PRESERVING ELECTRICAL SAFETY

Significant changes to wind farm safety requirements are expected in the near future with the upcoming revisions to the NFPA 70E standard

By James R. White
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The 2015 edition of NFPA 70E is due for publication in October, and with it will be many changes that will affect wind farm safety requirements. NFPA 70E forms the basis for most electrical safety programs, but it can be confusing when the standard is updated regarding what has actually changed. There are many more changes than can be covered in this article due to space constraints, but I can review a few. I will be revising my pocket guide, "Significant Changes to NFPA 70E — 2015 Edition," published by American Technical Publishers (go2ATP.com). Also, please note that this article does not attempt to provide a formal interpretation of NFPA 70E. To receive a formal interpretation, please contact NFPA directly.

Outlined below are some changes to Chapter 1 of NFPA 70E.

SECTION 130.2(A)(4)

One of the issues the 70E Committee has addressed over the last three cycles is that of operating electrical equipment, and working near electrical equipment that is in operation. In the 2012 edition of NFPA 70E, Section 130.(7)(a) IN No. 2 was added, stating:

It is the collective experience of the Technical Committee on Electrical Safety in the Workplace that normal operation of enclosed electrical equipment, operating at 600 volts or less, that has been properly installed and maintained by qualified persons is not likely to expose the employee to an electrical hazard.

This Informational Note explains that normal operation of equipment that has been properly installed and maintained is not likely to pose an increased arc flash risk. The key to this statement is "not likely." "Not likely" does not mean "never," nor does it imply that personal protection equipment (PPE) is not required under all circumstances. Qualified persons will still have to assess the risks involved in performing any task and dress out accordingly. This is true whether the PPE Category Tables are used or Arc Flash Hazard Warning Labels. Turn the autopilot to the OFF position.

That being said, there still seemed to be some confusion in the industry. In an attempt to bring more clarity to the committee's intent, 130.2.(A)(4) was added:

Normal operation of electric equipment is permitted when all of the following conditions are satisfied:

- The equipment is properly installed;
- The equipment is properly maintained;
- All equipment doors are closed and secured;
- All equipment covers are in place and secured; and

• There is no evidence of impending failure.

The inclusion of 130.2(A)(4) should make clear that it is not the intent of the Technical Committee to force the wearing of arc-rated clothing and PPE to operate an electrical device in the manner specified by the manufacturer. That being said, the Technical Committee would encourage workers to wear such PPE and clothing whenever that worker believes it might be needed or is more comfortable wearing such equipment.

As an example, if I were about to operate a 480 V circuit breaker with a continuous current rating above ~1,000A I would dress out on HRC 2 PPE and arc-rated clothing. It should also be noted that "nor-

ALSO IN THIS SECTION:

mal operation” means to operate the equipment in the manner specified by the manufacturer. If the manufacturer states that a push button must be used to operate the equipment, operation by any other means would be outside the scope of this statement and it would not apply.

Section 130.2(A)(4) includes an Informational Note that explains what is meant by “properly installed” and “properly maintained”:

Informational Note: The phrase “properly installed” means that the equipment is installed in accordance with applicable industry codes and standards and the manufacturer’s recommendations. The phrase “properly maintained” means that the equipment has been maintained in accordance with the manufacturer’s recommendations and applicable industry codes and standards. The phrase “evidence of impending failure” means that there is evidence such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration.”

This is the first time these terms have been defined in NFPA 70E and provides a basis for determining equipment condition.

SECTION 130.4(B)

The 70E Committee has been trying to make the 70E more user-friendly. To meet that goal, the committee has worked to clarify and simplify the 70E.

One such effort was to eliminate the Prohibited Approach Boundary by looking at the way the shock approach boundaries are used in the field. The Limited Approach and Restricted Approach Boundaries both are triggers for certain actions.

The Limited Approach Boundary is the closest an unqualified person can approach exposed energized conductors or circuit parts and the Restricted Approach Boundary is the point at which a qualified person must wear insulating rubber gloves or take other action to protect themselves from the shock hazard.

The Prohibited Approach Boundary contained no such trigger and people in general seemed to be confused as to its purpose.

SECTION 130.5(B)

The requirements for labeling of electrical equipment have been a point of confusion for the last cycle or two. Part of the reason was the

2009 edition of NFPA 70E only stated that electrical equipment had to be labeled. This led some to believe that anything electrical had to be labeled.

