Automation NOTEBOOK

Your guide to practical products, technologies and applications

Mastering Machine Maintenance

Machine builders, robot builders and system integrators offer advice for maintaining industrial machines.

Open System Provides Precise Temperature Control

Automation NOTEBOOK®

Your guide to practical products, technologies and applications

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For those who prefer to speak with us in person, please call 1-800-633-0405 x1845. Thanks for your interest, and we look forward to hearing from you.

They say experience is the best teacher, and I'm sure we can all agree with that. After all, you only need to get shocked once to learn that "it should be off" doesn't mean it's actually off. And you only need one "free" haircut to realize how costly it can be to your self-confidence. These little life experiences, that we hopefully learn from, make us better, wiser individuals. At AutomationDirect, we want to take that a step further and use your experiences to be a better, wiser company. We strive every day to improve the experience you have with us as a customer because we don't just want your business, we want your trust. But we can't do it without you. So please let us know how we are doing. Visit the "Company Reviews" section located under "Learn More" on the left-hand side of our homepage (**www.automationdirect.com**) or any product overview page to submit company and/or product reviews. Tell us how you really feel and don't hold back, because anyone can sell a product, but it's the experience that counts!

This issue of NOTEBOOK is loaded with informative content such as our PLC Speaking section, which discusses the importance of PLC scan time in any control system. We also have a great Cover Story on how designing with maintenance in mind can reduce downtime and provide a bigger ROI from your automated systems. The User Solution shows how the Do-more PLC was able to provide precise temperature control for cold, warm and freezer chambers at UNC Chapel Hill, and our Student Spotlight catches up with Copley High School's engineering students and their recent projects. In the FYI section, we answer commonly asked questions about our multi-conductor cable, the New Product Focus portion provides information on our absolutely free online PLC training and the new WEG variable frequency drives, and the What's New section highlights some of our many informative content pieces. As always, the Break Room is stocked with fun brainteasers so see how many puzzles you can solve.

WEG High-Performance AC Drives

The WEG CFW300 variable frequency drive is a high-performance VFD for three-phase induction motors. It is ideal for applications on machines or equipment that require precise control with easy setup and operation. The CFW300 features a compact size with contactor-style electrical connections (top in / bottom out). The VFD's performance can be scaled to match the application by selecting WEG vector control (VVW) or scalar control (V/Hz).

The CFW300 includes a built-in keypad and SoftPLC with free WEG Programming Suite (WPS) software for custom tailored control schemes. The integrated WPS tool assists in the creation of automation applications, allowing graphical monitoring, parameter setting and programming in Ladder language (IEC 61131-3).

Built-in I/O capabilities include four configurable (PNP or NPN) digital inputs, one 0.5 A / 250 VAC relay output, and one 0-10 VDC / 4-20 mA analog input. A variety of plug-in option modules for additional I/O and communications protocols can be added to extend capabilities. A remote keypad and flash memory module are also available.

Starting at $138.00, sixteen units are available from 1/4 hp to 5 hp. Single-phase 100-127 VAC, and single or three-phase 200-240 VAC power supply options are available. WEG CFW300 series AC drives are cUL, CE approved and are backed by an 18-month warranty.

Go here to learn more about WEG CFW300 Drives

**Prices as of March 2019. Check www.automationdirect.com for most current prices.*

Free Online PLC Training

AutomationDirect first partnered with Interconnecting Automation in 1996 to create a hands-on training program to familiarize customers with the ins and outs of their PLCs. Eventually, this program led to the creation of an online video training series that encompasses various levels of training from entry level programming to advanced PLC functions. Due to the high demand and requests for training in the field of industrial automation, AutomationDirect is now offering unlimited access to selected Interconnecting Automation training series for anyone interested in learning about industrial controllers. A repository of training videos is available to all registrants free of charge with no purchase necessary.

One online video series initially offered covers non-brand specific PLC basics with topics on logic gates, basic switches, sinking and sourcing, scan time, I/O fundamentals, memory addressing and more. Also available with the initial release are videos specifically covering the AutomationDirect CLICK PLC and include topics on how to use CLICK's navigation, address picker, rung editor, logic instructions, internal control relays, data view window and many other functions.

These completely free online PLC training courses are available 24/7, allowing users to learn at their pace and at their convenience. To get unlimited access to the free online PLC training program, or to learn more about what is provided, visit **www.automationdirect.com/plc-training**

Also available are videos specifically covering AutomationDirect CLICK and Do-more PLC families and include topics on how to use their navigation, rung editors, logic instructions, internal control relays, data view windows...

Frequently Asked Questions about Multi-Conductor Cable

By Bill Dehner

At AutomationDirect, we are always on the lookout for ways to save you even more. Recently, we decided to offer our bulk multi-conductor cable in any length you specify. So, not only are our cable prices very affordable but now you can cut out (pun intended) the expense of paying for extra cable you do not need. Below are some of the most frequently asked questions about bulk multi-conductor cable and the new cut-to-length process.

Why use a shielded cable?

The shield in a control cable acts as a Faraday cage to reduce the effect of electrical noise on the enclosed signals, and to reduce electromagnetic radiation from the cables that may interfere with other signals or devices in the vicinity.

Shields are typically made of braid or mesh of wire, a spiral wrap of copper tape, or a layer of conducting polymer, or some combination of those three constructions. The shield may be applied as the outside layer (just inside the jacket) for the entire cable – or there may be individual shields for particular groups of wires (typically twisted pairs) within the cable – or both.

If the control signals in a cable are sensitive to outside disturbance OR if they are expected to cause a disturbance themselves, OR if the installation is in an electrically noisy environment (such as a factory) it is wise to specify a shielded cable to maintain the highest degree of signal integrity along the length of the cable run.

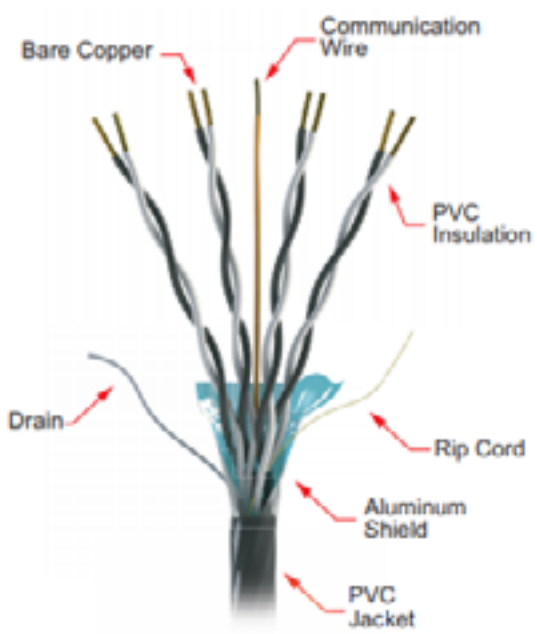
In addition to specifying shielded cables – it is a good idea to become familiar with proper shield grounding techniques. In most installations, it is advisable to ground the shield of the cable at one end only – but there are certain situations that may require different techniques.

All Flexible Control Cable from Automation Direct are available with or without a shield.

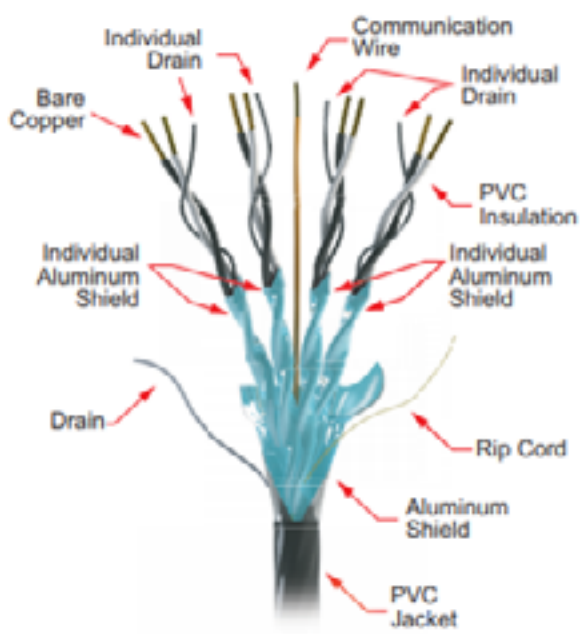
What is the difference between cord and cable?

