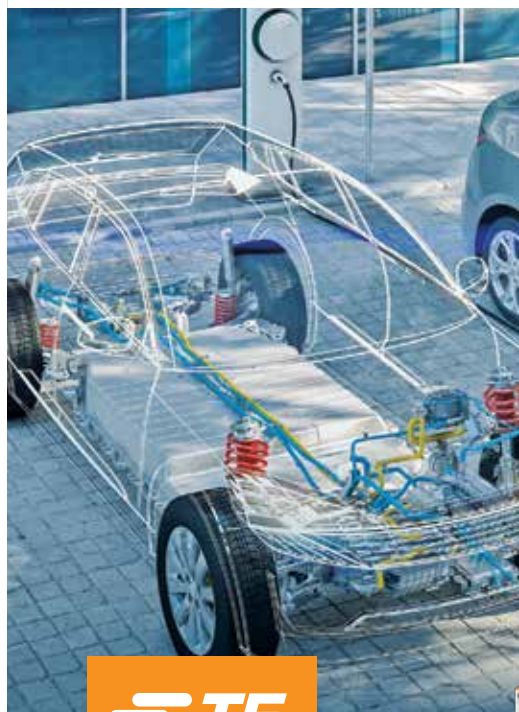
It was truly a win-win-win. The co-op student gained tremendous knowledge and a tactile education in manufacturing. The managers gained real time information delivered to them in ways that mattered to them. The plant benefitted by seeing insights extracted from data quickly, and then put into action and driving results. Plus, they now have first dibs on an excellent long-term and highly effect employee upon graduation.

*For more information on this topic, or other best practices tips, contact Paul at Hogendoorn.paul@gmail.com*

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## High Performance Cable Jacketing for the eMobility Market

The eMobility sector is creating many opportunities for the harness industry. OEMs rely heavily on contract manufacturers to guide them in choosing wire with the proper performance capabilities. Increasingly, this includes not only an understanding of wire

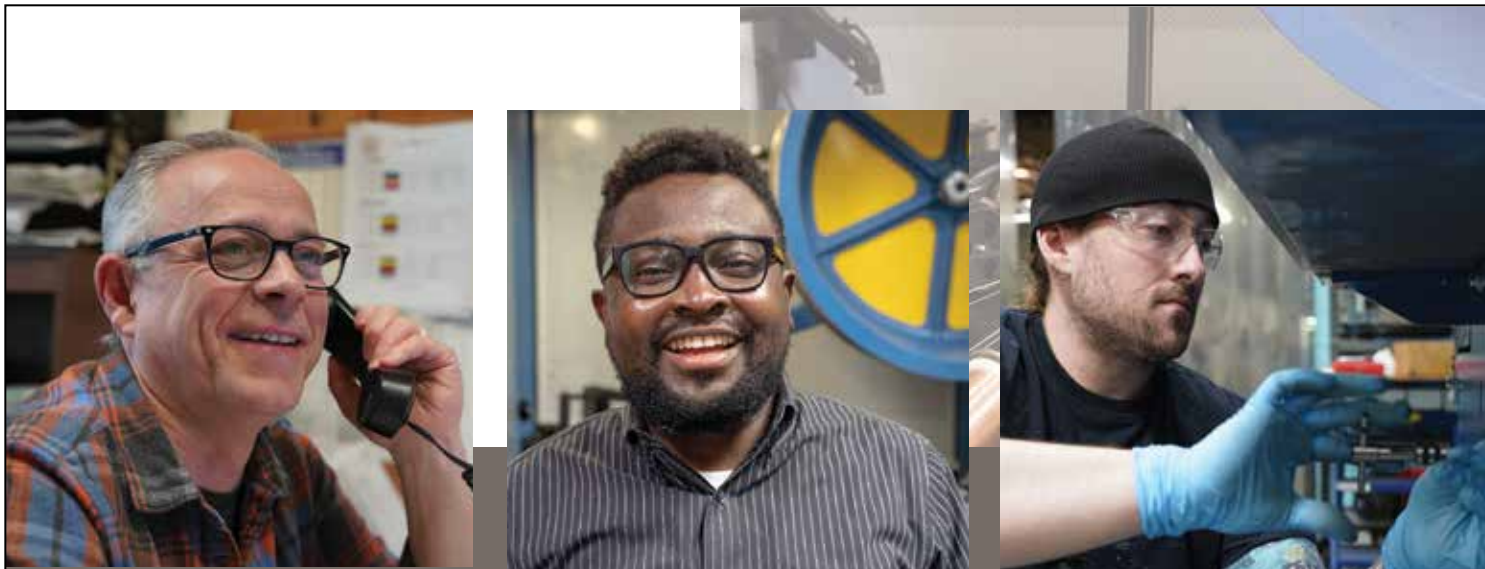
and cable conductors, but also knowledge of the polymers that surround and mate to them. These can be connectors, grommets, strain reliefs or anything that makes up the completed assembly. This article deals with materials used in eMobility, and more specifically, charging

cables and BASF's Elastollan® material.

WHN spoke with Christopher Bradlee, Market Segment Manager at BASF about how their Elastollan brand of thermoplastic elastomers (TPUs) is meeting the challenges of the eMobility sector. Elastollan is a premium jacketing material engineered through years of experience. It offers superior flame retardant properties while still having the physical performance of a TPU.

This TPU has a wide range of uses across many markets and products. Its properties are particularly useful in eMobility, and more specifically charging stations. "A big part of the global requirement for charging cable outer jacket material is low conductivity," Chris mentioned. "You've got high voltage running through these cables, so you don't want them to conduct electricity." Another crucial requirement met by Elastollan for EV charging cables is hydrolysis resistance. As these cables are subjected to prolonged exposure to the elements, it's crucial that the chemical bonds in the material do not break down with water over time.

Charging station cables must also have good abrasion properties, along with good temperature flexibility. "These materials have to be resistant to cold, heat, sun and rain, but they must also have good abrasion resistance. They are dragged along the ground continuously and would



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easily wear if they didn't have good abrasion toughness," Chris informed. Excellent resistance to tears, cuts, oil and grease along with good tensile properties are also charging station cable essentials. Elastollan has all of these bases covered. He also mentioned that the material meets the challenge of coiling as well. It holds the coil and does not harden or break along the bend radii.

It's also important that these jacketing materials do not bloom. "Blooming is when the functional additives inside the product bloom, or come up to the surface," Chris explained. "Polymers often times have additives that enhance their processability, impact resistance or other performance benchmarks. But it doesn't do you any good if your UV resistance additive blooms to the surface over time."

Chris was then asked about any challenges with sealing Elastollan. "It really depends on the compatibility of the polymers, but overall, it seals quite well. TPUs generally have good compatibility with many polymers, but poor compatibility with a polyester, so if you're putting a TPU and polyester together, you may need an adhesive," he clarified.

Elastollan TPU does have good compatibility with most overmold materials. "These materials are generally TPUs or other elastomers, and their improved adhesion to Elastollan is due to its low filler content. High filler content can greatly affect adhesion," he revealed. "This is one of the big value propositions of Elastollan, that it has good grommet adhesion."

As far as processability, Chris mentioned that Elastollan TPU is pretty standard. It's similar to other materials that harness manufacturers would be using, with no special handling or stripping requirements. One thing it does have is excellent colorability, with a wide spectrum of colors available. This can be very important to OEMs when they design cables. Another important aspect about the material is that it is globally available.

As you may have surmised, BASF does not actually make the cables. They supply bags of pellets to the cable manufacturers who extrude the material over various conduc-

tors to make different types of wire and cable. But sourcing cable with Elastollan is pretty simple. "They can contact me, and I will point them to a supplier," Chris suggested. In fact, with any questions regarding the suitability of a cable to an application, Chris encouraged reaching out to him. "We have a whole team of experts who know the standards for charging cables and connectors, and we also have a whole product regulatory support group who know the regulations globally." He stressed that regulations vary from country to country. These regulations extend to things like cable specifications and to important restrictions that may also exist. "Not only do we have the product development experts who know the chemistries and how to develop solutions, but we also have the regulatory and stewardship experts who can help navigate product development."

Chris wanted to stress the fact that BASF covers a wide range of offerings to the wire harness industry. "We already covered the cable jacket material, but readers should know we have the Engineering Plastics group who do all the fire resistant PBTs for the connector industry." Fire resistant PBTs are an emerging trend within the wire harness industry, and BASF has the same level of product and regulatory experts to handle PBTs that they do with the TPUs. Both materials can be used to produce high-strength cable management components like wire ties, holders and mountings.

In closing the discussion, Chris wanted to mention that BASF is a leading expert in sustainability. "I think as your readers go forward and learn more about us, they'll see that we put a tremendous amount of effort into recycling, circular economy, and bio-based materials. I like to say that we create chemistry for a sustainable future at every level."

You can contact Chris at +1 (734) 512-3527, or at christopher.bradlee@basf.com. Jump on the BASF website at wireandcable.basf.us for a plethora of information useful to our industry.