The wording in the 2015 edition should clarify exactly what the intent is. It states:

> Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be field-marked with a label containing all the following information:
>
> (1) Nominal system voltage
> (2) Arc flash boundary
> (3) At least one of the following:
> a. Available incident energy and the corresponding working distance
> b. Minimum arc rating of clothing
> c. Site—specific level of PPE
> d. PPE category in 130.7(C)(15)(b) or 130.7(C)(15)(d) for the equipment.

Only equipment that may require inspections, adjustment, servicing or maintenance while energized are required to have the field marking (label) in place. If the equipment does not require inspection, adjustment, servicing or maintenance while energized, it does not require the label.

Section 130.5(B) also states:

> Exception: Labels applied prior to September 30, 2011, are acceptable if they contain the available incident energy or required level of PPE."
>
> The method of calculating and the data to support the information for the label shall be documented. *Where the review of the arc flash hazard risk assessment identifies a change that renders the label inaccurate, the label shall be updated.*
>
> *The owner of the electrical equipment shall be responsible for the documentation, installation, and maintenance of the field-marked label.* [emphasis added]

The emphasized portions of the above two paragraphs show the added requirements for 2015. If the label becomes inaccurate for any reason, it must be updated to reflect the current requirements for that piece of equipment. It also states that the equipment owner is the person responsible for the required labels. The owner does not have to personally install or maintain the labels, but he is responsible to see that it is done.

Task	Equipment Condition	Arc Flash Hazard
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	Any	No
Reading a panel meter while operating a meter swtich	Any	No
Normal operation of a circuit breaker (CB), switch, contactor, or starter	All of the following: • The equipment is properly installed • The equipment is properly maintained •All equipment doors are closed and secured • All equipment covers are in place and secured • There is no evidence of impending failure	No
	One or more of the following: • The equipment is not properly installed • The equipment is not properly maintained • Equipment doors are open or not secured • Equipment covers are off or not secured • There is evidence of impending failure	Yes

Table 1: Proposed NFPA 70E 2015 Table 130.7(C)(15)(a), Partial; Note that the numbering on these tables could change by the time the 2015 edition is published.

NEW ARC FLASH PPE TABLES 130.7(C)(15)(A) AND (B)

The NFPA 70E technical committee has agreed to a new format for choosing arc-rated clothing and PPE. Table 130.7(C)(15)(a) will be split into two tables. The first table is used to determine if an arc flash hazard exists. One of the complaints about the current table method is that tasks that do not pose an arc flash hazard are listed in the table, such as operating a panelboard meter.

If no arc flash hazard exists, why have that task in the table? The answer is that in using the old table method, all tasks common to that equipment were listed to ensure workers knew that some tasks were not an arc flash hazard. It is somewhat clumsy and confusing. The HRC for a category of equipment could be down-rated by one, two or even three numbers, based on perceived risk.

Under the new table method, no such reduction is used. If there is an arc flash hazard, you must wear all the required PPE and clothing.

Table 1 shows a portion of the proposed table for the 2015 NFPA 70E. No arc flash hazard means nothing further is required. If there is an arc flash hazard, then you would move to a second (added) table and choose the arc flash category of the recommended clothing and PPE. This is based on the same limits as the current table and the categories remain the same. The difference is that there is no risk factored in. Risk is still a factor, but now the level of risk is determined by conducting a risk assessment for that specific task on that specific piece of equipment, but only for tasks that pose an arc flash hazard.

Note that in the added table there is no perceived arc flash hazard if the equipment is properly installed, properly main-

Equipment	Category	Arc-Flash Boundary
Panelboards or other equipment rated at 240V and below Parameters: Maximum of 25 kA short-circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	1	600 mm (19 inches)
Panelboards or other equipment rated >240V and up to 600V Parameters: Maximum of 25 kA short-circuit current available; maximum of 0.03 sec (2 cycles) fault clearing time; working distance 18 inches	2	900 mm (3 feet)

Table 2: Proposed NFPA 70E 2015 Table 130.7(C)(15)(b), Partial; Note that the numbering on these tables could change by the time the 2015 edition is published.

tained and there is no evidence of impending failure on some of the listed tasks. This is critical, as these factors have to be part of the risk assessment required by NFPA 70E. If a worker is troubleshooting electrical equipment, it is no longer normally operating; it is in distress and arc flash protective equipment must be worn to operate it or perform any other task on or with it. If an arc flash hazard is present, the second new table is used to determine arc-rated clothing and PPE. Table 2 shows a portion of the proposed new table.