In the context of electrical power connections, these terms are used somewhat interchangeably in common speech, and both refer to a collection of electrical conductors that are enclosed in a single jacket. Cord usually refers to a connection that is either temporary or intended for frequent handling by factory personnel, while Cable

Overall Cable Shield



Individual and Overall Cable Shields



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is typically used to indicate a fixed or permanent power connections.

Automation Direct sells both Flexible Portable Cord and several types of cable intended for more permanent installations, such as VFD Cable and Continuous Flexing Motor Supply Cable.

Why use VFD cable?

Variable Frequency Drives (VFDs) generate disruptive electrical noise in the environment around them. The noise emitted can affect other devices such as electronic equipment, commercial-grade Ethernet systems, and instrumentation wiring. Combined with proper grounding techniques, VFD cables are a key component to combat these problems with high-quality shielding, and insulation/cable construction rated for the extreme transient voltages that VFDs can produce.

- Grounding Configuration and Termination -
  An improper cable connected to VFDs creates noise-related issues within the system and improperly terminated cables can release captured noise current. AutomationDirect VFD cables offer both a ground conductor equal to the size of the power conductors as well as separate drains for the shielding.
- Proper Shielding to Contain Noise -
  To avoid noise problems, VFD cable needs to be effectively shielded. Research suggests that shielding systems that include a combination foil & braid types are the most appropriate for VFD applications. Automation Direct VFD cables include:
  - 100% coverage aluminum/mylar/aluminum foil shield
  - 85% coverage tinned copper braid shield
  - Tinned copper drain wire(s)

What does "Exposed Run" mean?

An "exposed run" of tray cable is any tray cable that extends from a cable tray or raceway to a machine or other electrical device. Exposed runs of standard tray cable more than 6 feet long must be protected with conduit or additional raceway. However, there are special -ER cable types that can save significant installation costs – as they can extend as far as 50 feet or more from the cable tray if certain conditions are met:

- Exposed runs are only allowed in industrial environments which have qualified staff to maintain, supervise, and service the installation.
- The cable should be routed along existing machine supports and must be adequately protected by struts, channels or angles, and it must be secured at least once every six feet.
- Type TC-ER cables are required (by NEC) to include an equipment grounding conductor.
- Type ITC-ER cables are limited to an exposed run of 50 feet; PLTC-ER and TC-ER cable have no set length limitations.

These -ER cable types must meet additional crush and impact tests – but the ability to install them without conduit or raceway can offer significant savings: the cable itself is likely to be less expensive than an armored version of the same cable, and the cost and labor to run conduit or extend the cable tray may be eliminated.

AutomationDirect offers Flexible Control Cable with multiple ratings and approvals, including:

- Type TC-ER (eliminates need for conduit/armor)
- Type MTW (meets NFPA 79)
- WTTC wind turbine tray cable
- Class 1 Division 2 hazardous locations
- Direct burial
- Wet and dry location
- Oil & sunlight resistant

What is the difference between 'flexible' and 'flexing' cable?

These terms sound similar, but they have specific meaning in terms of cable selection and

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application. Most all cable is 'flexible' to a certain extent, and it is designed to be bent and routed during installation. However, in applications that will require constant movement during everyday use or routine machine operation be sure to specify 'flexing' cable. Flexing cable is often used in cable track (c-track) to protect the cable and to regulate its motion path. Flexing cable will have a rating for the maximum number of bends over the lifetime of the product – usually several million cycles. Designers should also pay special attention to the minimum bend radius for flexing cable and make sure that the required radius for each application exceeds that minimum.

Flexing Cables are often installed in cable track (photo courtesy igus, inc.)

AutomationDirect sells both Flexible Control Cable and Continuous Flexing Control Cable. AutomationDirect also offers Continuous Flexing Motor Supply Cable and Continuous Flexing Industrial Ethernet Cable.

What do the letters on service cord mean?

Flexible portable cord (also called drop cord, service cord, or SO cord) can have long acronyms or partial part numbers associated with the various constructions. Service cord is available in a number of UL and CSA types including SO, SOW, SOOW, SJ, SJO, SJOW, STO and SJTO. Each letter of the cable type indicates a particular feature of the cable. For example: S = service (600 volts), SJ = junior service (300 volts), E = elastomer jacket, O = oil-resistant jacket, OO = oil-resistant insulation AND jacket, and W = weather resistant. Note: It's confusing, but "Type W" is a different spec than the aforementioned "W" (see below). Automation Direct currently sells:

- SOOW and SJOOW with a thermoset rubber jacket
  - Best abrasion resistance
  - Rubber, unlike plastic, is resistant to melting on momentary contact with a hot surface
  - Lowest cost
  - Temp Range: -40°C to 90°C (-40°F to 194°F)
  - Available in 2, 3, and 4 conductors, from 18 to 10 AWG (SEOOW now with 5 conductors)
- SEOOW and SJEOOW with a thermoplastic elastomer jacket
  - Wider continuous temperature range
  - Better flexibility at very low temperatures
  - Temp Range: -50°C to 105°C (-58°F to 221°F)
  - Available in 2, 3, and 4 conductors, from 18 to 10 AWG (SEOOW now available with 5 conductors)
- Type W has a chlorinated polyethylene (CPE) jacket
  - Rated for heavy-duty service
  - 2000 Volts
  - Temp Range: -40°C to 90°C (-40°F to 194°F)
  - Available in 8 AWG, with 4 conductors (only)

What types of bulk multi-conductor cables are currently offered by AutomationDirect (2/13/2019)?

- Flexible Portable Cord

Flexible portable cord (also called service cord) is cable with multiple conductors used for electrical power connections requiring flexibility. Typical indoor and outdoor applications include wiring for industrial machinery, large appliances, heavy-duty tools, motors, and temporary

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electrical power and lighting for construction sites.

- RS-485 & RS-422/RS-232 Cable

  RS-485 and RS-232 high-quality data cable helps prevent electrical noise problems in factory floor environments which can interfere with device-to-device communication circuits, causing delayed signals or data loss. These low-capacitance multi-conductor data cables with up to 3 twisted pairs are designed with impedances specific for RS-232/RS-422 and RS-485 communication applications.

- Flexible Control Cable

  Control cable is most commonly used to organize and simplify control signal wiring in facilities and during assembly of machinery. These flexible multi-conductor control cables have a premium-grade PVC outer jacket that is resistant to sunlight, oil, and moisture, making these cables ideal for wet or dry indoor locations as well as outdoor applications.

- VFD Cable

  VFD cable is used to organize and protect the input and motor power wiring for variable frequency drives. It is specially designed to reduce VFD-related interference (EMI) on nearby equipment. These foil and braid shielded multi-conductor power cables have a black thermo plastic elastomer (TPE) outer jacket and offer 4 conductors in up to 2AWG wire size.

- Instrumentation Cable

  Instrumentation cable is typically used in industrial instrumentation, control, alarm, and energy management circuits. These UL ITC/PLTC listed instrumentation cables are available with up to 8 twisted pairs; overall shields with drain wire protect against electrical noise interference, while individually shielded pair models also protect against crosstalk.

- Continuous Flexing Control Cable

  Continuous flexing control cable is used to organize and simplify control signal wiring and is specifically designed for constantly moving applications such as robotic arms, or when installed inside C-track on moving equipment. These cables have a premium-grade PVC jacket that is sunlight and oil resistant, and flame retardant; ideal for wet or dry locations.