*Special thanks to Patti Presswood, MARCOM at BASF, for organizing the interview and keeping us on track.*



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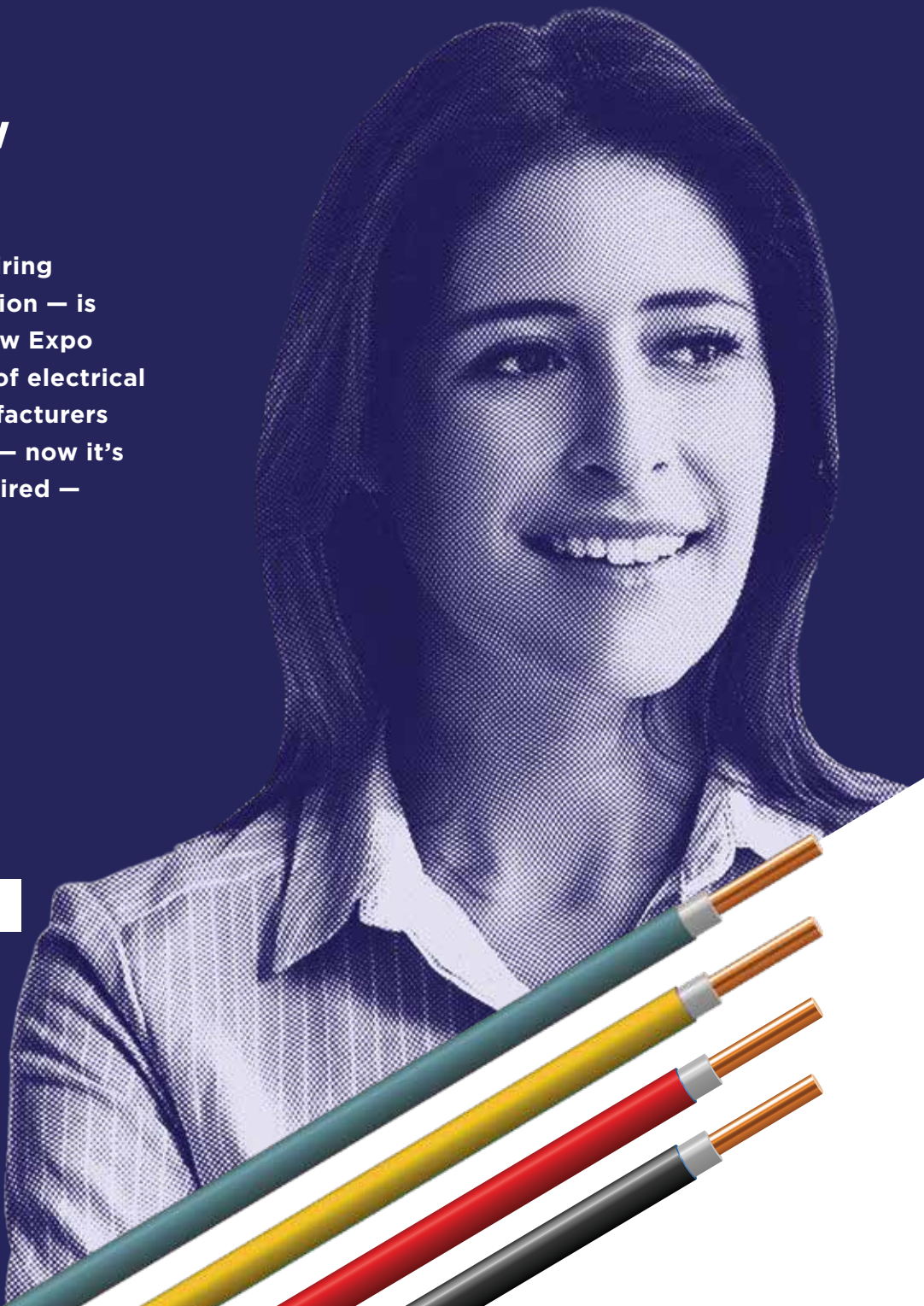
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Decision-makers who design, specify, purchase, install, sell, maintain or manufacture electronic cable assemblies, cord sets, wiring harnesses and other related products for the following industries:



## Schedule at a Glance

### Tuesday, May 10

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7:00 am . . . . .Registration Opens

9:00 am-6:00 pm . . .Conference

### Wednesday, May 11

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7:00 am . . . . .Registration Opens | Coffee Service in Lobby

8:00 am-8:45 am . . . . .Keynote

8:45 am . . . . .Ribbon Cutting Ceremony

9:00 am-7:00 pm . . . Exhibits Open

9:00 am-10:30 am . . .Networking Morning Refreshment Break with Mimosa Bar

9:30 am-4:30 pm . . . . .Conference

2:00 pm-3:30 pm . . . . .Networking Afternoon Refreshment Break

4:30 pm-7:00 pm . . . . .After Hours VIP Party

### Thursday, May 12

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7:00 am . . . . .Registration Opens

7:00 am-8:30 am . . . . .Networking Breakfast with Exhibitors (Exhibit Hall)

8:30 am-1:30 pm . . . . .Conference

9:00 am-10:30 am . . .Networking Morning Refreshment Break with Bloody Mary Bar

9:00 am-3:00 pm . . . . .Exhibits Open

1:30 pm-3:00 pm . . . . .Networking Afternoon Refreshment Break

\*Times subject to change



# Education

## Tuesday | May 10

---

### 8:00 am-10:00 am

**Workshop:** Quality in Wire Processing – Troubleshooting Techniques and Tools

**Speakers:** Greg Douglas | Technical Services Manager for North America, Schleuniger and Rob Boyd | Senior Product Manager, Schleuniger

### 9:30 am-11:00 am

**Workshop:** Beyond Continuity & HiPot Measurements

**Speaker:** Christopher E. Strangio | President and Founder, CAMI Research Inc.

### 10:30 am-11:30 am

**Seminar:** Technological Solutions for the Post-COVID Labor Gap

**Speaker:** Lee Humphreys | Komax

### 1:00 pm-4:00 pm

**Workshop:** Basics of Ultrasonics and Ultrasonic metal welding

**Speaker:** Home Mojal | Telsonic Solutions, LLC

### 1:00 pm-5:00 pm

**Workshop:** Improving Reliability of Continuity & HiPot Testing

**Speaker:** Christopher E. Strangio | President and Founder, CAMI Research Inc.

## Wednesday | May 11

---

### 9:30 am-10:30 am

**Seminar:** High Voltage Harness Automation – Trends, Challenges and Solutions

**Speaker:** Rob Boyd | Senior Product Manager, Schleuniger

### 11:00 am-12:00 pm

**Seminar:** From Design to Test in Minutes: Fast Setup of Cable and Harness Testing Equipment

**Speakers:** Kevin Shelley | Product Manager, Cirris Inc. and Peter Rauch | Sales Engineer, adaptronic, Inc.

### 1:00 pm-2:00 pm

**Seminar:** Making Customer's Designs Work for Your Manufacturing Team

**Speaker:** Fergus Kendall | Cadonix Ltd

### 3:00 pm-4:00 pm

**Seminar:** Islands of Automation: Charting a Course for Design-to-Manufacturing Automation

**Speaker:** Paul Harvell | Product Director of E<sup>3</sup>.series, Zuken USA, Inc.

## Thursday | May 12

---

### 8:30 am-10:30 am

**Workshop:** IPC/WHMA-A-620 Meet the Industry's standard

**Speakers:** Teresa Rowe | Sr Director, Assembly and Standards Technology, WHMA/IPC and Cathy Hanlin | General Manager, Precision Manufacturing Company Inc.

### 10:00 am-10:30 am

**Conference:** Common Misconceptions in Testing - Limits of Fault Detection

**Speaker:** Christopher E. Strangio | President and Founder, CAMI Research Inc.

### 10:30 am-11:00 am

**Conference:** Solutions for Final Assembly and Test in Large Installed Applications

**Speakers:** Kevin Shelley | Product Manager, Cirris Inc. and Peter Rauch | Sales Engineer, adaptronic, Inc.

### 10:30 am-12:00 pm

**Workshop:** WHMA's Wire Harness Operator program

**Speaker:** Carlos Plaza | Sr. Director of Education Development, WHMA/IPC



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## Cathodic Protection: Keeping Corrosion to a Minimum

Whether we're talking about a steel water holding tank like those found in residential hot water heaters or massive submerged offshore oil platforms, inhibiting corrosion on metal surfaces is critical. Cathodic protection, or CP, is a widely-used technique to control corrosion on metal surfaces by essentially making it the cathode of an electrochemical cell.

The simplest method of protection connects the metal to be protected to a more easily corroded "sacrificial metal" to act as the anode. The sacrificial metal then corrodes instead of the protected metal.

For structures such as long pipelines, where passive galvanic cathodic protection is not adequate, an external DC electrical power source is required to provide sufficient current.

Cathodic protection systems protect a wide range of metallic structures in various environments. Common applications include:

- Steel water or fuel pipelines and steel storage tanks
- Steel pier piles
- Ship and boat hulls
- Offshore oil platforms
- Onshore oil well casings
- Offshore wind farm foundations
- Metal reinforcement bars in concrete buildings and structures

Another common example is galvanized steel, where a sacrificial coating of zinc on steel parts protects them from rust.

Cathodic protection prevents corrosion by converting of the anodic (active) sites on the metal surface to cathodic (passive) sites by supplying electrical current (or free electrons) from an alternate source. Usually this takes the form of galvanic anodes, which are more active than steel.



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Understanding the corrosion process is essential to truly grasping how cathodic protection cables work.

#### How does steel corrode in water?

To understand cathodic protection, you must first understand how corrosion is caused. For corrosion to occur, three things must be present:

1. Two dissimilar metals;
2. An electrolyte (water with any type of salt or salts dissolved in it); and
3. A metal (conducting) path between the dissimilar metals.

The two dissimilar metals may be totally different alloys - such as steel and aluminum - but are more likely to be microscopic or macroscopic metallurgical differences on the surface of a single piece of steel.

In this case, let's consider freely-corroding steel, which is non-uni-

form. If the above conditions exist, the following reaction takes place at the more active sites: two iron ions plus four free electrons.

The free electrons travel through the metal path to the less active sites, where the following reaction takes place: oxygen gas is converted to oxygen ion (by combining with the four free electrons), which combines with water to form hydroxyl ions.

The key takeaway is that engineers have found a way to keep this corrosion to a minimum.

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# Three Considerations for Choosing the Right Enclosure

By Rittal  
North America LLC

Enclosures are the foundation to ensuring products run smoothly. They protect your electronic controls and equipment to run vital machinery. However, it is critical to use the right enclosure for the application. Ratings, material types and finishes, and style all play an important role in maximizing the protection of all electrical components inside enclosures.

If you are using the wrong enclosure for the environment, you risk exposing the internal components to hazards from dirt, dust, and debris to chemical and liquid ingress which can cause equipment failure. Understanding the basics of enclosure selection will help in choosing the enclosure that will protect your indispensable equipment and keep operations running.

## 1). Ratings

The National Electrical Manufacturers Association (NEMA) and the International Electrotechnical Commission (IEC) provide a set of standards that describe the degrees of ingress protection from dirt, debris, water, chemicals, and other liquids. Enclosures that fit the ratings laid out by NEMA or IEC will need to be certified if they are to display the UL or TUV mark. Manufacturers will conduct

product testing to verify that their specified ratings meet the testing requirements.