HRC 0 was eliminated, as the committee felt that this table should only show requirements where arc-rated clothing was required. HRC 0 would mean the worker was outside the arc flash boundary and did not need arc-rated PPE or clothing. Section 130.7(C)(11) states, “Clothing consisting of fabrics, zipper tapes, and findings made from flammable synthetic materials that melt at temperatures below 315°C (600°F), such as acetate, acrylic, nylon, polyester, polyethylene, polypropylene, and spandex, either alone or in blends, shall not be used.” This section as well as section 130.7(C)(12) prohibit the wearing of meltable fabrics.

The category of the arc-rated clothing and PPE is still determined by the type of equipment and has the same limits, but is no longer task-based. The arc flash boundaries (AFB) are rounded up to the nearest foot (except for PPE Category 1) and working distances are the same as in the current table.

Risk is removed as a determining factor in the table, although risk must be determined by the user. PPE Category 1 was stated in inches, as rounding up caused a conflict with the requirement that “all parts of the body inside the Arc Flash Boundary (AFB) must be protected”. At 24” the back of the head would probably be within the AFB and the worker would have to wear an arc-rated balaclava.

Summary

The 70E continues to improve with each cycle. The Technical Committee wants to have a standard that is usable, easy to interpret and will provide a means to guide technicians and electricians to establishing a safe work environment.

There is some disagreement within the committee about how the 70E should fulfill that role. Should it represent “best safe work practices” or should it provide “minimum acceptable guidelines”?

I fall into the “minimum acceptable guidelines” group. A qualified person should be able to assess the hazards and risks involved in performing the task at hand and also be able to assess equipment condition. If they are unable to perform those requirements, they should not be considered a qualified person and require additional training.

I don’t believe the 70E should attempt to provide “best safety work practices,” because it is not practical for the committee to properly evaluate and establish specific when there are so many variables.

Qualified persons must be able to perform their personal evaluations based on site and equipment conditions at the time of the task being performed.

A standard cannot address that situation, and should not attempt to do so.

Electrically conductive paste provides life cycle cost savings for turbine electrical connections

By Tom Gibson

High-voltage equipment such as this transformer used to step up current from the wind turbines has many crucial connections.

Drive down a country road in many states, and you're likely to see a wind farm on a distant ridge-top sporting a dozen or more wind turbines slowly spinning. Wind farms are becoming ubiquitous, larger, and more complex. Harnessing their power and transferring it to the grid requires this complexity, which now includes power electronics and remote diagnostic systems.

At the same time, manufacturers are also standardizing wind turbine systems to make them similar to other electrical systems familiar to maintenance technicians, using established modular industrial connectors for plug-and-play convenience. Plug-in connectors are used when possible, eliminating the time required by traditional mechanical bolt-type connectors. But are the manufacturers and installers taking a serious look at protecting these electronics? Are they preventively protecting the hundreds of electrical connections in a wind farm? Is it really possible to minimize down time by improving connections?

Perhaps the answers lie in looking at how electrical connections on other types of equipment around the world are protected from moisture and corrosion. They often benefit from the use of electrically conductive paste on connections, extending their life span, enhancing safety, and raising their electrical efficiency.