- Continuous Flexing Motor Supply Cable

  Continuous flexing motor supply cable is specifically designed for constantly flexing applications with high mechanical loads such as robotic arms, or when C-track is used to power motors on moving equipment. Offered with 4 conductors in up to 2AWG wire size with shielded or unshielded construction, the cable's PVC jacket is sunlight and oil resistant and flame retardant.

- Continuous Flexing Industrial Ethernet Cable

  Continuous flexing Ethernet cable is specifically designed for constantly moving applications such as robotic arms, or when

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C-track is used to provide Ethernet signals to moving equipment. Available in shielded or unshielded styles in lengths up to 1000 ft, this cable's industrial jacketing has excellent weather and hazard resistance.

Note: We are always working to increase our product offering – so please click here to see the most up-to-date list of available types of Bulk Multi-Conductor Cable that we offer.

How do I order various sizes of VFD cable or any cable?

Ordering cable in your specific lengths is easy on our website. Just choose the cable you need and on the item page you will see the length and quantity selections in the sidebar on the right. Simply enter your selections and add them to your cart. If you need more length and quantity entries, click the blue "add more cuts…" text below the selections.

Once you have placed your order, each of your cables will be cut separately. We do not aggregate your specified lengths into one cable and we will ship your order the same day if ordered by 6pm ET.

What if I made a mistake and ordered the wrong length?

No problem, our 30-day return policy also applies to our custom-cut cable. Simply return it as you would any other product by visiting the "Product Returns" section of our store (**www.automationdirect.com**).

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Importance of PLC Scan Time in any Control System

When designing a PLC controlled system, one aspect that should not be overlooked is how the PLC scan will affect your operation. The PLC scan consists of a sequence of operations the CPU will follow repeatedly. The amount of time the CPU needs to complete this sequence is known as scan time and it can adversely affect your process if you are not careful.

It may seem to the naked eye, when an output is set ON in the ladder code that this change is immediately reflected in the output card. Or that when an input is activated, the CPU instantly sees it. But that is not actually the case. The output and the input will only be updated once the PLC scan gets to the appropriate step in the sequence. To us, that seems immediate, but to a computer it may not be. With inputs, the time it takes the CPU to notice a change can vary depending on where the CPU was in the sequence when the input turned on. For outputs, the CPU will completely execute the ladder program before changing the output state on the output card. Although extremely fast, these changes are not instantaneous.

The Sequence

As a programmer, you're mostly concerned with three main steps in the PLC scan - the Update Inputs, Execute Program and Update Outputs steps. But there are other steps that need to be considered as well. Most PLCs will have similar sequences, some with a few variations, and an example is as follows:

1. Power Up – this is the starting point when the PLC is first powered
2. Initialize Hardware – at this point, the CPU will verify and initialize the installed hardware
3. Restores Retentive Values – any CPU memory locations that were configured as retentive will be restored to their previous value
4. Updates Inputs – the CPU will now read in the inputs stored in the input table, on the next scan this will be the starting point for the CPU
5. Updates Specialty and Remote Inputs – the CPU will take in any inputs from specialty modules, like high-speed counters, and remote I/O racks
6. Service Peripherals – in this step, the CPU will handle any requests from the serial or Ethernet communication ports
7. Executes Program – if in the RUN mode, the CPU will now execute the ladder program using the updated inputs
8. Updates Outputs – If there were any output state changes from the ladder execution, the CPU will now write them to the output tables and in turn the output cards
9. Diagnostics/ Housekeeping – finally the CPU will run a self-check and tie up any loose ends before repeating the scan - returning to the "Update Inputs" step

What to watch for

Modern PLCs can run the scan in milli-seconds and for most applications that's not a problem. But as your code complexity increases, the time it takes to execute can begin to slow the CPU. This can be greatly alleviated by using program efficiencies like sub-routines and task management. Another thing to watch for regarding CPU scan time is the amount

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of communication requests coming into the CPU. If the application is communication heavy and there's a lot of polling of information, the CPU scan can be adversely affected.

PLC scan time can be a big issue with high-speed applications. Let's say you are controlling a high-speed sorting facility, and for packaging tracking purposes your encoders are supplying 1000 pulses per revolution for every foot of a 140-fpm conveyor.

That is over 2,000 pulses per second or over 2 pulses every milli-second. At that rate, it wouldn't take much for the average CPU to miss a few pulses and in turn cause a swinging diverter arm to miss or crush a box. In these situations, specialty modules like high-speed counters, can be used to ensure no pulses are missed. These counters are designed to work independently from the CPU scan, meaning they have their own processor dedicated to tracking the pulses coming in and nothing else. They then feed the count over to the CPU when it is requested.

We are here to help

Understanding PLC control is becoming more of a demand as our world becomes more automated. PLC scan time is just one of the many topics that anyone new to PLCs needs to have a firm grasp of. To help those who would like to learn more about industrial control, we are now offering absolutely free online PLC training.

There is no purchase required for this training and it is available 24/7/365 so you can learn at your pace and at your convenience. Some of the general topics covered include:

- Logic circuits
- Basic switches
- Sinking and sourcing
- I/O fundamentals
- PLC memory addressing

Also available are videos specifically covering the AutomationDirect CLICK and Do-more PLC families.

To get started today with your unlimited access to FREE online PLC training, simply register at www.automationdirect.com/plc-training.

AutomationDirect growing to serve better

As a direct sales business model, AutomationDirect works hard at controlling the cost of doing business so we can pass the savings on to our customers. We have made major investments in technology to streamline and automate processes that improve our customer service and make our people more effective and efficient. We strive to provide a productive work environment, the most recent expansion being a new building on our campus to house the Marketing and Web technologies teams, among others.

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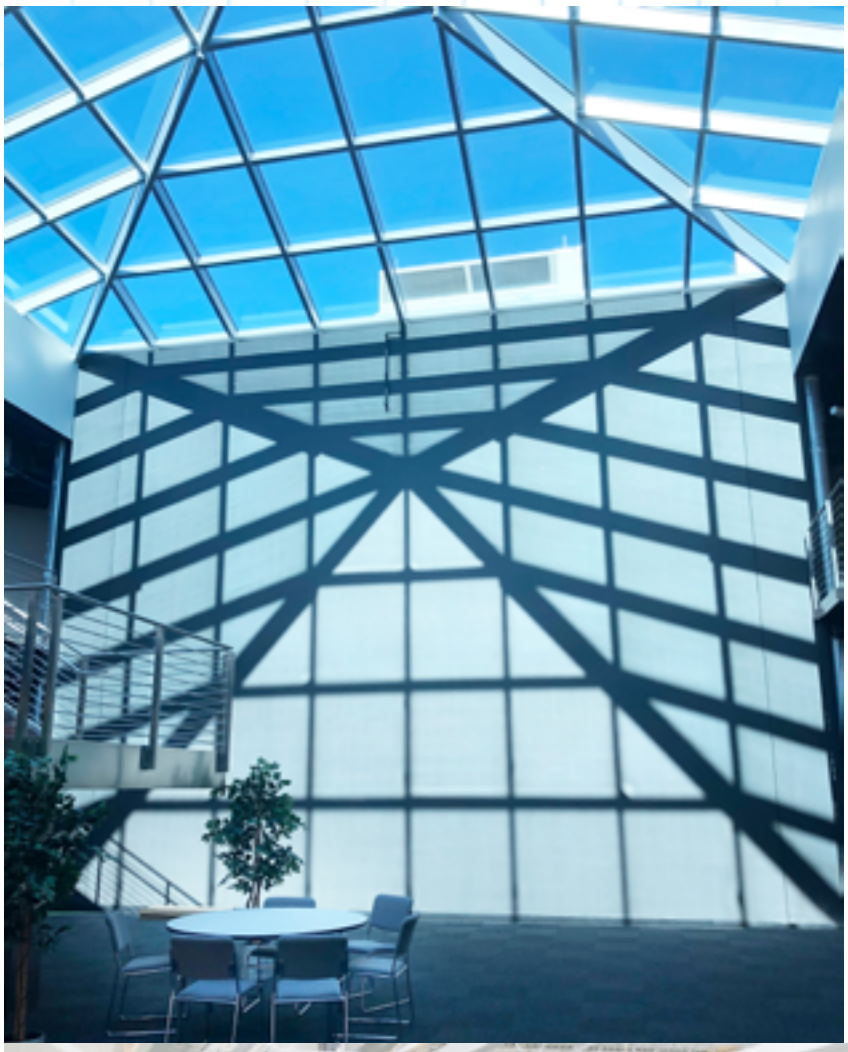

The purpose-built design includes spaces devoted to our in-house production of photography and videos. All product and application photos are shot in a studio laid out for efficient flow, speed and flexibility. Movable fixtures, lights and tables allow multiple shoots concurrently without scheduling conflicts. The photos are used on the Web site, in the catalog and manuals, in print ads and videos.