Products that meet this level will have a mark of certification from companies including UL and TÜV. Enclosures with this mark ensure that the enclosure you're selecting will provide the required protection for the environment and application as stated in the standard. Proper protection will help ensure a long service life of the equipment and controls being housed inside.

## 2). Materials and finishes

The material the enclosure is constructed from can play an important role in protecting the internal components. From protecting against environmental factors like rain or chemicals used in washdown to protecting data integrating and preventing electromagnetic interference, the right material will provide added protection.

Polycarbonate is a thermoplastic and is used in applications where total weight is a concern such as in maritime use. It also resists corrosion and UV rays and offers a degree of water protection, so it is commonly used in outdoor applications including solar or wastewater treatment. As it is a non-metallic material, it naturally prevents electrical arcing or shorting. Its composition further

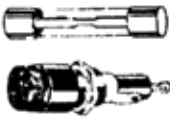
Continued on page 40

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THE POWERHOUSE OF ULTRASONICS

# Three Considerations for Choosing the Right Enclosure

Continued from page 38

allows radio-waves to penetrate allowing for protection of equipment that requires wireless transmission. Aluminum is a lightweight option that provides more durability than plastic. One of the main benefits of aluminum is that it allows heat to dissipate in addition to protecting against outside elements. Unlike its plastic counterpart, there is natural shielding from radio-frequency interference (RFI) making this a choice for those that need added security for the internal equipment. This material is commonly used in telecommunications, traffic control, and battery storage applications due to its resistance to weather fluctuations. Additionally, it provides protection from alcohol, solvents, oils, and more.

Carbon and Stainless Steel are frequently used in industrial applications as they both provide added protection and durability for most environments. Carbon steel is suited for most environmental conditions and have four grades based on carbon content - Low Steel, Medium Steel, High Steel, and Ultra High Steel. Stainless Steel has two composition types - 304 and 316 offering varying degrees of protection from corrosion, temperature fluctuations, and water. Its composition is fitting for oil and gas production, pharmaceutical manufacturing, food and beverage, and many other industrial facilities.

Finishes can play an important role in the total cost and aesthetics of the enclosure. If you plan to make modifications to the enclosure, you'll want a finish that is resistant to scratches and chipping whereas a consistent and clean looking enclosure layout may be important in other areas of



operations or customer interactions.

Blasting, Polishing, and Buffing will smooth out any roughness and create a polished finish. Blasting has the added benefit of completing the cleaning and finishing in one step which can reduce some of the cost. However, these options provide limited surface protection from external factors.

Wet or Powder Coating is an affordable option that creates a clean look and provide more color customization options compared to other finish choices. However, it is prone to scratching and chipping which can add costs if the panels are being modified. Any finish damage will need to be redone to provide the proper grounding protection and keep the aesthetic of the enclosure looking clean.

Zinc plating provides a grounded coating that does not chip or scratch. This ensures the integrity of the enclosure remains intact even throughout modifications. The entire surface is immersed in the zinc coating ensuring complete protection and keeping the aesthetic appeal of the finished enclosure.

### 3). Enclosure style

Choosing an enclosure style to fit your application specifications is crucial to creating a solution designed for your needs. Deciding on unibody, modified, or modular can be challeng-

ing; starting with your unique needs will put you on the path to success. Determining how the enclosure will be used today and what the future application needs are will help in the decision-making process.

**Unibody:** Heavy gauge sheet steel welded together are the defining characteristic of unibody enclosures. They can create a durable enclosure; however, fewer access point will be available. This can make it challenging for maintenance and modifications. Additionally, it limits flexibility so using this option in certain environments including maritime or earthquake prone areas, may actually diminish its integrity due to the vibrations and shock the structure will undergo.

**Modified:** While there is a lot of talk around modified enclosures, they only allow you to add customizations to an existing structure. Creating cutouts for controls, switches, and more is a necessity, but you are limited to how customized the complete enclosure will be.

**Modular:** Choosing a modular solution, presents more control over the final customization. The ability to modify all panels with the necessary cutouts or additions is still an option, but you gain the ability to create additional updates or modifications as facility and operational needs change. In a modular solution, the strength of the enclosure system is in the frame, making this a strong, durable, and flexible option. It also allows replacement of a single panel if numerous changes are needed, supports the

separation of sections within the enclosure using various sized panels, or connecting enclosures together across all sides. Modular enclosures grant ultimate control over your end solution and accommodate the needs of tomorrow in a more cost-effective way than unibody.

Making an informed choice on enclosure selection will lead to a successful solution built for longevity. Along with understanding the environment and application needs of your enclosure, insight into the ratings, material types, and enclosure styles will boost your knowledge throughout the enclosure selection process. You will be able to confidently select the enclosure for your unique needs and have assurance that your choice will not only support current needs, but the requirements of tomorrow.

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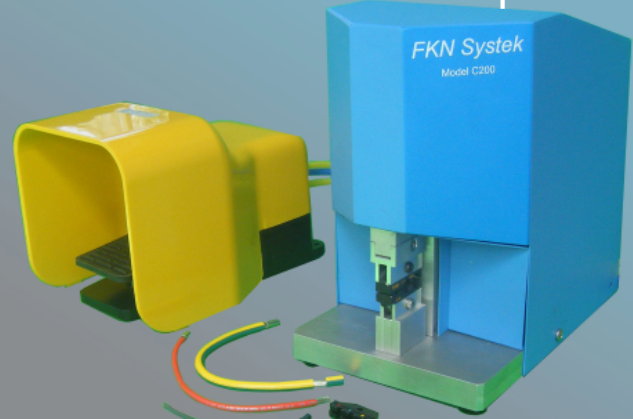
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# Training in the Virtual World

When the pandemic hit in 2020, DIT-MCO International—a leading designer and manufacturer of electrical wiring test equipment—vowed to make NETS programming and operation training easily accessible for their customers. Next Generation Electrical Test Suite (NETS) is DIT-MCO’s software for test script creation and execution. Prior to COVID-19, a NETS programming and operation class could only be taught with a live, face-to-face instructor at DIT-MCO’s Kansas City, MO facility. The pandemic forced everyone to rethink how business was done, and DIT-MCO was no different.

Traveling for business and pleasure was almost non-existent, but the need for training did not go away. Being a manufacturer on the governments “essential business” list, the doors of the operation were able to remain open, and with a great team, they were able to safely continue manufacturing wiring harness test systems. However, the doors to visitors were closed. This affected all of DIT-MCO’s customers, especially the ones who needed NETS training as classes are regularly held throughout the year. Rather than asking for customers to risk their safety, the technical training specialist, Danny Roth, and his team went to work creating a solution to meet the training restraints.

**What is the solution?**

E-Learn NETS 460 training and Virtual Instructor-Led Training (VILT).

**What is the difference?**

**E-Learning NETS Training**

While they are both completed online from the comfort of the customer’s home or office, there is a difference. E-Learn NETS training is a pre-recorded, self-paced learning method where the instructor is not live or immediately available. The class breaks NETS down by topic and goes through modules that can be paused, rewind, and restarted. You can complete this form of training over the course of 10 days. All questions about the NETS course are answered by the trainer via email or phone call.

**Virtual Instructor-Led Training (VILT)**

VILT is a live training class with an instructor who is teaching a class full of students. The difference is that VILT is completed virtually

in an online meeting format. A live instructor gives students the opportunity to interact and ask questions as they arise. Throughout the course, there are a number of class exercises. VILT makes it easy to not only complete these assignments, but it also allows for the ability to ask questions in real time. Students can take this class from the comfort of their work or home office.

Even as the pandemic continues, concerns for safety remain at an all-time high. Traveling to Kansas City to DIT-MCO’s facility presented a challenge that some customers did not want to face. DIT-MCO quickly sprang into action and offered two alternate options to meet training needs. This kept people out of airports and away from other students.

An important aspect of having alternate training options is convenience. Apart from safety, DIT-MCO created training options that can be used long after the pandemic is over. VILT NETS Training and E-Learn NETS Training eliminate travel time and costs, along with keeping people available for their own company. A live, in-person NETS training class runs for four days, Tuesday through Friday. Depending

on the location of customers, this often involves two travel days, along with four to five days in a hotel room. VILT is designed to reduce that stress. Gone are the costs for flights, rental cars, and hotels. In addition, the student eliminates all of the hours spent traveling.

DIT-MCO knows how important it is for customers to have all of their employees available. Having an alternate option for training gives customers that same sense of comfort. This is especially true in the case of an emergency. No one expects or wants a crisis to happen, but the reality is an emergency can occur at any time. Keeping employees in their office and available for immediate communication can be the difference between an emergency being resolved versus it causing further issues.

**Effectiveness and Engagement**

However, in order for VILT to be a success for both DIT-MCO and the students taking the class, students need to fully understand NETS when they complete their training. Danny Roth, technical training specialist, said this about VILT’s effectiveness,

*Continued on page 44*

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# Training in the Virtual World

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“It can be just as effective as physically being here. I’ve found it often depends on the environment of the students. Are there distractions from their surroundings? Are they being interrupted by co-workers or if working from home, small children? If the students are able to limit these distractions and remain engaged, VILT is an excellent alternative to attending a physical class. If there’s a high likelihood of external distractions and

interruptions, then the cost and time spent attending physically is well worth it.”

In order to have an effective VILT training class, the students need to be engaged. Without being face to face, it can be a challenge to know if the students are engaged. That is a challenge that the trainer must overcome. DIT-MCO’s trainer often has a classroom full of face-to-face students, plus a screen full of virtual

students. He offered some advice on ensuring full engagement for the virtual students that trainers can’t see: “The best advice I would give to anyone transitioning to VILT is to always remember your virtual students are there with you. Learn their names and ask direct questions, not just “Are there any questions?” Give time to formulate an answer. Take 10 to 15 minute breaks after every hour or so of instruction. Remember, the students are likely sitting at a desk in front of a computer or laptop watching your presentations and listening to you. Give everyone time to stretch and move around a bit, grab a drink or snack, etc.”