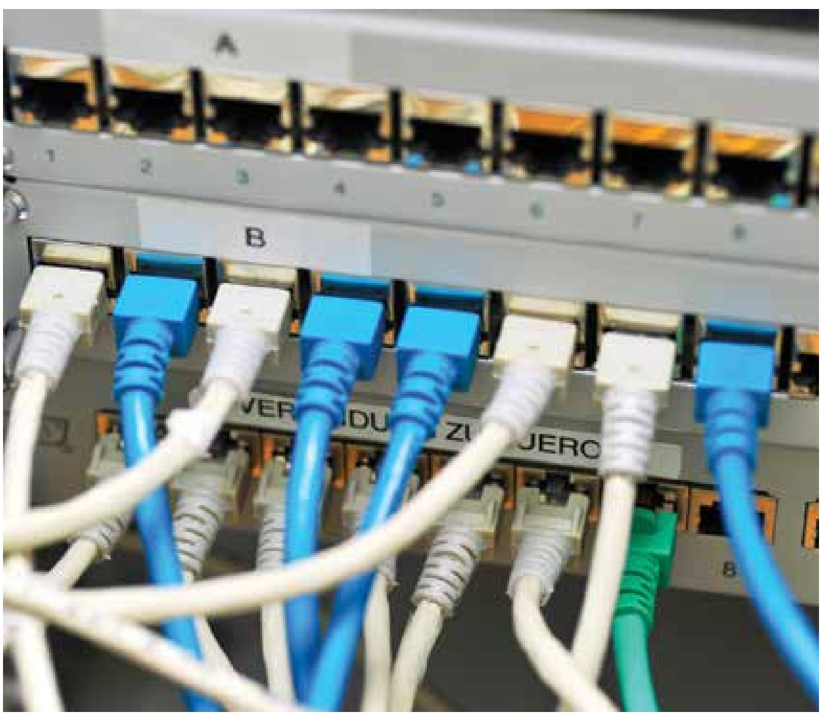
Electrically conductive (EC) paste is designed to work on new and existing connections of all types, including wired, bolted, clamped, blade, plug-in, and crimped varieties. These pastes are NOT the same as dielectric grease, which simply blocks out moisture. EC pastes prevent corrosion from reducing conductivity by keeping moisture out and, most importantly, by cutting through any existing corrosion. The key to their effectiveness is in the sharp, minute, conductive metal particles suspended in oil or grease, which create multiple parallel pathways for electrical current in a connection. In many environments, corrosive electrolytes are present, sometimes from the manufacturing process, producing corrosion even when the eye can't detect it. Electrical connections near the ocean or other bodies of water especially benefit from the protection pastes afford. Ruggedized computers are available, of course, but paste costs a fraction of the price and lasts a long time. However, selecting a NON-silicone based paste is essential, so that no hardening or residue occurs.

EC pastes perform other functions as well. They act as a locking mechanism that prevents loose connections caused by thermal and vibratory stress, common in wind turbines. Some formulas reduce resistance and heat buildup in the electrical interface, an important function in many types of connections, including computer connections. On plug-ins, silver paste also acts as a lubricant and keeps connectors from abrading.

According to John Ebbinghaus, a veteran engineer with Prohmtect, a manufacturer of electrically and thermally conductive pastes in Sioux Falls, SD, "Paste can be used on all electrical connections safely — even light bulbs — provided the correct formula is applied. Our company produces formulas for computers and other electronics, automobiles, boats, lighting, agricultural equipment, and electric power conversion equipment such as generators, converters, transformers, and inverters. It's also beneficial on cathodic protection systems and grounding applications."

Originally from New Rochelle, New York, Ebbinghaus developed a unique stainless steel alloy paste in the 1970s for the U.S. Navy to use on guidance systems for jet fighters on aircraft carriers. Today his company produces half a dozen formulas for various applications. They fall into two broad categories, stainless steel and silver. Several types of unique stainless steel pastes are

High-voltage equipment such as this transformer used to step up current from the wind turbines has many crucial connections.



Computers in harsh environments can benefit from electrical paste, as it maintains conductivity and minimizes abrasion from frequent insertion.

available with varying sizes and amounts of particles, depending on their application. The formulas come in a variety of sizes ranging from 1 cc syringes to 300 cc caulking tubes.

Paste products are typically packaged in syringes, sometimes with a needle tip, for ease of application in small spaces. For field application, kits are available containing a syringe, a lint-free cloth, alcohol wipes, and finger cots for applying the paste. It should be applied in a very thin coat to all faces in a connection after cleaning away loose dirt and other contaminants and drying the connectors with warm air.

Ebbinghaus advises that in computer connections, EC pastes are particularly important when the equipment must operate in harsh environments such as near a body of water or in any humid environment. This means that in wind turbines, especially those offshore, EC paste could make the difference between down time and profitable power production. With industrial Ethernet emerging as a major protocol for monitoring and controlling wind power systems, there is even more motivation for EC-protected connectors, especially if tightly-sealed connectors are not installed in the system. Paste would also protect hybrid connectors, used in many drives and motors with higher levels of intelligence built in. These contain up to eight power contacts and an Ethernet interface in a compact package.