The technical marketers who produce all our videos each have their own personal studio space designed to accommodate various video styles, be it live on camera or voiceover with graphics and animation. Sound booths allow voiceover recording with no ambient noise interference. Video cameras are frequently upgraded to take advantage of the latest advances in technology such as 4K resolution. A network of high-performance computers increase video and animation

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rendering speed, improving production throughput.

Other productivity benefits the new building brings are more collaborative spaces, and an additional campus auditorium for more training capacity. The marketing team is now all in one location, ready to execute the initiatives we hope will improve your experience, including more written and video educational content, more selection tools on the Web site, and more technical knowledge sharing. See you online!

C-more Wins Again

January 2019 marks the 8th year that Automation World readers have voted for their "FIRST TEAM" suppliers in PMMI Media Group's Leadership in Automation program. Automation World, a leading business magazine serving automation professionals, asks their subscribers to vote for their favorite automation vendors in unaided-recall surveys. Kurt Belisle, Publisher of Automation World, shares his enthusiasm. "We're pleased to recognize the First Team Honorees who offer both excellent customer service and best-in-class product innovation. We appreciate the end-users who took the time to vote for their favorite solution providers. Congratulations to the honorees!"

More than two dozen categories are featured which represent a wide variety of automation technologies, software and products in use by today's manufacturing professionals across the discrete, batch and continuous process manufacturing industries.

In the HMI Hardware category, AutomationDirect was awarded "First Team" status for their C-more HMI line. C-more recently won this title in 2015, 2016 and 2017. Tina Gable of AutomationDirect says. "We are very pleased to receive this recognition; we continually strive to improve our C-more HMI line and being awarded this distinction by Automation World readers is a great honor for us! Thanks to all of you who took the time to vote for us."

To read the full press release from PMMI Media and Automation World, or for more information about this program, please click **here**.

2019 Digital Animation Contest: AutomationDirect Announces Award Winners

By Rick Folea

AutomationDirect's staff was thrilled with the number and quality of digital animation

submissions this year. These young techno-artists really stepped up their game and it was difficult to choose a winner, but we had to go with FIRST Robotics Team 0846 "The Spaces I'll Fill" animation.

This year's robotics competition is "Destination Deep Space" so we provided a theme for the animation contest of "Space." It's up to the animators to use that however they want: Space in your room, space on your robotics team for new members, space exploration, etc.

How they interpret the theme isn't important. It's how well they present their story using digital animation techniques.
You may be wondering – why does an automation company care about digital animation? Well … that's a bit of a story.

AutomationDirect is a huge supporter of all things STEM – Science, Technology, Engineering, Math – because it helps get young minds interested in learning and it gets them on track for a productive and fulfilling careers. One program we support is the FIRST Robotics Competition where high school age students build 120 lb. robots to compete in an arena.

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Our lead animator got his start animating through that competition which had a side competition for digital animation. When the previous sponsor decided to discontinue support for the animation competition we jumped at the chance to pick it up and promote it because we have seen firsthand the impact it has on young minds. And it has come full circle! That AutomationDirect employee is now the lead animator for the FIRST Robotics annual game animation which presents the competition to the world. You can see this year's animation here: Destination Deep Space Game Animation.

The FIRST Robotics Competition is currently active (March/April 2019) and will culminate with a championship in Houston and another in Detroit in mid-April. You can find local teams to support events to attend in your area here.

It was a pleasure for us to promote the Digital Animation Award again this year. You can see all of the results along with judges' comments here

Mastering Machine Maintenance

Machine builders, robot builders and system integrators offer advice for maintaining industrial machines.

In the May 2019 issue of Control Design magazine, the cover story focus was machine maintenance. The story, titled *Machine design with maintenance in mind*, discussed best practices for maintaining machines, with input from numerous sources including machine builders, robot builders and system integrators.Let's start by looking at machine maintenance from the original equipment manufacturer (OEM) point of view.

OEMs Know Their Machines

"Ideally operators would like to be able to load a part, push a button and have a machine pop out a perfect part every time," says Mark Horton, chief engineer, advanced process technology, at Kollmorgen in the cover story. "The machine would require no changeover, and the tooling would never wear out. Also, they would never have to perform any maintenance. Managers want pretty much the same thing. They want to have a stable process with no unplanned downtime. This makes planning and execution much easier. Since the scenario I've presented almost never exists, especially in a low-volume, high-product-mix environment, much can be done to improve machine reliability and reduce its operational maintenance during the design phase."

As the cover story points out, it's important to design and build machines that will exceed the end user's expected product lifecycle. "The best method for achieving a long machine life is utilization of quality, proven and commercially available components within our designs and providing a thorough maintenance manual and schedule," says Dean Colwell, controls manager, assembly, welding and AGV Systems at Fori Automation in Shelby Township, Michigan. "Fori also trains the end users during the buyoff and installation phase of the project. This is important to ensure the maintenance schedule is completed on time and as expected. Completing the preventive maintenance will help to keep the machine up and running for its expected life (*Figure 1*)."

Figure 1: (courtesy of Fori Automation) Fori Automations customers achieve long machine life by following the maintenance practices imparted by Fori during the commissioning, startup and training phases.

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Another OEM chimes in with his thoughts in the cover story. “Our equipment customers are performing less scheduled maintenance than in years past”, says Doug Putnam-Pite, director of software development at Owens Design in Fremont, California. "It therefore behooves us as tool designers to develop robust tool designs that can work for extended periods of time without routine maintenance," he says. "Additionally we need to ensure that the software in the tools can detect errors and fail in a safe state without damaging the mechanisms in the tool."

OEMs are expected to provide their customers with information regarding which items and procedures are needed for preventive maintenance. "In particular, many ask about lubrication points and frequency of replacement for wear items," says Mike Krummey, electrical engineering manager at Matrix, a ProMach brand, in Saukville, Wisconsin in the cover story. "Since the beginning, Matrix focused on designing our machines with ease of cleanability. This allows for a more sanitary operating machine and one that is inherently more reliable as the preventive-maintenance procedures are very simple and fast to perform. If these things are too difficult and time-consuming, there will be a higher likelihood of those procedures being ignored and not performed."

"At Matrix, our control systems follow the same design intent as the mechanical componentry—simple is inherently more reliable," says Krummey. "If many complicated components and dependencies are present on a machine, there is a greater chance of increased downtime. Control-system reliability is also a function of the number of machine sensors. The fewer sensors, the more reliable the system will be, as you can’t have downtime for a damaged sensor that isn’t on the machine. Control programs can be developed that reduce the number of sensors and thus increase reliability and continuous uptime."