An important aspect of being engaged in a class is the answering and asking of questions. This lets the trainer know that the student is paying attention and is engaged in learning the material. “Start the virtual meeting a few minutes early and stay online after the scheduled end of day for any student that may have questions they don’t feel comfortable asking with everyone else listening,” said Roth.

During an in-person or virtual class, a useful technique to create engagement and begin the training process is to give students programming assignments. Programming assignments allow students the chance to showcase what they have learned throughout the course and write custom test scripts. Whether the student is in person or virtual, each student’s script is submitted and run on a DIT-MCO analyzer by the trainer. These assignments allow the trainer to measure student progress in learning NETS and allow for helpful discussions if there are any issues with the assignment. Showing each student’s test script in front of the class allows the instructor to illustrate different ways to complete the assignment. Students are only given a schematic diagram and a wire list, and they are told to create a test script from scratch. Due to companies taking a different approach to testing, no two test scripts are the same. It can act as a confidence boost for the student to see their script run successfully on a DIT-MCO analyzer. Fol-

lowing the training class, they remain confident that they will be able to write test scripts for their company’s product as well.

## Challenges

Even with all of the hard work of the DIT-MCO team, it did not come without hurdles. It was an adjustment to all who were involved, students and the trainer. Roth explained, “The biggest challenge with hosting a four-day VILT course is time zones. The first VILT class we held had students from four different time zones. Students on the East Coast started their day a little later than they normally would while those on the West Coast started a bit earlier. To go along with this, we had to schedule lunch at a time that would accommodate everyone.”

Other than logistical challenges, DIT-MCO’s facility classroom wasn’t fully equipped to handle VILT classes. The AV equipment was lacking what it needed to effectively teach students through video conferencing. In order to change that, DIT-MCO bought all new video equipment. Luckily, they had recently bought an interactive touch monitor for in-person training, and the model also worked well with virtual students. It accommodated easy screen-sharing over video conferencing, all while allowing the digital pen to be used for writing on the presentation.

## Conclusion

When it came to training, DIT-MCO had one goal in mind: give customers more options to become fully trained on NETS software. While met with challenges along the way, DIT-MCO’s training should be more polished and well-rounded to meet everyone’s needs moving forward in 2022. With a full year of e-learning and VILT training, DIT-MCO’s training staff is more experienced and prepared. While there will always be a learning curve adjusting to the virtual world, DIT-MCO feels confident that their best years of training are ahead of them. Going forward, NETS training will remain easily accessible for all of their customers.



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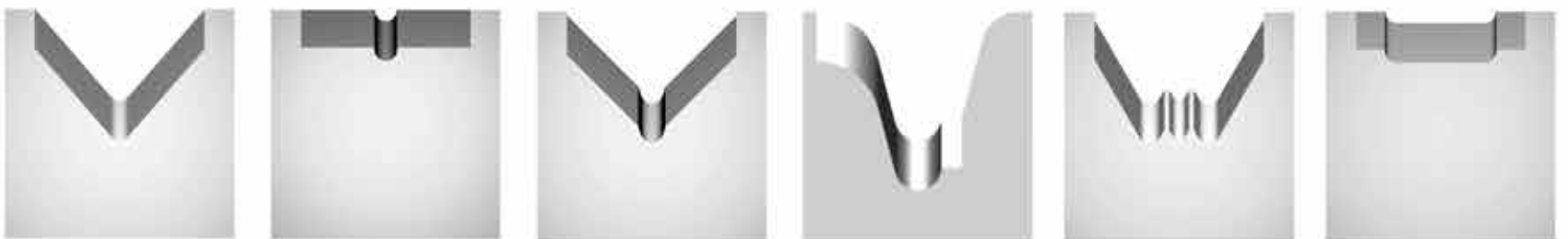
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# Electronic Device Manufacturers Shouldn't Fear Custom Connector Solutions - They Should Embrace Them

**By Chris Beevers  
Business Unit Director -  
Device Connectors, Phoenix  
Contact Americas Business Unit**

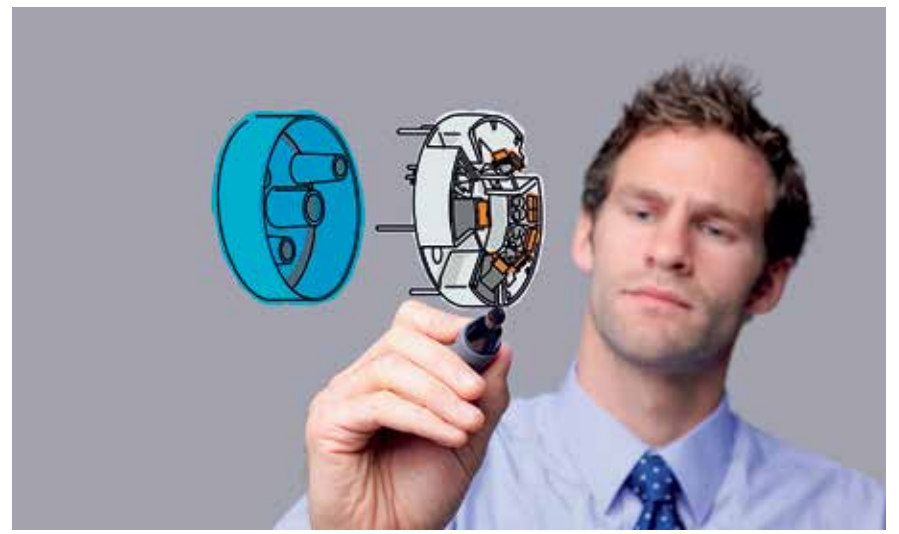
Devices used in industrial applications are undergoing multiple transformations in today's fast-paced industrial environment. OEMs creating new products are dealing with opposing challenges when trying to design in connectivity. The Internet of Things (IoT) is fueling end users' thirst for more data and faster processing. The upcoming 5G network only emboldens that thirst. Pressure to reduce the cost of equipment and systems is driving new products to offer increased functionality. Device manufacturers must take advantage of that functionality to ensure successful fu-

ture products. However, the pressure to minimize size and make end products easier to integrate and install is always present.

The balance of meeting new trends and the classic needs of the market are a major challenge, and device manufacturers must think differently when creating new products. Standard connectors are not always the best choice to accomplish this. Customized connector solutions can help achieve the balance needed with many of these challenges.

### Fast-forwarding to the IIoT

Today's megatrend of the Internet of Things (IoT) is creating new problems. Industrial device OEMs are under pressure to bring new products to market that increase intelligence and functionality, while reducing overall product size. All of this must be done



**While there can be the upfront time and investment costs, customized connector solutions can be a smart and affordable option in the long run.**

without sacrificing robustness. If new devices in industrial applications like controls, displays, or monitoring systems are not networked and easily accessible, the chance of their acceptance and success in the market is minimal. With the introduction of the IIoT in the industrial world, the ever-expanding IIoT is connecting more industrial devices to other industrial

things in the field. The 5G network has "hit fast-forward" on that trend in a major way.

The only way new devices can accomplish this is by expanding both the I/O counts at the controller and the networking capabilities of all field devices. Additional I/O for an industrial-grade device requires more connections that can be easily terminated in the field. Increasing the number of I/O counts within a device increases the size of that device. The constant pressure to reduce the overall size of devices on the floor and within a cabinet directly opposes this. Adding I/O while reducing size means more high-density connectors must be used.

When trying to increase the functionality of your product, the need for more data to process and the more signals to connect presents itself. The access to additional data of networked devices has only fueled the interest of acquiring even more data. Reports of 40 billion-plus connected devices within the IIoT over the next



**5G networks will accommodate more users and devices, making the IIoT possible.**

*Continued on page 48*



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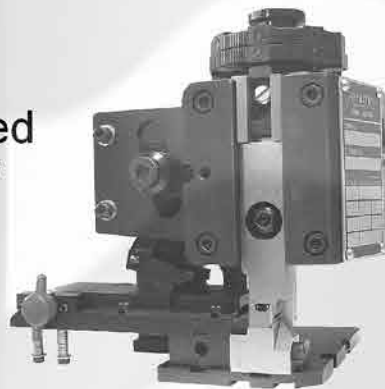


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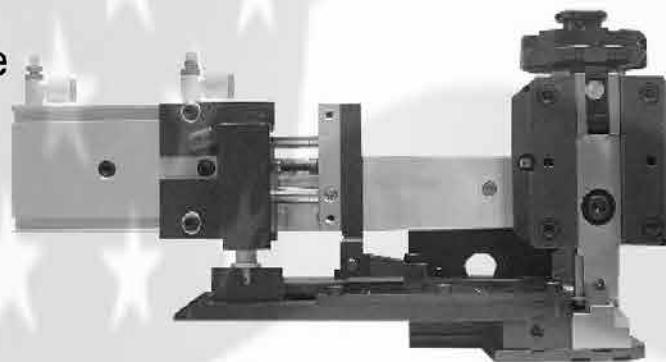


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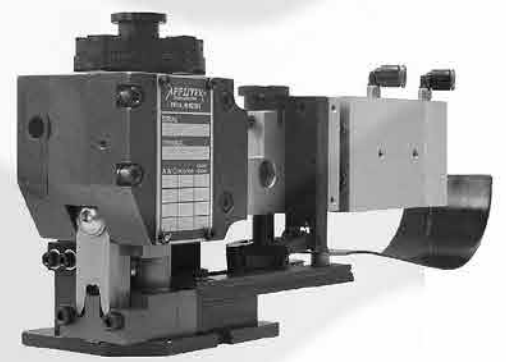


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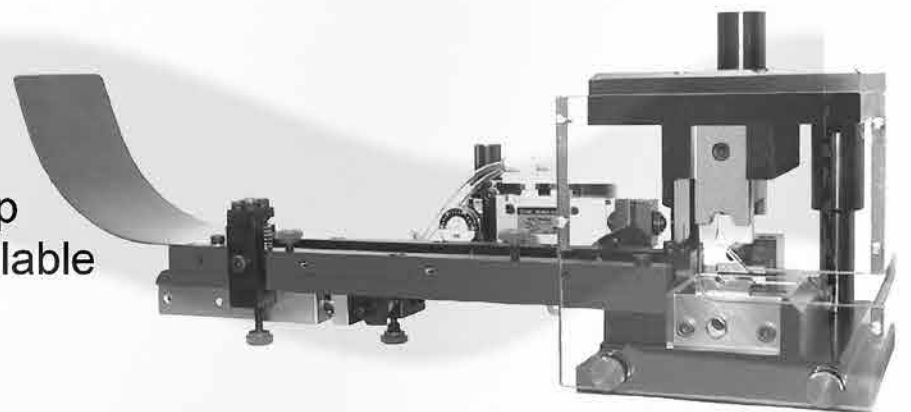


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# Electronic Device Manufacturers

Continued from page 46

few years are everywhere.