To grasp the potential for using EC paste on the connections in wind turbine behemoths, it pays to understand how they operate electrically. Turbines installed on land vary from several hundred kilowatts to three megawatts and generate current at various output voltages ranging from 480 to 1,000VAC with 600 and 690 volts the most common. In a typical farm, underground cables interconnect individual turbines as part of a medium-voltage power collection system and communications network. These are typically 34.5 kV, an industry standard. At a substation on site, a transformer steps this medium-voltage electrical current up to several hundred thousand volts for the high-voltage electric power transmission system. For the 600-volt levels within the turbine, eight or ten cables deliver this low voltage to the step-up transformer. Transformers, with their multiple bolted connections are excellent candidates for the life cycle-lengthening properties of paste.

Using advanced power electronics in each turbine, wind farms regulate their voltage and reactive power levels to ensure they interconnect properly with the electrical grid and to help maintain reliability. As stated in a paper published by Tyco Electronics Energy Division, “Components for the Electrical Network in Wind Turbine Farms,” various connector types include bimetallic lugs, mechanical terminal lugs and connectors, wedge connectors, earthing connectors, and controlled torque shearbolt connectors.

With the collector network underground, reliability becomes critical, as a failure can take several turbines offline. Similarly, a failure in the feed from the collector network to the substation can disrupt the entire wind farm. Because of this, wind turbine manufacturers look at the life-cycle costs of components such as connectors as well as initial costs. Electrically conductive paste can insure that down time is held to a minimum. “An interesting test result with our silver paste,” says Ebbinghaus, “is that in multi-megawatt fuel cell connections, the reduction in resistance provided by the paste actually raised the conductive efficiency of the cell’s output to 94 percent, which was very satisfactory to the manufacturer of the cells. If this dynamic occurs in fuel cell connections, we know that it will transfer to other industries with power connections, resulting in increased power output in addition to huge life-cycle cost savings for their equipment.”

According to Lisa Rinaldo, Ebbinghaus’ daughter and Prohm-tect’s owner, “Electrically conductive pastes provide a simple preventive measure against failure, which a lot of people in industry don’t often think about. They assume that if their product is well built, failure is unlikely to happen, and if it does, you just replace the failed parts. But that gets expensive. No electrical connection is completely immune to the wicking of moisture and electrolytes. Actually, about 75 percent of all electrical problems in equipment are due to poor connections. One cc of EC paste can keep a huge, expensive piece of equipment like a wind turbine up and running and save a company manpower and time.”

With wind power generation burgeoning, the industry would profit from looking more and more to the type of preventive maintenance EC pastes can provide, to ensure cost-effective ways of maximizing electrical output, in the process saving themselves thousands of dollars and guaranteeing minimal down time.

Wind farms transfer their power to the grid seamlessly through a host of electrical equipment such as this transformer (foreground).

A technician monitors electrical equipment inside a wind tower at the base.

Profile

Bicron Electronics Company

For a half-century, customers have been trusting this Canaan, Conn.-based company with their high-frequency transformer and solenoid needs

By: Tim Byrd

Bicron Electronics Company doesn't deal in standard products, but rather takes a "platform" approach for its VoltBoss® transformer line — allowing for each customer's needs to be addressed without necessarily driving up costs with unique or rarefied materials.

A small business established in 1964 and based in the northwest corner of Connecticut, the privately held company — which builds high-frequency specialty transformers and other specialty magnetic products — turns 50 this year.

"Everything we do is customer needs driven," said director of sales Kevin Bradley. "Our customers come to us because of our proprietary designs, which eliminate breakdown caused by partial discharge and the corona effect."

The corona effect, according to Bradley, involves ionization and the release of caustic ozone gas. If you've ever heard crackling of a large transformer, "That's partial discharge," Bradley explained. "Partial discharge is a breakdown of the insulation system which can devastate electrical systems, especially those built to handle high voltages in an intimate space. "Once you lose your insulation," said Bradley, "that's it. You're fried."

The corona effect is especially difficult to detect — very few engineers even pay attention to it in their designs. Bradley said, "An engineer might look at 15 different components before she or he finally decides, 'The transformer is causing this problem.' In the end, though, it can destroy a system."

Bicron's transformers thrive in the kinds of applications where reliability and safety — endurance, if you will — are critical. It's fitting, then, that their tagline is, "Bicron, when your transformer must not fail."™

There are many companies that rely on Bicron for transformers, and for its custom design work. For some of Bicron's applications — such as in methane gas testers — lives are on the line.