"Maintenance information can be integrated into the control system and provided via the operator screens," says Colwell at Fori Automation in the cover story. "Information such as cycle counts, run time and maintenance schedules can be made available, which will help to ensure that preventive maintenance is completed within the expected time frame. Additional maintenance information of this sort can be pushed to a MES and other maintenance databases and dashboards (*Figure 2*)."

Figure 2: (courtesy of Fori Automation) Maintenance information such as cycle counts, run time and maintenance schedules can be made available to ensure preventive maintenance is completed on schedule.

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I Robot, You Maintain

According to the cover story, a typical robot is designed to achieve more than 10 years of life with proper maintenance, says Jason Tsai, vice president, product development at Fanuc. "Maintenance items can include cable, sensors, mechanical drive components, electronic hardware, calibration and grease," he says. "Proper maintenance is critical to keep the machine functioning properly and avoid any premature component failure. For a high-throughput production factory, any machine breakdown could cause significant production downtime and profit loss, which can impact the business' bottom line (*Figure 3*)."

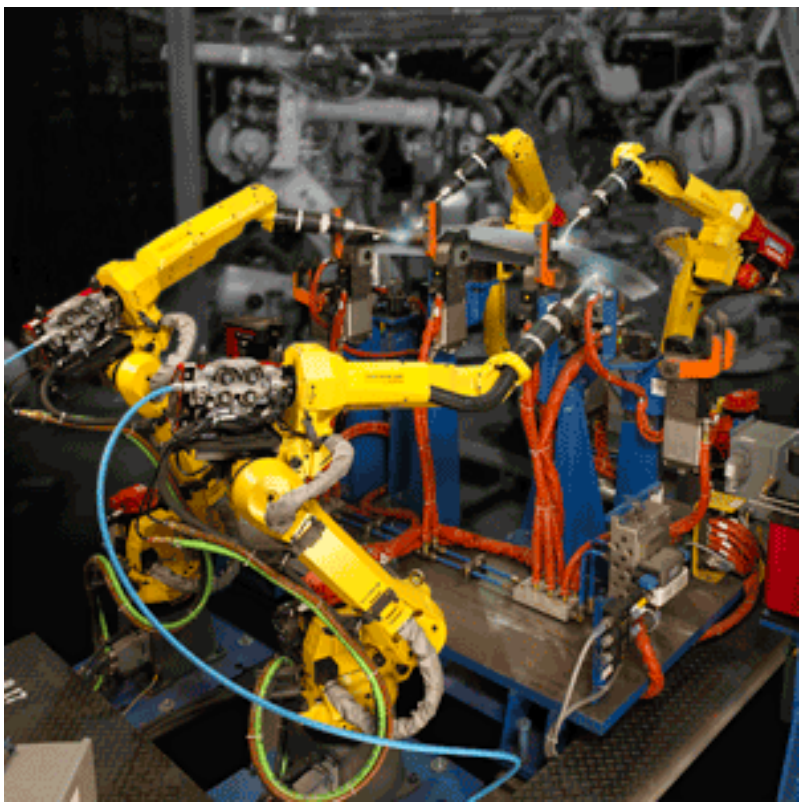

Figure 3: (courtesy of Fanuc) Typical items on a robot requiring maintenance include cable, sensors, mechanical drive components and electronic hardware.

Product reliability is a must-have requirement in production factories with robot automation, continues Tsai. "If the machine is designed poorly with low product reliability or safety design margin, the machine breakdown can cause production downtime and significant profit loss," he says. "Therefore, proper maintenance and high product reliability are absolutely critical to maintain high production throughput and increase profitability."

Robots can present unique maintenance challenges. "They answer to the laws of physics, but they can't communicate that easily," says Sam Bouchard, CEO, Robotiq in the cover story. "An interface, whether it's on a machine, in a robot teach pendant or coming from a monitoring software, allows us to know more about what's going on with the equipment and taking the right actions to prevent problems and of course to improve production."

"It may be basic to say that a broken machine can't make parts, but oftentimes the fight that maintenance has to deal with is its own plant management," says Daniel Moore, tech support manager, Universal Robots in the cover story. "Whether you're talking about robotics or my past life in laser welding systems and automatic monitoring systems, if there's a cause for repair, then you basically have two options: Do it right, carefully and slowly the first time, or guarantee another, worse failure."

Pressure on plants to produce parts right now often means that there is pressure to not do it right and leave the failure to another shift or another week, continues Moore. "Ultimately this is a horrible idea for any company, but it's often the kind of thing I saw working on laser systems in automotive suppliers or in the auto shops themselves," he explains.

An Integrator's Viewpoint

System integrators have experience with many different types of machines in a wide variety of production environments, giving them keen insights. "A best-practices design approach needs to be taken when specifying components in automation control panels, so that the selected parts are not operated at or near their design limits," says David Paul, engineering design manager at Maverick Technologies a member

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of CSIA, headquartered in Columbia, Illinois in the cover story. "There are also best-practices design choices to include surge suppressors, electrical filters and other similar devices in control panel design. While these devices can potentially increase up-front machine costs, there is a long-term payback in reduced maintenance and component failures."

Unfortunately, due to the highly technical nature of these added components, many purchasing decisions are made solely on a machine-cost basis, continues Paul. "This is the tradeoff that occurs between capital expenses (CapEx) and operating expenses (OpEx) budgeting within many companies," he says (*Figure 4*). "During projects, many times the corporate-level project team is focused on staying within a CapEx budget but not so concerned with long-term OpEx costs. Operations teams are much more focused on OpEx costs because of their role in day-to-day plant operations and maintenance. Some companies now involve plant operations in CapEx equipment selection, which is a best practice to assure minimal long-term maintenance is required."