This increasing appetite for data translates to increasing the number of networked end devices, and more connection points for the controller to manage. Increasing the amount of I/O in a device or integrating a new data connector for different networking protocols would be a simple achievement. However, the robustness of data connectors comes into question. Today's data connectors are fast and inexpensive. But industrial networks require more robust data connectors with wider temperature ranges, higher and vibration protection, and protection against liquid ingress, such as IP67 ratings.

### Advantages and disadvantages of off-the-shelf connectors

Today's OEMs face even more challenges than just robustness, functionality, and density. They are constantly battling with competitive pressure. The features of their products alone may make them stand out. When that is the case, the OEM can simply go

out and get a connector that works. When speed to market increases in importance, it's great to have an off-the-shelf connector available. But the connector that works won't always distinguish the individual product. Using an off-the-shelf connector comes at the expense of having an individual look and feel. New products are being developed faster than ever, making the market more crowded. With this influx of new devices, branding connectors with an individual look and feel becomes more important and can help a company's device stand apart from the competition.

The risk of quality problems is another concern for OEMs.

Going with a new contact system could open unknown problems that an off-the-shelf contact system has already addressed. The validation process of a new contact system can be long and pose unknown problems that could lead to

production delays. Given the speed at which the industrial world is moving today, a delay in production could have significant costs, including loss of market share and loss of trust by the customer base.

To bring products to market faster in this global economy, strong communication with development and manufacturing partners is critical. For example, when development is in one country, and production is done by an EMS partner in another country, and distribution centers are in a third country, OEMs need to have better communications and work with partners who can handle global communications.

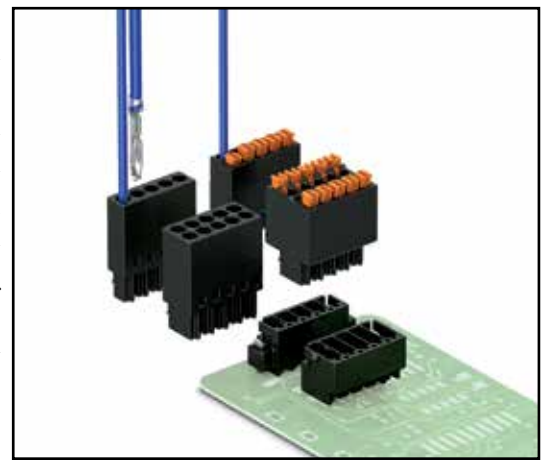


Figure 2. Connectors with spring termination reduce size without sacrificing reliability.

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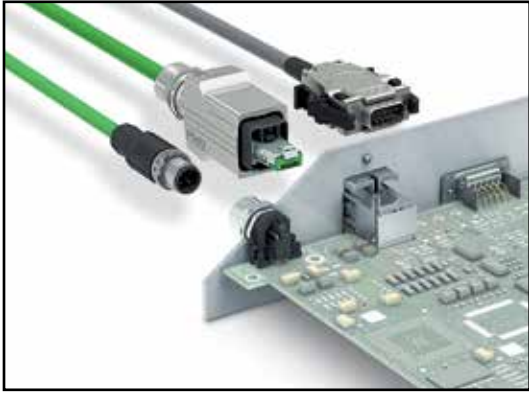
Grid of past issue covers for Wiring Harness News, including titles like 'Electrex Inc.', 'Flux Connectivity', 'TMA Cables', and 'Extreme Cables'.



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**Figure 3. Hybrid connectors combine signal and power into a single connector, saving space.**

#### Addressing concerns

Each of these problems can have a relatively simple solution when taken on its own. However, the balancing between these issues is what poses the greater challenge.

When taking on the challenge of increasing the I/O and reducing the overall size of a device, the only answer is higher density connectivity. That sounds easy enough. But when taking into consideration the installation of your product and its usability, this becomes a significant challenge. For devices that require connection to multiple field devices, discrete wire termination will need to be accomplished somewhere. Utilizing a high-density connector on the controller and pushing the discrete wire connections to another part of the control cabinet only pushes the increased cost to another location that has the same challenge of space constraints.

Some connectors available today can help to reduce size. For example, moving from screw to spring terminations can reduce the overall size of the connection point, while increasing reliability and reducing cost (Figure 2). Another option might be to move to a hybrid-style connector that contains both power and signal connections, so it reduces the overall size of the connector (Figure 3). But when considering data connectivity, very few options are available. High-density office-grade connectors can't withstand the high temperatures, higher shock, and vibration requirements, and in many cases the ingress protection from liquids, that

industrial-grade connectors commonly possess. Standard off-the-shelf connectors just won't meet the needs of industrial devices designed for the future. For example, adding screw flanges to a data connector can help, but the temperature ratings are not the same, and vibration at the contact interface can cause problems when using the thin gold plating often used in office-grade contact systems.

If you also need to consider the look and feel of your end product and want to create brand recognition, an off-the-shelf connector cannot provide that individual look and feel. Thus, marketing managers must spend time differentiating their products to achieve the brand recognition they need.

Time to market is critical today. Using an off-the-shelf standard connector solution will allow you to design in the connector quickly. But the design process may require additional time due to considerations to make that connector more

Continued on page 50

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## Electronic Device Manufacturers

*Continued from page 49*

robust. That means additional time in development and potentially additional costs in production.

### Finding balance with custom connectors

When considering all challenges, a customized solution becomes more and more attractive. If one connector met everyone's needs, there wouldn't be thousands of different types of connectors available today. A customized solution can be designed for the OEM's spe-

cific application and meet the individual needs better than an off-the-shelf option. Customized solutions can meet the density requirements while integrating the connector into the individual product's packaging. A customized solution can consider usability in various environments and provide the individual look and feel to make end products stand out from the competition and strengthen the OEM's brand.

A customized design can make the most efficient use of space in an application by in-

cluding the power, signal, and data connectivity needs. By designing a connector for the specific need of a new industrial device, OEMs can achieve the greatest space savings without sacrificing the number of I/O or data connections. Increased robustness for data connectivity can also be achieved. A customized data connector can meet the typical shock and vibration requirements, temperature ranges, and ingress protection of liquids typical in industrial applications. With a customized solution, you can

also integrate the connection technology into the electronic housing, ensuring the most efficient use of space and reducing overall assembly costs.

It is a common misperception that customized solutions are too expensive and take too long to design. When looking only at the unit cost of mass-produced commercial connectors and lead times for tooling, a customized solution might be higher. But considering the concessions that are needed in the design to meet the new trends, like increased functionality and reduction of the overall size and robustness in industrial environments, the cost for a custom solution becomes more attractive.

Tooling lead times must be considered, although new technologies like prototype tooling and additive manufacturing can greatly reduce times. Additive manufacturing technologies are getting close to the same performance of the materials used to make a connector. Printed metals are coming closer to the performance of stamped and formed high-conductivity copper, and plastic materials are also coming closer to the various high temperature ranges and flame retardancy needed for agency approvals (Figure 4 page 52).

But it is not just the connector components that can benefit from additive manufacturing. It is also the tooling used to make them. Additive manufacturing can create tooling that otherwise can't be made with traditional machining. As an example, additive manufacturing provides enough flexibility to place cooling lines in an injection mold in places that traditional machining cannot. In addition to how

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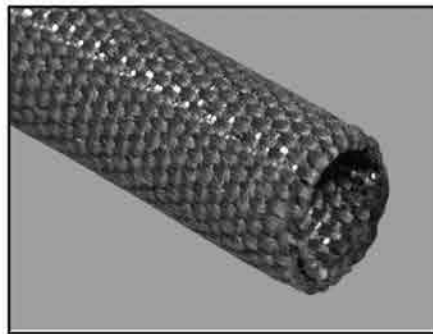
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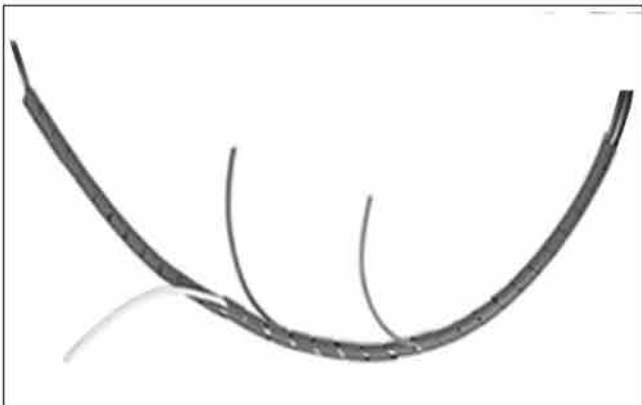
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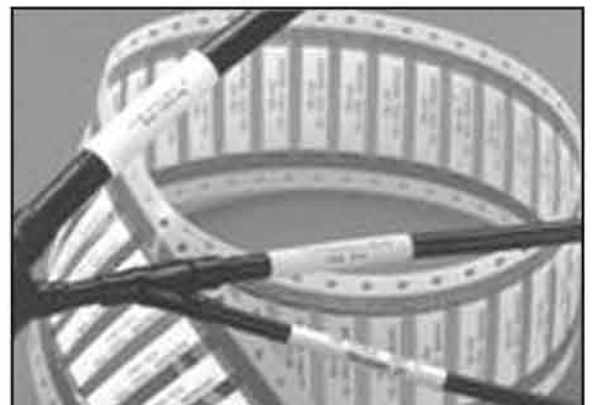
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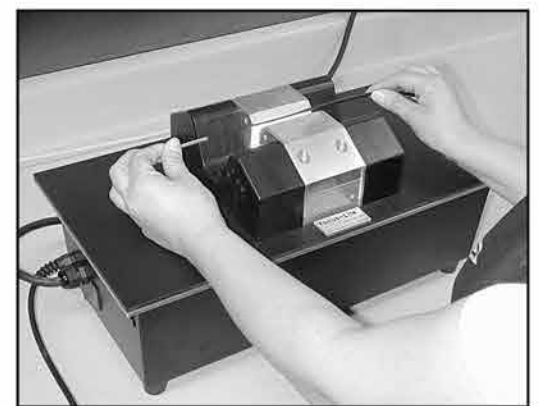
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# Electronic Device Manufacturers

Continued from page 50

the molds are designed, printing injection molds and inserts can greatly reduce the lead time for injection-molded components, making it possible to get a custom connector solution up and running quickly.