Other applications include offshore wind turbines, which require an $80,000 helicopter ride to fix. Many of its customers make large power supplies and other industrial controls. Bicron's transformers are even found in the locomotive braking and medical fields, where reliability and continuous operation are very important ("You don't want to see any spikes or loss of power when someone is undergoing a medical procedure!") The company has maintained continuous ISO certification since receiving initial approval in 1997.

Bicron places a great deal of emphasis on its intellectual property, which Bradley describes as "all about the design itself. We are able to design transformers that reduce the footprint to the smallest possible size for a customer to use, which gives them flexibility of design and lowers their cost, but will also avoid all the electrical problems of a design that is too tight. We pride ourselves on being able to perform to the power specifications necessary, all while keeping the footprint small."

Bicron's designs also enable its transformers to operate at the lowest possible temperatures. Bradley explained, "Heat rise in an electrical system is dangerous to the system. It aggravates the materials. You want to operate the system with minimal heat rise. Because of our design capability and proprietary material systems, we can withstand harsh environments better than other transformers.

Their newest line of low partial discharge transformers is called the VoltBoss, a product able to "do more with less." It can increase efficiency, and even a small gain in power efficiency is important. It also lowers component costs by helping customers avoid costly heat sinks. Finally, it gives customers more real estate to work with.

"Our transformer designs are leading the way — board-mount transformers and torroidals," said Bradley. "We also have an excellent niche business in our solenoid business. Our solenoids are found in electronic locking devices, military hardware, pharmaceutical equipment, and diesel motor fuel controls. We are the exclusive distributor for Shindengen solenoids, and we have partners that we work with to design custom solenoids."

"Transformers are really our bread and butter, heavily utilized in the wind industry and in the industrial control environment," said Bradley. "We guarantee our transformer for 'one day more' than our customer guarantees its system. We have built and supplied over a million and a half transformers without a single field failure in the last 15 years."

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Could you tell our readers about hand tools designed for use in high-voltage environments, and how Snap-on differs from traditional insulated hand tools?

A typical insulated tool is a steel tool dipped in a layer of non-conductive coating. You're holding a conductive material in your hand, but there's a layer of non-conductive material that comes between you and the electricity.

At Snap-on, we have a line of insulat-*ing* tools. The difference is that instead of just a coating, our insulating tools themselves are made out of a non-conductive, composite material. This line primarily consists of screwdrivers and similar tools that are often used around electrical equipment. Our insulating tools are rated at 1,000V and tested to 10,000V.

How does the strength and durability of these tools compare with traditional hand tools or even insulated tools?

Our insulating tool line is the product of quite a bit of research, development and testing. These tools are designed to provide the same kind of strength you'd get with a standard tool. In some cases, composite tools can actually be stronger than standard steel tools. The design of our composite sockets, for example, is such that there is a metal insert inside of socket, but the whole body is built out of composite. The part of the tool that is actually on the fastener is metal, but the body is composite.

Would you say there is a distinct advantage, safety-wise, of Snap-on's insulating tools when compared to traditional insulated tools?

Certainly. With insulated tooling, you run the risk of that non-conductive coating becoming compromised. You're actually supposed to inspect them regularly, and even get them tested. If that coating becomes compromised, an arc can occur because the metal is exposed. That can be a dangerous situation.

With composite tools, if they get chipped or scratched on the outside, you're still safe because the entire tool is made out of non-conductive composite material.

Speaking of safety, one of our core areas of emphasis is hand tool safety training. We find that many times, someone may be unknowingly putting himself at risk by using the wrong tool for a job. In our "Right Way Every Day" tool safety training program, we try to lessen that risk by encouraging our customers to always use the right tool for the job.

Can you give us an example of the risk of using the wrong tool?

Let's say someone is working on a wind turbine. It's fairly common that the person may not have the right tool because he left it in the truck or back at the shop. He needs to complete this task — not only on this turbine, but on others down the line. In this instance he decides to use a different tool that he has with him. Not only may that tool not be the best for the task, it may also be unsafe for the job he's doing.

Are there any unique services that Snap-on is able to provide for its customers?

One of the things that we do very well is kit-building. We build custom tool kits for all different applications. For example, we have designed and built high-voltage tool kits — which included a variety of hand tools and insulating tools — and shipped a them to number of our wind power customers. That's all done at our custom kitting center located in Kenosha, Wisc.

What other tools does Snap-on offer that may be of note to wind energy technicians working in electrical environments?

With regard to electrical applications, we have a complete line of electrical meters and testers. Also, we also carry a line of insulating gloves.