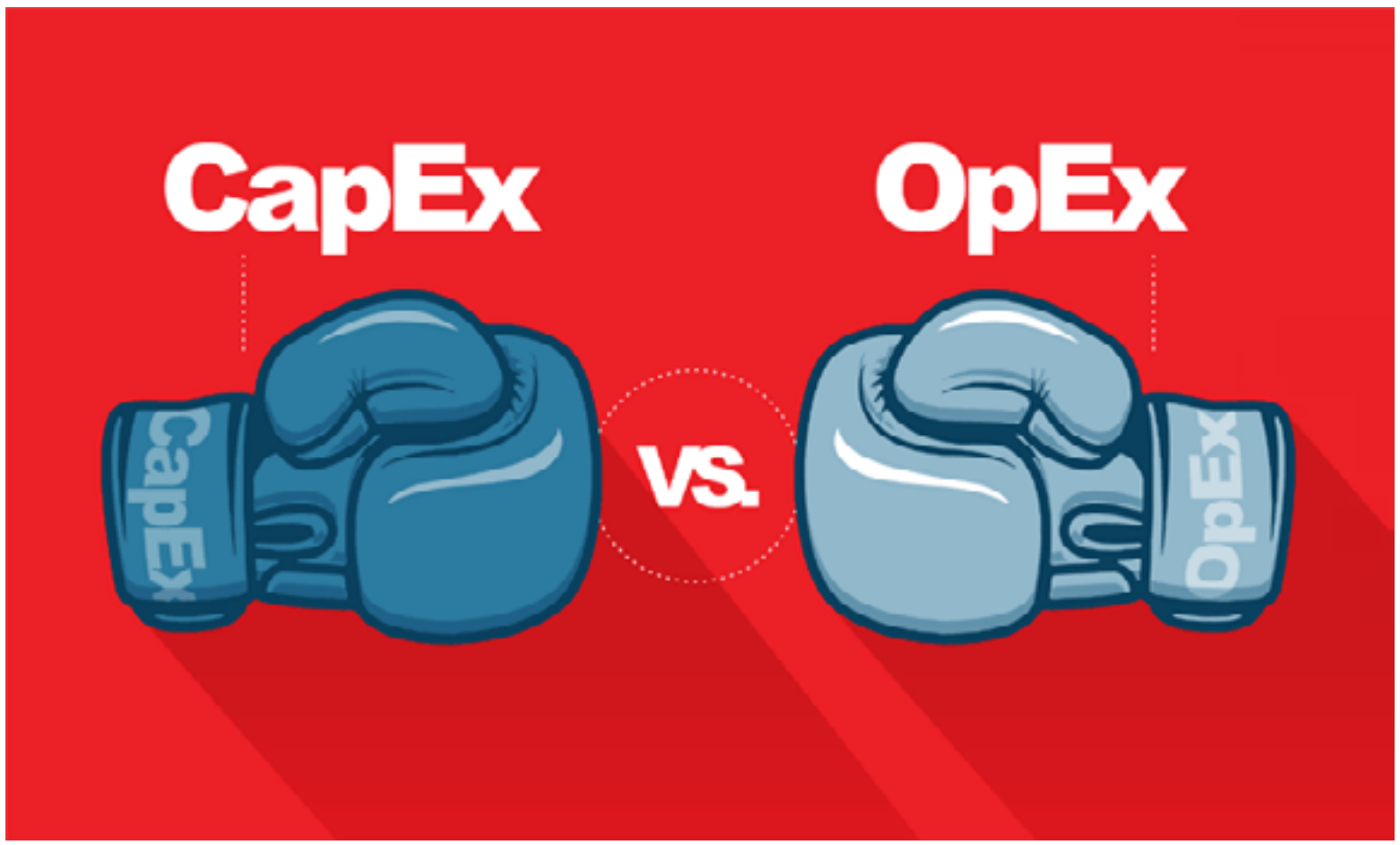

Figure 4: (courtesy of Maverick Technologies) CapEx and OpEx costs must be balanced to achieve the lowest total cost of ownership.

Another system integrator adds their point of view; Roger Beam, principal engineer at Optimation, a member of CSIA, in Rush, New York, provides a list of best practices of interest to managers and operators when it comes to machine maintenance including:

- maximize mean time between failure
- minimize time to repair
- maximize overall equipment effectiveness by minimizing unscheduled downtime
- provide easy access to equipment requiring frequent adjustment, inspection and/or replacement and points of lubrication
- provide or accommodate means of lifting heavy components

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- provide components sized for continuous 24/7 duty cycle with a service factor of safety
- design guarding for easy removal and installation

A good design is often quick to repair. "Providing a modular design enables sub-assemblies already assembled or aligned to be swapped out to minimize machine downtime for repair," says Optimation's Beam. "To help achieve this, have a design review with the customer, including maintenance personnel, of the machine's 3D conceptual model prior to detailed design or fabrication for the feedback and acceptance."

AI on the Horizon

Artificial intelligence (AI) has been the technology of the future for quite some time and continues to be just out of reach for many applications, including machine maintenance. "Artificial intelligence (AI) is a very cutting-edge technology, especially for an industry that is slow to adapt new technologies," says Putnam-Pite of Owens Design in the cover story. "At this time, I would image that most of the AI initiatives for machine tools will take place on the production-floor side of the world. We have not had customers asking us to implement AI platforms to improve machine maintenance and reliability. I would also think, given the expense of these implementations, that the cost would be prohibitive except for a few key industries."

But when implemented correctly, AI can help unearth value from data. "Perfection of AI reliability scenarios requires machinery in a wide variety of applications, so as not to make incorrect assumptions," says Matrix's Krummey in the cover story. "Our machinery has a very large installed operating base across every part of the packaging industry. This application experience has resulted in machinery that can perform at optimum levels with minimum cost and complication."

The answer to the AI implementation issues may be focusing on one area, such as predictive maintenance. "The systems and tools available now allow predictive maintenance programs to substantially reduce downtime," says Justin Olivier, product manager, Mobility, at Pepperl+Fuchs in the cover story. "However, it is important to make sure that workers in the field are equipped with tools that allow them to be connected to those Industry 4.0 systems. Not only does this allow them to monitor systems in real time, but it also makes sure that any maintenance performed is accurately recorded and helps to close the loop so that all parts of the system can work together for peak efficiency. Other related technologies, such as augmented reality, can also help to simplify and shorten training time for new employees."

Choosing an Industrial Automation Controller - White Paper from AutomationDirect

AutomationDirect announces the release of a new White Paper, "How to choose an Industrial Automation Controller", which discusses the evaluation of critical factors required in the specification of an automation controller for the industrial environment. The controller selected, such as a PLC or PAC, can control a single station, a machine, a process unit, a whole assembly line or an entire plant.

Factors to be considered when choosing a controller include new or existing system automation, environmental issues, I/O locations (local and remote), discrete and analog devices, loop control, specialty features and modules, communication and programming.

This White Paper discusses the number, types and location of I/O; communications requirements among multiple controllers, peripheral devices and enterprise-level systems; memory, scan-time speed and battery backup hardware aspects; software platform and programming methods; and the availability of PID loops, floating-point math, drum sequencing, program interrupts and subroutines.

Whether the system is new or existing often dictates many of the critical factors for selection. If extreme environmental conditions exist, ambient temperature limits can be a critical issue. Actual conditions at the plant floor level or specific codes in force at the facility may demand tougher design considerations.

The "How to choose an Industrial Automation Controller" White Paper can be downloaded at:
https://library.automationdirect.com/choosing-industrial-automation-controller

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Basic Pneumatic Circuits- White Paper from AutomationDirect

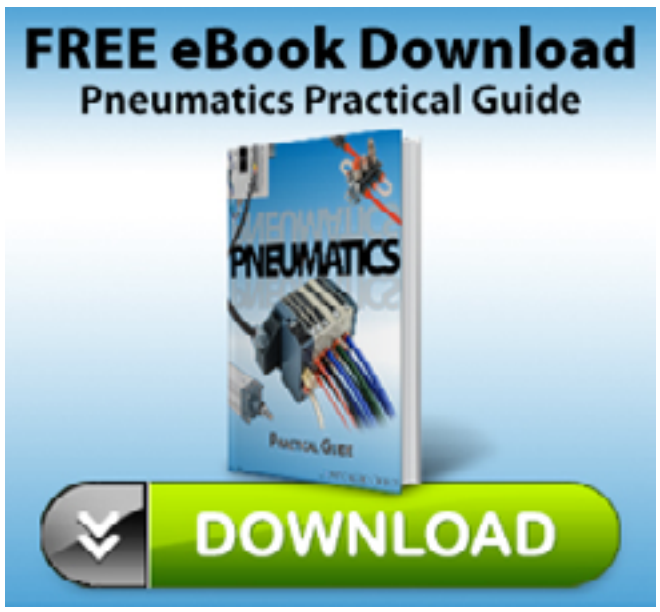
AutomationDirect announces the release of a new White Paper, "Basic Pneumatic Circuits", which discusses common pneumatic circuits that can be used alone or as building blocks in larger pneumatics systems.

This white paper examines pneumatic design best practices and presents four basic pneumatic circuits commonly used in machine automation. The four basic pneumatic circuits examined in the paper include the air preparation subsystem, double-acting cylinder circuits, continuous cycling cylinder circuits and two-hand control circuits. As discussed, the first basic pneumatic circuit needed provides consistent plant air pressure and flow required for pneumatic devices to operate consistently and reliably. Common in many machines, a pneumatic circuit consisting of a 4-way solenoid valve operating to automatically extend and retract a double-acting air cylinder is detailed. A circuit example of how pneumatic components are combined in a well-thought-out design to continuously cycle a cylinder is discussed, as is the pneumatic circuit for a two-hand safety control system for a press application.

There have been many innovations over the years, and the basic pneumatic components such as valves, solenoids, cylinders, hoses and fittings are well developed and mature. These devices can be combined in many ways to provide simple and reliable machine control.

https://library.automationdirect.com/basic-pneumatic-circuits-white-paper

Pneumatics Practical Guide



This eBook is for users who wish to advance their pneumatic knowledge. It covers a wide range of topics such as circuit symbols, component capability, integrating pneumatics with controls as well as improving pneumatic efficiency.