Connector manufacturers today that have additive manufacturing capabilities in-house can be very valuable partners. They can experiment with new metal composites that can be printed and closely match the quality of traditional stamped and formed contact systems, or plastic materials that can come close to the performance of agency-approved

plastics used in connector designs. Additive manufacturing is changing the way many OEMs consider custom connector solutions.

Working with a proven supplier with experience in customized solutions can help in multiple ways and greatly reduce the development timeline. By doing the necessary work, such as design validation and mold flow analysis, up front, a partner can reduce the development time by several weeks. In addition to that up-front work, when a connector partner has access to components from other connector designs that can be used in new custom solutions, they can address concerns regarding un-



**Figure 4: Additive manufacturing can pave the way for custom connectors**

known problems with new contact systems.

A proven supplier with global rec-

ognition of the highest quality available is critical. By utilizing the connector components or the know-how of an existing contact system from a broad product offering and redesigning that into a new connector housing, the development timeline and tooling costs can be greatly reduced. That strategy can also reduce the time and cost associated with new agency approvals. The validation of a contact solution is a critical step in making sure you have a high-quality connection. Utilizing that know-how and existing validation is a significant savings.

All quality connector manufacturers have a development process with milestones. However, the typical development process for standard

products is much different than one for custom products. When considering a standard product, a connector manufacturer needs to identify a need in the market, develop concepts, and revise and validate those concepts through customer feedback. This is usually done with multiple customers, all of whom have their own needs in mind. Designing a connector to meet multiple customers' needs can take several concepts and variations to meet only a percentage of what all customers want. All that work must be done before the manufacturer finalizes the design or orders the component tool and assembly machines. This process could take months and sometimes years to finalize a concept. When developing custom solutions, that process needs to be weeks, not months. OEMs must find a connector supplier that understands this and can adjust the development process in the concept stages to meet critical timelines.

A good custom connector partner will have a development process designed for customer-specific applications. It should be one that can be adjusted for the OEM's specific timing needs. Providing budgetary proposals quickly with a high degree of accuracy is important (Chart 1). As the design concept becomes finalized and the development process continues, the accuracy of the proposal can increase. A connector partner with experience in developing custom connector solutions is extremely valuable.

When a custom connector solution is the

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right choice for an OEM, the next decision is choosing the right company to partner with. The wrong partner would only increase costs and development time, and ultimately create frustration.

Given the investment in time and money to develop custom solutions, choosing the right partner is critical for success. A valuable connector partner today should be able to offer consultation on connector design, not just provide the service of acting as a subcontractor for a new connector concept. Just defining the technical requirements can be difficult. But OEMs need to combine the technical requirements along with commercial requirements to come up with a solid business case and the best solution possible. A connector partner should have a deep understanding of not only plastics and contact design, but how those two components come together to make a quality connector that can be manufactured quickly and easily. A connector partner should be able to document a de-

velopment plan, including a test plan at every step from concept through to high-volume production. The right partner should have a history of innovation and previously established global communication channels with multiple manufacturing locations in low-cost regions or locally in the U.S. and Europe.

#### Conclusion:

Industrial OEMs today face many challenges. Customized connector solutions offer great benefits compared with off-the-shelf connectors. What may seem like a large investment in time and money is really an affordable option, when considering the costs associated with trying to make an off-the-shelf connector fit in a new application.

When you consider the balance in meeting new trends of industrial devices and the development challenges they pose, a customized connector solution really stands out.

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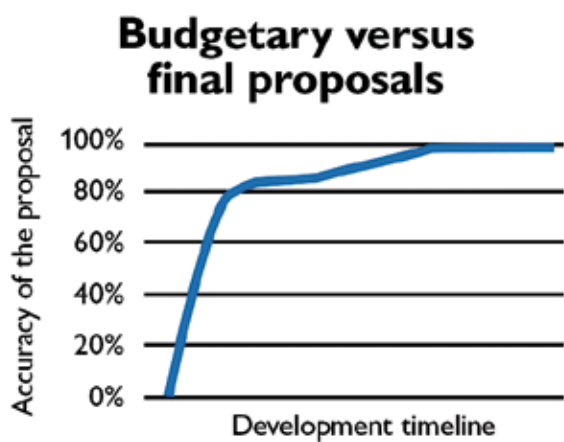


Figure 4: Additive manufacturing can pave the way for custom connectors



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#### Configuration

A leader in the development of PC-based cable and wire harness test systems, CAMI offers the CableEye suite of products complete with accessories – including auto-detected, plug-in connector boards for fast, convenient set-up and testing of standard cables. There is an extensive and growing stock library of these test fixture boards – several of which are populated with families of connectors, such as the video market's CB16A for BNC, SMB, SMA, and N connectors. Many boards are sold unconnectorized, a high proportion of which are configured for specific connectors, such as the CB41 through CB44 for Micro D connectors.

When pre-populated and pre-configured boards are used, the tester GUI automatically displays a graphic of the connectors and wiring under test. The tester can be readily programmed to

do the same for custom boards and fixtures. These boards are designed to fit all CableEye testers.

This generic custom interface board accepts a wide range of circular or other connectors and accommodates LIF test blocks and bulkhead and/or cable-mounted mating connectors. While a bulkhead connector mounted directly to the board produces a more compact interface, a cable-mounted solution would be preferred if the test cable consists of heavy-gauge wire or is bulky. Any panel-mount circular connector with four mounting holes fits the "X"-pattern slots. Total pin count cannot exceed 64.

Connector pins are wired to labeled pads surrounding the board. Bare area provided for custom labeling such as a bar code. Use two CB8H boards together, or a CB8H in combination with any other CB board or built-in connector to accept any cable type.

Sold as a set of two boards, each test board may be paired with other CableEye adapter boards to accommodate any combination of connectors. Incredibly versatile, CableEye testers are expandable to accommodate large and complex harnesses, and users can connect and configure them in numerous ways — set up an array of QuickMount™ Housings fitted with connector boards, plug custom interface cables directly into any of the 64 pin headers on the control and expansion modules, or use a test interface panel, perhaps on a rack-mounted system. Not just a tester, a CableEye test system is a complete cable management system offering features

not available on any other cable test equipment, and may be used to test unlimited types of connectors.

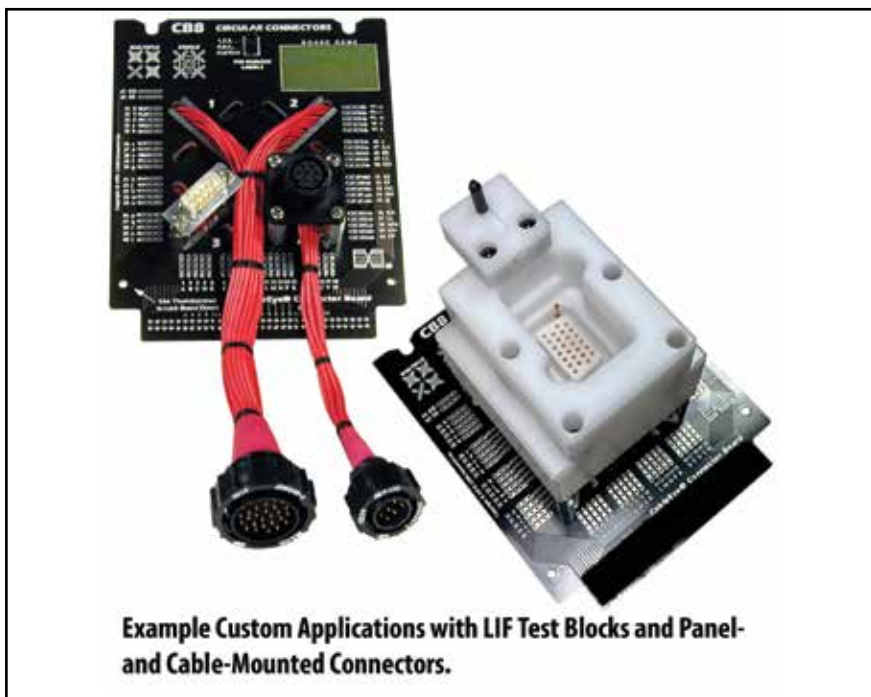
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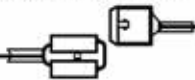


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### Panduit Board Names Shannon McDaniel as Next CEO

Panduit announced that its Board of Directors has appointed Shannon McDaniel as its next Chief Executive Officer (CEO) and President effective January 1, 2022. McDaniel, who currently serves as the company's chief financial officer, will succeed current CEO and President Dennis Renaud, who retired at the end of 2021.

"As a results-focused leader, Shannon brings his collaborative mindset to the role, drawing from his commercial and financial background, while leveraging the power of Panduit to move the company forward," said Panduit Executive Chair Andrew Caveney. "Shannon has also built the trust of our employees, and the Board is confident that he will apply his deep industry knowledge and keen business acumen to lead Panduit."

Caveney added that McDaniel is taking over the role of CEO at an ideal time. "Our long-term investment horizon, outstanding employees, and agile business processes have allowed us to

build business momentum through the downturn," he explained. "The digital economy, the drive for zero carbon emissions, and electrification trends are having a profound impact on our markets. Panduit is well positioned to apply our problem-solving mindset to solve technical challenges as new technologies transform our data center, enterprise, and industrial businesses."