What's Inside:

- Why Use Pneumatics
- Circuit Symbols Explained
- Electro Pneumatic Systems in Action
- Energy Efficient Pneumatic Systems

And much more!

Plus a collection of pneumatic application stories to see what others are doing with their pneumatic components to inspire you!

Open System Provides Precise Temperature Control

System integrator Affinity Energy worked with the University of North Carolina at Chapel Hill to design and install a new temperature control system for their research chambers.

By Allan Evora, President of Affinity Energy

The University of North Carolina (UNC) at Chapel Hill was spending too much time and money supporting an existing control system. That's unacceptable for UNC Chapel Hill, which has nearly $1 billion in annual research expenditures and ranks eighth in research activity among public and private universities in the United States (*Figure 1*).

Figure 1: (courtesy of Affinity Energy) According to its website, UNC-Chapel Hill is the nation's first public university, opening its doors to students in 1795, and is known for its innovative teaching, research and public service.

Much of this research is done in about 1,000 cold, warm and freezer chambers located around campus. Some chambers store millions of dollars of products, while others are used to perform critical research in life science. In many cases, the chamber temperature must be controlled accurately to within half a degree due to the controlled experiments conducted within.

Obsolete Control System Hardware

Many of the research chambers at UNC were installed more than 20-years ago, and it was becoming difficult to find parts for the controllers used to control temperature and other variables *(Figure 2*). During maintenance of one particular chamber, the UNC staff couldn't find a supplier to repair a malfunctioning temperature controller. This maintainability concern was recognized as a possible campus-wide issue since many of the chambers were put into service at about the same time.

In addition, needs were expanding, with researchers requesting tighter, more accurate temperature and humidity control, and the ability to view temperatures in real time. None of these requests were possible with the old control and monitoring systems. Investigation showed it would be too expensive to upgrade the existing proprietary systems, so the university sought a more affordable and flexible solution.

After speaking with many system integrators wanting to employ proprietary programming technology, UNC

Figure 2: (courtesy of Affinity Energy) The original chamber control system was more than 20-years old and difficult to support, and an upgrade by the original manufacturer would be have been too expensive.

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Chapel Hill decided to work with Affinity Energy (**www.affinityenergy.com**) after hearing of the company's reputation for open-system PLC integration for critical systems.

Specifying a New Control System

Several types of hardware were being used to control the chambers. Each performed essentially the same functions, but there were changes in newer iterations of cooling technologies. Affinity Energy designed a customizable, universal panel prototype to regulate temperature in all of UNC Chapel Hill's chambers, regardless of the existing controller or cooling technology.

There are three types of heating or cooling systems in the chambers, distinguished primarily by solenoid valves controlling liquid or hot gas, or by proportional valves controlling liquid, hot gas or reheat. Solenoid valves operate differently from proportional valves, so different control methods are used, as well as different program logic. This is typically addressed by using a controller specific to the type of valves, so a controller for solenoid valves could not be used on a chamber with proportional valves.

A primary goal of the project was to find a programmable logic controller (PLC) that could be used in any of the chambers, regardless of the devices being controlled. This first controller was considered a prototype since it would have to be used in many different chambers.

Figure 3: (courtesy of Affinity Energy) Affinity Energy replaced the obsolete controller with an AutomationDirect PLC and HMI due to the open, precise control capabilities and ease of use of these components.

After extensive hardware and controller research, UNC Chapel Hill and Affinity Energy specified AutomationDirect PLCs. Because AutomationDirect's PLC programming software is open, the university wouldn't have to be held hostage to proprietary software or a single system integrator's services if they wanted to adjust or completely overhaul the system in the future.

Using the New Control System

Previously, researchers had only rudimentary indication of a room's temperature, and in case of failure, there was no indication until opening a cold room door and feeling a warm blast of air. The old controller also had significant fluctuation between set point thresholds. Affinity Energy designed a temperature control system using AutomationDirect's Do-more PLC (*Figure 3*).

The new controller provides smoother and more accurate control than the legacy control systems. The controller enclosure is built with the PLC and other control devices (drivers, relays, etc.) as a unit. Field devices are wired to terminal blocks included for connections, and the panel is mounted on a wall outside the environmental chamber.

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The Do-more PLC is fast, has plenty of memory, and includes multiple communication options such as serial, USB and embedded Ethernet. It can be configured for several separate Ethernet communications ports, each running multiple protocols. The Do-more PLCs are programmed with the Do-more Designer software, available free online.

Affinity Energy also installed an AutomationDirect C-more human machine interface (HMI). This color touchscreen monitor displays data points such as temperature, humidity, defrost cycle activity, and liquid line and hot gas valve status. The HMI is installed in the door of the custom-built enclosure, and is located outside and beside the chamber entrance door.

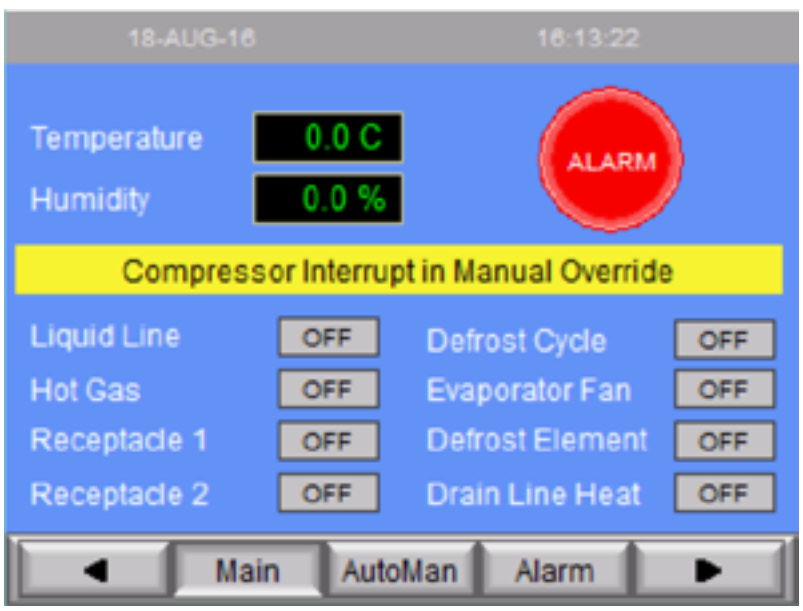

Figure 4: (courtesy of Affinity Energy) The AutomationDirect C-more HMI's main status screen provides temperature and humidity indication, along with field device status.

The main HMI screen displays the temperature in the room and alarm indicator (*Figure 4*). It also includes status indicators for the various field devices such as liquid and hot gas valves and evaporator fans, and shows whether a defrost cycle is active or not. An operator adjusts the room temperature using the HMI by entering a password-protected screen.

"Not only is the HMI designed for us by Affinity Energy a lot easier to navigate, having the capability to plug into the controller to conduct maintenance and troubleshooting is a real home run for our techs," says Mark Obenshain, Assistant Director of HVAC Operations for UNC Chapel Hill.

To alert researchers and maintenance personnel of out-of-tolerance temperature values, Affinity Energy included alarming functionality. In addition to an alarm message displayed on the HMI, an audible alarm mounted on the control enclosure sounds as soon as a temperature rises or falls outside a specific set of parameters.

Not only does the HMI make it much easier to operate the environmental chamber, it also provides data logging to a built-in SD memory card. It can also send an e-mail, access an FTP server, act as a web server and provide remote Internet access. All of these functions are easy to add at a researcher's request.

Due to the nature of research conducted in the chambers, a chart recorder was still required. Affinity Energy replaced the outdated chart recorder with a new circular chart recorder by Future Design Controls, saving money without compromising accuracy.