"I am thrilled for the opportunity to serve as Panduit's CEO and lead the company into its next phase of growth," said McDaniel. "We have a great strategy, an incredibly talented and dedicated workforce, and an innovative culture that is continually looking to create value for our customers. I am very excited about our future and the opportunities in front of us."

McDaniel has served in a variety of leadership positions over his 30-year career. Prior to joining Panduit as CFO, he excelled in global financial leadership roles during his 14 years with Eaton Corporation, including serving as the company's Director of Finance for its EMEA electrical business and Vice President of Finance for the Americas systems and services group. McDaniel holds a Bachelor of Science in Accounting from Northern Illinois University in DeKalb, Ill.

Following his planned retirement, Renaud will continue supporting the transition in an advisory capacity through the first quarter of 2022.

"It has been my distinct personal and professional honor to serve Panduit for 10 years – the last four as CEO. Panduit's unrivaled legacy of innovation, quality, service, and continuous

improvement has fueled our business growth," said Renaud. "I'm proud of how Panduit's people embodied togetherness, inclusion, change, and a drive for innovative excellence throughout my tenure. The company is in experienced and capable hands with Shannon, the leadership team, and our outstanding employees."

"I thank Dennis for his contribution to the success of Panduit. Throughout his career, he has challenged our team to be focused and to always be innovating," said Caveney. "He has had a profound impact on our culture, from his passionate support of our diversity and inclusion program to his drive for use of 80/20 principles. Dennis has also displayed tremendous leadership during these unprecedented times, putting our employees and customers first and operating with transparency."

Since 1955, Panduit's culture of curiosity and passion for problem solving have enabled more meaningful connections between companies' business goals and their marketplace success. Panduit creates leading-edge physical, electrical, and network infrastructure solutions for enterprise-wide environments, from the data center to the telecom room, from the desktop to the plant floor. Headquartered in Tinley Park, Ill., USA and operating in 112 global locations, Panduit's proven reputation for quality and technology leadership, coupled with a robust partner ecosystem, help support, sustain, and empower business growth in a connected world.

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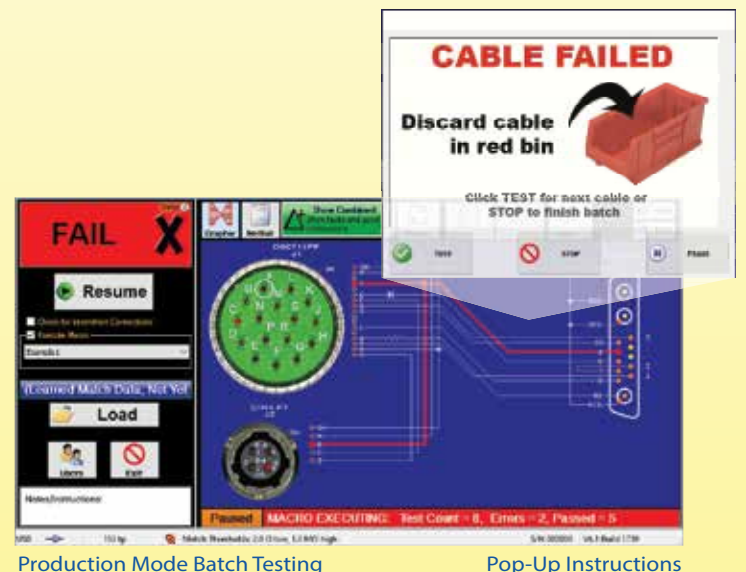
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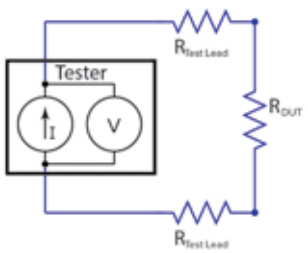
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# Four-Wire Kelvin Testing

In the previous two articles in this series, (Sept/Oct and Nov/Dec 2021) we compared automated to manual electrical testing and then examined how automated cable/harness testers make measurements. During those discussions, basic continuity, isolation, and high voltage testing were considered. In this article we'll expand that range slightly by looking at 4-wire Kelvin testing, a capability possessed by many automated testers.

When we looked at a continuity test last time, we saw that the tester performs this resistance measurement by applying a known current through the circuit, measuring the voltage drop and then calculating the resistance using Ohm's law. That formula states  $R=V/I$  where "R" is the resistance in ohms ( $\Omega$ ), "V" is the voltage in volts, and "I" is the current in amps. Continuity resistance measurements are typically performed using a standard 2-wire measurement configuration, which connects one test point to each side of the measurement. As seen in Figure 1, the

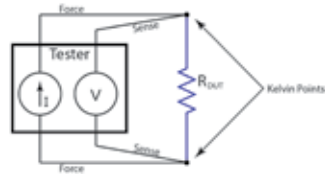
Figure 1  
Standard 2-wire Measurement



voltmeter measures the voltage drop across the entire circuit including the resistance of the two test leads in addition to the resistance of the Device Under Test (DUT), which is the value of interest.

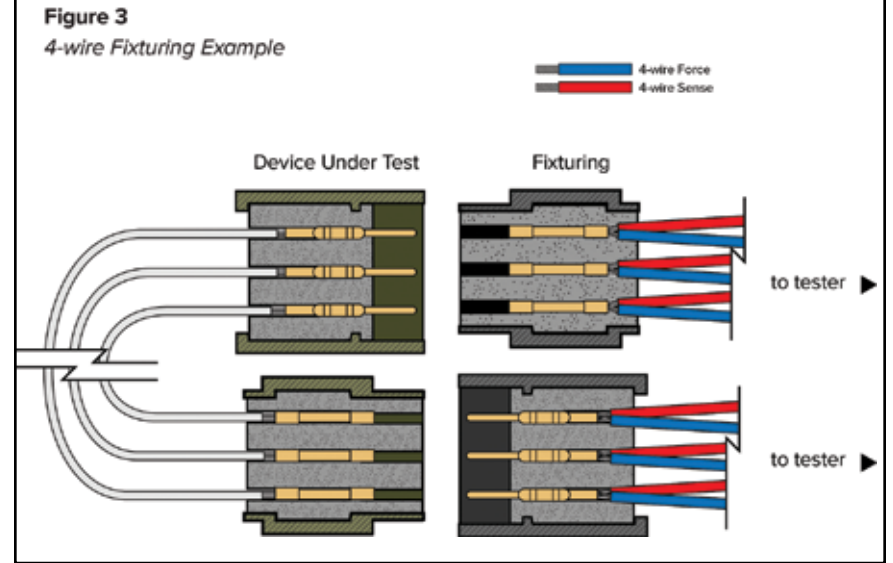
In a Kelvin (4-wire) measurement two test points are connected to each side of the measurement. One point acts as the "force" that supplies the current and the second as the "sense" which is used to perform the voltage measurement. The place at which the force and sense paths meet is called a Kelvin point. The key benefit is that the measurement only includes the resistance between the Kelvin points (Figure 2).

Figure 2  
4-wire Measurement



In addition to providing the capability to eliminate the resistance of the test leads, the Kelvin measurement method typically provides a lower measurement range. It's not uncommon for automated testers to provide a low limit of .1  $\Omega$  (100 m $\Omega$ ) for 2-wire resistance measurements, but a low limit of .001  $\Omega$  (1 m $\Omega$ ), or even lower, for 4-wire measurements.

When considering test fixturing, Kelvin testing obviously requires ac-



cess to more test points. Additionally, assembling test fixtures using two pairs of connections for each Kelvin measurement introduces challenges. As Kelvin measurements include only the resistance between the Kelvin points, the force and sense paths should meet as close to the desired measurement as possible. A practical solution is to make this connection in the test fixture's product mating connectors (Figure 3). In this configuration the connection resistance of the connector contacts is included in the measurement in addition to the DUT resistance, but it's often the best practical solution.

It's also important to remember that automated testers allow the user to mix standard 2-wire measurements and 4-wire measurements in the same test. Therefore, 4-wire measurements

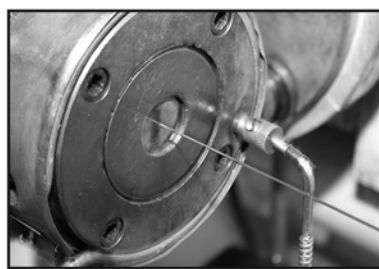
are most often used only when necessary, which brings us to the subject of applications and when to use the Kelvin measurement method. Sometimes this decision is made by the requirements of a test specification that calls for a resistance threshold below the test equipment's 2-wire measurement range. However, it can also be the case that while the measurement is technically within the range of a 2-wire measurement, such a test can't be practically implemented.

When faced with difficult test criteria it's best to do some quick math to calculate the lowest practical acceptance threshold using a 2-wire measurement. If the calculation produces a value above the specification criteria, the Kelvin measurement method should be considered.

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Briefly, the formula looks like this:

	<b>Calculated highest resistance of an acceptable DUT</b>
+	<b>Accuracy tolerance of the tester</b>
+	<b>Fixturing resistance</b>
<hr/>	
=	<b>Lowest practical resistance threshold for DUT test</b>

The calculated resistance of the DUT should be based on the highest acceptable resistance. Measuring a single sample will NOT provide a suitable substitute. Variables to include in the calculation:

- The resistance of the wire. Use the longest length allowed by the drawing tolerance and allow for any extra wire required in the connectors. If a wire specification isn't readily available, consult a wire resistance chart or do an internet search for a wire resistance calculator to find the resistance for the appropriate wire gauge over a given unit of measure.
- There are differences in the resistance of solid and stranded wire and between stranded wire with different numbers of strands for a given gauge. Therefore, it's best to use the resistance value specified by the wire manufacturer.
- Twisted pair wire has a higher resistance per unit of measure because the actual wire is longer than the overall measured length due to the twists. Typically, twisted pair wire has between 0.5% and 3% higher resistance than wires without twists.
- Most wire resistance charts are based on 20 degrees C (68 F). The wire resistance increases

by approximately 4% for every 10 degree C increase in temperature (2.2% for every 10 F increase in temperature).

- Add the contact resistance of the connectors using the high-side of the manufacturer's specified tolerance ranged. Depending on the characteristics of the connectors, the contact resistance will also increase with wear over time.

Next, the measurement accuracy of the tester must be included in the calculation using the high-side of the tester's tolerance for the measurement range.

Finally, the resistance added by the test fixture should be considered. The same calculation process used for the DUT can be used again, however, as the fixturing is typically a fixed set, the actual resistance can be measured instead, if it's possible to do so accurately. Be sure to include the contact resistance for the connectors and again, keep in mind that the contact resistance will increase with wear over time. However, as we've seen, this is the point at which Kelvin measurements can be extremely helpful as it can remove the resistance of test fixture from the equation. If using the Kelvin method, it's only necessary to include the resistance in the test fixtures that exists between the Kel-

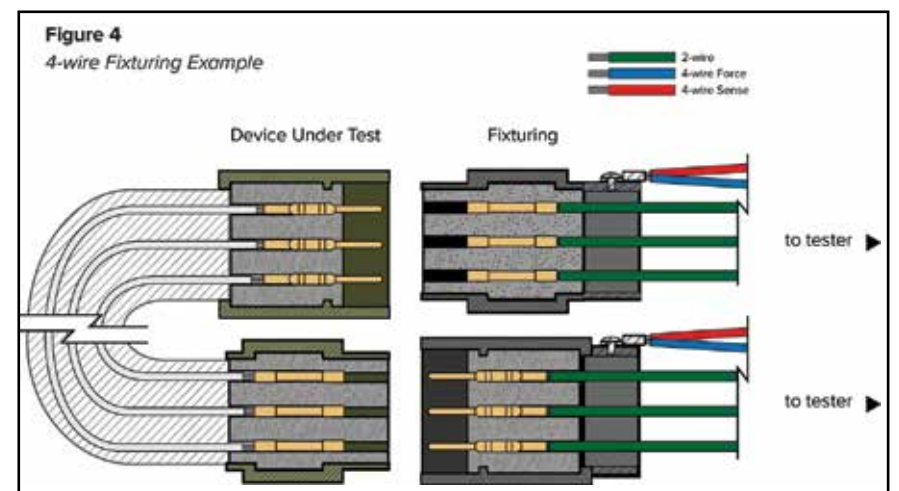
vin point and the DUT. For example, in the setup shown above in Figure 3, the contact resistance of the connectors is included in the measurement.

One real-world example that is often encountered is a very low resistance requirement from connector to connector through a shield. Frequently, the shield is terminated to the connector body and also wired through a connector contact to assure a good connection to the mating hardware. However, the test specification may require that a very low resistance measurement be made through the connector bodies to ensure good connections. In all cases, the key point to remember is that the 4-wire measurement is made from the point where the source and sense points meet (the Kelvin point). Depending on the characteristics of the connector, the Kelvin point can be made on the test fixture's product mating connector body to simplify the testing process (Figure 4). Using this setup, the measurement would include the connection resistance of

the two connector shells. This may be acceptable if that connection is expected to be very low resistance.

Another option would be to connect the Kelvin force to the test fixture's product mating connector and the sense to the DUT connector body using an alligator clip or other temporary connection method. Both the force and the sense could also be connected together on the DUT connector using a similar temporary connection. Either option is only acceptable if the plating on the DUT connector body is conductive or if there is conductive hardware on the connector that can be used as a connection point.

In this example, as well as in other applications, once the Kelvin measurement method is understood, the best option can be selected depending on the test requirements and the circumstances. In a broader sense, it's beneficial to know that Kelvin testing is an available tool and to recognize its benefits and the circumstances in which it can be most useful.



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## Five Differences Between a Wire Harness and a Cable Assembly

By Christine Siebert

The terms wire harness and cable assembly are often used interchangeably, but

they are not the same. Instead, they have definite differences. In this article, I will discuss five main differences between a wire harness and a cable assembly.

Before starting with those differ-

ences, I want to define a wire and a cable. A wire is a single strand of an electrical conductor, typically copper, aluminum, or sometimes steel. A cable is a bundle of wires with two or more insulated wires wrapped in one

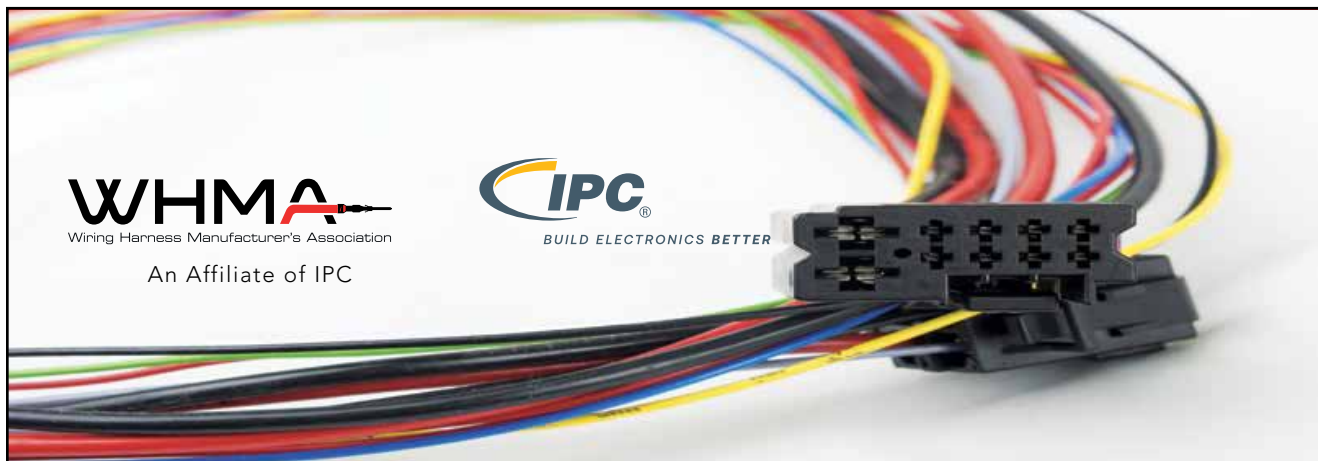
jacket. Most cables contain a positive wire, a neutral wire, and a grounding wire.

**Five key differences between a wire harness and a cable assembly:**

**1. Environments** - Each is utilized in various environments. Wire harnesses provide minimal protection for wires. Their purpose is to organize wires and cables efficiently. They typically cannot be shielded from extreme temperatures or friction between one another. They are fundamentally for indoor use.

Cable assemblies guard all the products safe in the most extreme conditions and are ideal for outdoor use. They have high-level resistance to outside variables such as heat, dust, and moisture. They also protect the wire and cables from friction and corrosion.

**2. Cost** - Wire harnesses are a low-cost electrical solution that best keep electric cables and wires organized. By bundling these wires and cables together, engineers can keep their wiring systems organized and identifiable. They don't concentrate on giving added protection to the individual wires and cables and usually require less material and effort. Thus, they cost less compared to a cable assembly. Although cost-friendly, they still rely on the type, number, and



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quality of cables, wires, or connectors used in the production.

However, the cost of the cable assembly is satisfactory because of the added protection it provides. Cable assemblies offer more vigorous protection by keeping components snug within a rugged outer sheath. In addition, cable assemblies are intended to be utilized in demanding environments where things like heat, friction, or moisture could untimely wear out a cable or wire.

**3. Physical Attributes** - The essential difference between a wire harness and a cable assembly is their physical attributes and function. A wire harness offers a cover that encases single cables, usually from the same material utilized in a cable assembly. One can see and remove an individual cable from a wire harness. In comparison, a cable assembly has multiple wires but is bundled together by a single external sleeve. It comes as a only one thick wire.

**4. Products** - Many of our everyday household products and tools use wire harnesses. These products are computers, televisions, monitors, microwaves, and refrigerators. These products use wire harnesses rather than of cable assemblies because these products come with a protective shell, which removes the requirement for added protection. Wire harnesses are also present in most automobiles and airplanes.

Cable assemblies are used for severe environmental conditions or extreme temperature changes. In addition, many heavy industries such as medical, military, aerospace, and construction generally use cable assemblies in their manufacturing processes. They need the cable assembly to protect things like electrical flow in the individual wires or cables. They are perfect for high-speed data transfers.

**5. Purposes** - Wire harnesses serve two primary purposes:

- a. To protect outside factors from harm caused by the flow of electricity.
- b. To ensure wiring systems are organized and straightforward for technicians to understand.

Cable assemblies serve three primary purposes:

- a. To protect outside factors from harm caused by the flow of electricity.
- b. To ensure wiring systems are organized and straightforward for technicians to understand.
- c. To protect the wiring or cable against wear and tear or other harsh environmental conditions.

If this overview still has you a bit confused, feel free to reach out to WHMA with any questions. We are happy to answer any of your questions. Contact WHMA at [contact.us@whma.org](mailto:contact.us@whma.org).



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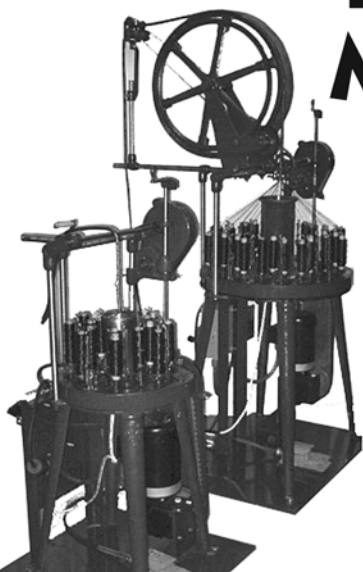
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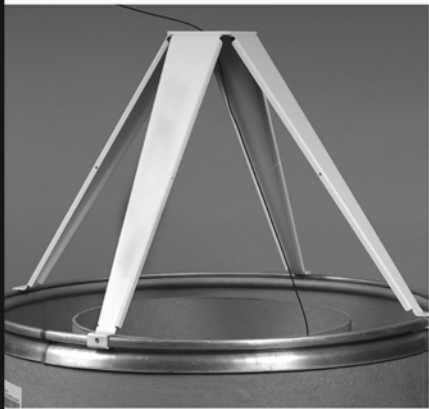
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