Precise Temperature Control

The refrigeration process includes the typical compressor, evaporator and condenser devices. A refrigeration cycle begins at the compressor which pressurizes the gas returning from the evaporator coil in the chamber. This high-pressure refrigerant gas condenses into its liquid state, but can only do so if it can release heat.

As the gas travels through a condenser coil located outside of the chamber, it gives off heat, becoming a high-pressure liquid. This liquid refrigerant travels through an orifice and becomes a low-pressure liquid, which wants to evaporate to a gas, but must absorb heat to fuel the transformation. The gas travels through

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the evaporator coil located inside the chamber where it can absorb heat, cooling the room and becoming a low-pressure gas, which is returned to the compressor to begin the cycle again.

In this application, temperature is controlled and maintained by managing the liquid line and hot gas valves. The liquid line valve is open all the time except during a defrost cycle. As a result, the temperature in the room would continue to become colder and colder, reaching temperatures below freezing, were it not for the hot gas valve injecting a portion of the gas leaving the evaporator coil inside the chamber back into the inlet of the evaporator coil.

Adding some of the hot gas into the liquid entering the evaporator coil slows the cooling process, bringing the temperature toward a desired point. Since the liquid line valve is always open, the hot gas valve is modulated at the duty cycle required to reach and maintain a specific temperature.

Humidity is controlled by heat injection to manage how much moisture in the chamber condenses on the evaporator coil.

A custom PID control method was needed to manage both the positive and the negative side of the operation curve. “Keeping temperatures within a half a degree Celsius, with researchers going in and out all day long, is not an easy thing, but Affinity Energy's integrated solution has been running flawlessly” notes Steve Hargett, Facilities Maintenance Supervisor at UNC Chapel Hill.

Although it is an advanced control function, it was relatively simple for Affinity Energy to develop the custom-control algorithm in the AutomationDirect PLC. The algorithm is essentially a PI loop, but coded explicitly rather than using the off-the-shelf PID programming module in the controller.

Even with researchers going in and out of the room throughout the day, the prototype control solution holds the temperature steady within a half a degree Celsius. With their new control system, and with PLC programming supplied by Affinity Energy, UNC Chapel Hill has the freedom to introduce future enhancements using their own personnel.

The plan is to replace controllers on other chambers across the UNC campus using this open design based on AutomationDirect PLCs and HMIs. Program changes will be incorporated into this universal control solution as needed for the different types of chambers to maintain consistency. As the university integrates this new control solution into the rest of their environmental chambers, all they need to do is copy it and provide a few minor calibration tweaks based on each room's characteristics.

UNC Chapel Hill's future plans include full access to room temperature and alarm history using remote access. This will provide quick access to critical historical data required by various regulatory agencies.

Author Bio

Allan D. Evora is the President of Affinity Energy. He's a leading expert in control systems integration with over 20 years of industry experience working in every capacity of the automation project life cycle. With a background at Boeing Company and General Electric, Allan made the decision to establish Affinity Energy in 2002. Allan is an alumnus of Syracuse University with a B.S. in Aerospace Engineering, a graduate of the NC State Energy Management program, and qualified as a Certified Measurement & Verification Professional (CMVP).

Copley High School Student Project and Update

By Chip McDaniel, AutomationDirect

We've covered the engineering students at Copley High School twice in recent years here in the Student Spotlight. Copley HS is a suburban, public high school just west of Akron, Ohio. The school's engineering program works closely with local industry and with their disabled employees to help automate various processes to achieve additional productivity for these dedicated workers. The student team also enters the Source America Challenge every year. The **Source America Design Challenge** is a national engineering competition in which participants create innovative workplace technologies for people with disabilities.

The Most Recent Project:

The Copley entry for the 2018 Source American Design Challenge High School Division was a cutting machine to prepare bulk packages of lottery receipts for secure shredding. The Paper Stack Cutter (PSC) cuts open packages of pamphlets to prepare them for shredding AND to ensure all employees at Weaver Industries SecurShred can prepare these materials for shredding. These bulk paper bundles are arriving at the shredding facility in bulk packages that are too large and too dense even for industrial shredding equipment to handle. The Copley High School students modified a commercially available, off-the-shelf bandsaw with various safety devices, and retrofitted the controls with AutomationDirect industrial pushbuttons to enable it to perform the required task in a safe fashion.

While not as highly-automated as earlier Copley designs, the PSC continues the success of the high school engineering team, and was awarded fifth place in the Source America Challenge for 2018 - results of the **2018 High School Division** are posted here.

Past Project Updates:

Back in 2017, the Copley Innovators created the "Delta Snap" machine to enable disabled workers to easily and efficiently assemble a grinding capsule and top into a salt and pepper grinder cap for the food industry. They won 2nd place in the Source America Challenge national competition for that effort. The machine was controlled by a CLICK PLC and an impressive complement of NITRA pneumatic valves, cylinders, and accessories were used to automate the machine's actions. You can read all the details in **this article**. Although the contract for producing the grinder caps has now been completed, Weaver Industries reports that over one million of the grinder caps were produced during the year-long production run of the machine.

3.5 Million Nozzles and Counting:

An even older machine dubbed the "Fomo Nozzle" machine, created by the Copley students in 2015, is still in production, is running two shifts per day - and recently passed the 3.5 million assemblies mark. This machine allows the disabled workers to assemble nozzles for low pressure polyurethane foam insulation, sealants, adhesives, and spray foam systems. This machine was designed and built entirely by the high school engineering team - and, like the Delta Snap machine, it is also controlled by a CLICK PLC and powered by NITRA Pneumatics. You can read the story of the Copley 2016 Challenge entry **here**.

Joe Buit, the Director of Production Services for Weaver ProPac commented, "We never expected the machine to last this long - the only downtime we have experienced in the past three years was due to lack of lubrication. The fact that this machine is still running 3.5 million nozzles later is a testament to this student team, and the engineering, forethought, and hard work that they put into the effort."

Video of the Fomo Nozzle machine: **https://youtu.be/m3QL1XAaFYc**

Brain Teasers

By Chip McDaniel, AutomationDirect

Running towards danger?

Smiley Guy leaves home at a mad sprint, he runs a distance and turns left, he runs the same distance and turns left again, then he runs the same distance and turns left yet again. When he finally gets home, there are two masked men waiting for him. Who are they?

Don't feed the wildlife!

Smiley Guy leaves his campsite one morning and hikes a mile south, then he turns and hikes a mile west, then turns and hikes a mile north, at which point he arrives back at his camp to find a bear rummaging through his tent. What color is the bear?

Poetic Riddles:

My life can be measured in hours,
I serve by being devoured.
If thin, I am quick; if fat, I am slow.
And the wind is certainly my foe…
What am I?

I have an eye, but am blind;
a sea, but no water;
a bee, but no honey;
tea but no coffee;
and a why, but no answer…
What am I?

Bobby's friends with Jimmy, but not Joe.
He plays in sleet but not the snow.
He rides in jeeps, but never vans;
Drinking bottles, never cans,
Always willing, seldom game…
He's mostly harmless, but not quite tame.
Bob never counts, when he can tally…
So, who would he prefer to name:
Would she be Sara, or call her Sally?

And a few one-liners:

What has a head and a tail but no body?

The more of these you take, the more you leave behind… What are they?

I am gentle enough to soothe the skin, light enough to fly, yet hard enough to crack a rock… What am I?

In 2015, a person was 15 years old. Yet, in 2020, that same person will be 10 years old. How can this be?

A sundial has the fewest moving parts of any time-piece. Which has the most?

Answers below…

Keep going (are you sure you don't want to solve these on your own?):

Answers:

The umpire and the catcher
White
Candle
(English) Alphabet
Sally (double letters)
A coin
Footsteps
Water (liquid, vapor, ice)
The person was born in 2030 BC
An hourglass (thousands of grains of sand)